ERGONOMIC JOB REDESIGN FOR MULTITASK PACKAGING WORK BY USING REVISED NIOSH LIFTING EQUATION

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SUPERVISOR'S DECLARATION

We hereby declare that we have checked this project and in our opinion this project is satisfactory in terms of scope and quality for the award of the degree of Bachelor of Mechanical Engineering with Manufacturing.

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STUDENT'S DECLARATION

I hereby declare that the work in this thesis is my own except for quotations and summaries which have been duly acknowledged. The thesis has not been accepted for any degree and is not concurrently submitted for award of other degree.

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DEDICATION

To mama and abah

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ABSTRACT

The purpose of this study is to analyze the existing operation of a manual multitask packaging work task which is hazardous to a worker and then suggest the improvements by providing practical guidelines ergonomically. The work task was suggested to be redesigned ergonomically and improved by looking for clues and reviewing previous complaints, by observing the work activities, and by talking to the workers, supervisors, and managers. Several National Institute for Occupational Safety and Health (NIOSH) assessment tools of assessing work task was conducted to quickly detect problem work tasks. The result of the analysis did show that the evaluated work task is physically stressful to even healthy workers but follow up actions were not done because the suggested improvements were not accepted and implemented. Despite the fact that the suggested improvements were not accepted, the ergonomic practical guidelines were still established generally and may only be reliable if were to be used in the evaluated section of BI Technologies Corporation Sdn. Bhd.

ABSTRAK

Tujuan pengkajian ini adalah untuk menganalisa operasi sejumlah kerja-kerja membungkus secara manual yang berbahaya bagi pekerja dan mencadangkan perbaikan dengan menyediakan pengarahan praktikal secara ergonomik. Tugas kerja telah dicadangkan untuk dicorak secara ergonomik dan diperbaiki dengan mencari tanda-tanda, meninjau kembali aduan-aduan yang terdahulu, memerhati aktiviti-aktiviti kerja, dan berbincang dengan pekerja, penyelia, dan pengurus. Beberapa kaedah pengkajian daripada Pengurusan Keselamatan dan Kesihatan Pekerjaan (NIOSH) telah digunakan untuk mengkaji tugas kerja bagi mengesan masalah tugas kerja dengan cepat. Keputusan bagi analisis menunjukkan tugas kerja yang telah dinilai adalah memberikan penekanan secara fizikal mahupun untuk pekerja yang sihat tetapi tindakan turutan tidak dilakukan kerana perbaikan yang dicadangkan tidak diterima, pengarahan praktikal secara ergonomik tetap disediakan secara umum dan mungkin hanya akan boleh digunakan sekiranya dilaksanakan di bahagian Syarikat BI Technologies Sdn. Bhd. yang telah dinilai.

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LIST OF SYMBOLS

ml	Millilitre
kg	Kilogram
min	Minutes
˚C	Degrees Celsius
˚F	Degrees Fahrenheit

LIST OF ABBREVIATIONS

AM	Asymmetric Multiplier
C	Coupling Classification
CLI	Composite Lifting Index
CM	Coupling Multiplier
DM	Distance Multiplier
FILI	Frequency Independent Lifting Index
FIRWL	Frequency Independent Weight Limit
FM	Frequency Multiplier
HM	Horizontal Multiplier
L	Load Weight
LBP	Lower Back Pain
LC	Load Constant
LI	Lifting Index
MMH	Manual Material Handling
MSD	Musculoskeletal Disorder
NIOSH	National Institute of Occupational Safety and Health
RWL	Recommended Weight Limit
STLI	Single Task Lifting Index
STRWL	Single Task Recommended Weight Limit
VM	Vertical Multiplier

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Ergonomics is a discipline in the health and safety industry that study the human relation with equipments, machineries, procedures, and working environment. It concentrates on effort to optimize human ability with the job done (National Institute for Occupational Safety and Health (NIOSH, 2005). Ergonomics is frequently associated with manual material handling (MMH) (lifting, carrying, pushing, or pulling) which represents an occupational risk factor that has to be confined within safe limits (Cheung et. al., 2007).

Acute and chronic work-related injuries may be attributed to excessive force demanded by the task (Chung et. al., 1996). In this study, the literature revolves around the effects of body posture, reach distance, arm orientations, speed, and duration of exertions are the issues frequently mentioned. Some important background factors will be considered including age, height, weight, sex, number of working hours per week, working time with present work task, number of working task, and anthropometry data ranges based on participants.

Scientific evidence shows that effective ergonomic interventions can lower the physical demands of MMH work task, thereby lowering the incidence and severity of the musculoskeletal injuries they can cause (NIOSH, 2007). Their potential for reducing injury related costs alone makes ergonomic interventions a useful tool for improving a company’s productivity, product quality, and overall business competitiveness.

But very often productivity gets an additional and solid shot in the arm when managers and workers take a fresh look at how best to use energy, equipment, and exertion to get the job done in the most efficient, effective, and effortless way possible. Planning that applies these principles can result in big wins for all concerned.

This study was conducted to help individuals recognize high risk MMH work tasks and choose effective options for reducing their physical demands. Also through out this study paper, approaches such as NIOSH MMH Checklist, NIOSH Hazard Evaluation Checklist For Lifting, Ergonomics Awareness Worksheet, and Ergonomic Checklist For Material Handling were used as assessment tools and briefly described. The Revised NIOSH Lifting Equation was used as the main analysis methods to hind the level of hazard imposed by a specific work task which will later be discussed through out the voyage of this paper.

Improvements towards positive construction of the work task were done during the redesign phase of the study. The improvements were clearly and briefly explained. Their each own significant justification of why it should be implemented were also stated together with the suggestions. These improvements generally are of the engineering point of view rather than from administrative point of view.

1.2 PROBLEM STATEMENT

The BI Technologies (Magnetic Component Division) is having the problem of improving the fit between the demands of works tasks and the capabilities of their workers. The workers are exposed to risk factors for musculoskeletal disorders (MSD) due to awkward postures while working.

Problems of working methods that are potential to cause injuries are to be solved, prevented, or reduced to eliminate the problems regarding MSD as described previously.

1.3 OBJECTIVE

1.3.1 To analyze the existing operation of packaging work that is hazardous to a worker.

1.3.2 To suggest improvements by developing practical guidelines for ergonomic job redesign.

1.4 SCOPE OF STUDY

The scope of the study is the investigation of the current implementation of MMH in BI Technologies (Magnetic Component Division) at Jalan Tanjung Api, Kuantan. The evaluation will be done by using Revised NIOSH Lifting Equation. The evaluations will be limited to two-handed task only. The gender that is involved with this study is female. The improvements that ought to be made would probably fit only to BI Technologies and may not be applicable anywhere else.

1.5 OVERVIEW OF THE THESIS

From the literature review done, important information was extracted and combined to create a hypothesis concerning ergonomic job redesign for a manual material handling task. It can be said that if ergonomic interventions and useful tools are used to improve the work task that are considered as hazardous, then the severity of the MSD incidence could be lowered because effective ergonomic interventions can lower the demands of MMH and improving the fit between work tasks.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

Manual material handling (MMH) activities are not a foreign issue in industrial jobs. MMH tasks such as manually lifting, lowering, pushing, pulling, or carrying an object are typical examples of the activities requiring human strength (Mital et al., 1999). Although countless jobs are becoming mechanized and automated, human strength is still required in many industrial activities (Chung et al., 1996). MMH is consistently recognized as a major hazard in the workplace (Marley et al., 1996). It is also frequently associated with numerous risks of injuries (Godwin et al., 2007) and have been discussed in ergonomics and other related realms for a long period of time due to the fact that they are known to be one of the main causes of musculoskeletal overexertion injuries (Chung et al., 1996). The accumulated fatigue is the cause for degraded performance in the musculoskeletal system, which is one of the distinguishing physiological characteristics (or symptoms) of the human worker.

Nearly every tasks of MMH requires repetitive dynamic force exertions. It can be hypothesized that repetitive force exertions also lead to physiological fatigue, although it is known that static tasks are more problematic (Chung et al., 1996). The prevention of overexertion injuries and those other muscle exertion while performing manual tasks can be done by investigating the implications of various tasks variable on muscle strength, applying appropriate correction factors for specific task conditions (Chung et al., 1996), and by having adequate postural stability (Holbein et al., 1997). Therefore, every effort should be made to improve working conditions within this field of activities. There is a need for recounting the ergonomic evaluation to the specific occurrences or tasks performed in the field of work. It may be significant in the analysis practice to identify particularly strenuous tasks, as a basis for interventions, or the mix of high and low load periods (Forsman et al., 1999).

2.2 MANUAL MATERIAL HANDLING CRITERIA

The most commonly used MMH criteria will be discussed briefly below. For a more detailed discussion of MMH criteria, the interested reader is referred to Dempsey (1999).

2.2.1 Biomechanical Criteria

Biomechanical criteria are related to limiting external or internal forces to levels that do not exceed the musculoskeletal system capacity. Joint and composite strengths can be compared to strength required to perform a task, whereas tissue limits can be compared to shear and compressive forces acting on intervertebral discs. Biomechanical models of the low-back are used to estimate the shear and compressive forces acting upon the spine, particularly the L5/S1 joint. Although shear forces are often estimated, the author is aware of only one epidemiological study incorporating shear loading as an exposure determinant. The most common spinal compression criterion is the 3400 N peak limit suggested by NIOSH (1981), although alternate values have been suggested (Jäger and Luttman, 1997). Jäger and Luttman (1997) recommended incorporating age and gender as important factors when setting a criterion. Lumbosacral compression is the most commonly used biomechanical criterion.

2.2.2 Physiological Criteria

Physiological criteria focus on limiting energy expenditure to levels that do not result in excessive whole-body or localized fatigue. The level of acceptable energy expenditure is dependent upon the duration of the task, as acceptable energy expenditure and task duration are inversely related. Physiological criteria apply to repetitive task performed continuously. Heart rate, rate of oxygen consumption (or the equivalent energy expenditure), and percentage of maximum oxygen uptake can potentially be used as criteria. It should be noted that physiological criteria have not shown much promise with regards to differentiating the low-back disorder risk of different work designs (Dempsey, 1998; Leamon, 1994); thus, their use as exposure measures may be limited. The rate of oxygen consumption is the most common measure of energy expenditure. Often, a rate is chosen that corresponds to a majority of the population being accommodated. Oxygen consumption can be expressed in absolute terms (ml/kg/min or ml/min) or in relative terms (percent of maximum oxygen uptake). A criterion of one liter of oxygen per minute has historically been the most commonly used physiological criterion, although recent NIOSH guidelines (Waters et al., 1993) used more conservative values.

2.2.3 Psychophysical Criteria

The most commonly used psychophysical criterion is the percentage of the population (male, female, or combined) that a task accommodates with respect to weight or force values found in tables of psychophysical data. The largest and most comprehensive single set of tables can be found in Snook and Ciriello (1991). A criterion that at least 75% of workers are accommodated has been suggested (Snook, 1978; Snook et al., 1978). In some more cases, more conservative values are used (Waters et al., 1993).

2.2.4 Composite Criteria

The term composite criterion refers to those criteria that are developed from two or more of the individual criteria discussed above. One of the most widely recognized composite criterion is the 1991 NIOSH lifting equation (Waters et al., 1993), which incorporates biomechanical, psychophysical, and physiological criteria. Another example is the guidelines developed by Mital et al. (1997). In general, guidelines such as these attempts to satisfy criteria based upon multiple approaches. These methods provide a common exposure metric for multiple criteria.

2.3 ERGONOMIC IMPROVEMENTS

In general, ergonomic improvements are changes made to improve the fit between demands of work tasks and the capabilities of your workers. There are usually many options for improving a particular manual handling task. It is crucial to make choices regarding which improvements will work best for a particular task. For a more brief explanation, interested readers should refer to NIOSH Ergonomic Guidelines for Manual Material Handling (2007). There are two types of ergonomic improvements:

2.3.1 Engineering Improvements

Engineering improvements include rearranging, modifying, redesigning, providing or replacing tools, equipment, workstations, packaging, parts, processes, products, or materials.

2.3.2 Administrative Improvements

Administrative improvements would consider alternating heavy tasks with light task, provide variety in jobs to eliminate or reduce repetition (overuse of the same muscle group), adjust work schedules, work pace, or work practices, provide recovery time (short rest breaks), modify work practices within power zone (above the knees, below the shoulder, close to the body), and rotate workers through jobs that uses different muscles, body parts, or postures. Administrative improvements, such as, job rotation, can help reduce workers' exposures to risk factors by limiting to the amount of time workers spend on "problem jobs". However, these measures may still expose workers to risk factors that can lead to injuries. For these reasons, the most effective way to eliminate "problem jobs" is to change them. This can be done by putting into place the appropriate engineering improvements and modifying work practices accordingly.

2.3.3 Training

Training alone is not an ergonomic improvement. Instead, it should be used together with any workplace changes made. Workers need training and hands-on practice with new tools, equipment, or work practices to make sure they have the skills necessary to work safely. Training is most effective when it is interactive and fully involves workers.

2.3.4 Improvement Options

As improvement options are evaluated previously, several crucial requirements need to be taken into consideration for the particular workplace of interest. Those improvements that need to be done need to be asked general questions such as below. Will this improvement:

(i) Reduce or eliminate most or all of the identified risk factors?
(ii) Add any new risk factors that have not been previously identified?
(iii) Be affordable for organization (e.g., simpler, inexpensive alternative that is equally effective)?
(iv) Affect productivity of efficiency?
(v) Affect product or service quality?
(vi) Provide a temporary or permanent "fix"?
(vii) Be accepted by employees?
(viii) Affect employee morale?
(ix) Be able to be fully implemented (including training) in a reasonable amount of time?
(x) Affect the rate of pay or any collective bargaining elements?

2.4 DESIGN GUIDELINES FOR MANUAL MATERIAL HANDLING

Several different guidelines are available to design and/or analyze manual material handling tasks. Among the well-known guidelines are those proposed by NIOSH (1981; Waters et al.1993) and Mital et al. (1993, 1997). While the NIOSH guidelines, both old and revised, are limited to manual lifting, the guidelines proposed by Mital et al. (1993,1997) extend to all kind of handling activities, including one-handed material handling activities (Mital et al., 1999). These various design guidelines will be applied throughout this study paper. The goal is to develop solutions or tool which can be used to analyze a specific task based on a well-defined task, including whole-body postures, locations and magnitudes of external loads, and worker characteristics (Holbein, 1997).

2.5 FACTORS AFFECTING HUMAN STRENGTH

A number personal and task factors influence human strengths were found based on Mital et. al. (1998). The factors that are particularly important are:

(i) Age
(ii) Gender
(iii) Posture
(iv) Reach distance
(v) Arm and wrist orientations
(vi) Speed of exertion
(vii) Duration and frequency of operation

2.6 REVISED NIOSH LIFTING EQUATION

Several important equations were found based on Waters et. al. (1994). Only a few were described briefly below. Interested readers should refer to Waters et. al. (1994)

2.6.1 Recommended Weight Limit (*RWL*)

This is one of the principal products of the revised lifting equation. The RWL as shown in Equation 2.1 states that for a specific set of task conditions as the weight of the load that nearly all healthy workers could perform over a substantial period of time (e.g., up to 8 hours) without an increased risk in developing lifting-related lower back pain (LBP). By defining healthy workers, it means that workers who are free from adverse health conditions that would increase their risk of having MSD. The equation for RWL is as stated below.

$$RWL = LC \times HM \times VM \times DM \times AM \times FM \times CM \tag{2.1}$$

Where;

LC	=	Load Constant
HM	=	Horizontal Multiplier
VM	=	Vertical Multiplier
DM	=	Distance Multiplier
AM	=	Asymmetric Multiplier
FM	=	Frequency Multiplier
CM	=	Coupling Multiplier

2.6.2 Lifting Index (*LI*)

The LI is a term that describes a relative estimate of the level of physical stress associated with a particular manual lifting task where *L* is the load weight. The estimate of the level of physical stress as shown in Equation 2.2 is defined by the relationship of the weight of the load lifted and the recommended weight limit.

$$LI = \frac{LoadWeight}{\mathrm{Re}\,commendedWeightLimit} = \frac{L}{RWL} \tag{2.2}$$

2.7 TERMINOLOGY AND DATA DEFINITIONS

The following brief term definitions which are also based from Waters et. al. (1994) is useful in applying the NIOSH revised lifting equation. To have a clear view of the terms described below, refer to Fig. 2.1 and Fig. 2.2.

2.7.1 Lifting Task

Defined as the act of manually grasping an object of definable size and mass with two hands and vertically moving the object without mechanical assistance.

2.7.2 Load Weight (*L*)

Weight of the object to be lifted, in pounds or kilograms, including the container.

2.7.3 Horizontal Location (*H*)

Distance of the hand away from the mid-point between the ankles, in inches or centimeters (measured at the origin and destination of lift).

2.7.4 Vertical Location (*V*)

Distance of the hands above the floor, in inches or centimeters (measured at the origin or destination of lift).

2.7.5 Vertical Travel Distance (*D*)

Absolute value of the difference between the vertical heights at the destination and origin of the lift, in inches or centimeters.

2.7.6 Asymmetry Angle (*A*)

Angular measure of how far the object is displaced from the front (mid-saggital plane) at the workers body at the beginning or ending of the lift, in degrees (measure at the origin and destination of lift). The asymmetry angle is defined by the location of the load relative to the worker's mid-saggital plane, as defined by the neutral body posture, rather than the position of the feet or the extent of body twist.

2.7.7 Neutral Body Position

Describes the position of the body when the hands are directly in front of the body and there is minimal twisting, at the legs, torso, or shoulders.

2.7.8 Lifting Frequency (*F*)

Average number of lifts per minute over a 15 minute period.

2.7.9 Lifting Duration

Three-tiered classification of lifting duration specified by the distribution of the work-time and recovery-time (work pattern). Duration is classified as either short (1 hour), moderate (1-2 hours), or long (2-8 hours), depending on the work pattern.

2.7.10 Coupling Classification (*C*)

Classification of the quality of the hand-to-object coupling (e.g., handles, cut-out, or grip). Coupling quality is classified as good, fair, or poor.

2.7.11 Significant Control

Significant control is defined as a condition requiring precision placement of the load at the destination of the lift. This s usually the case when:

(i) The workers have to regrasp the load near the destination of the lift.

(ii) The worker has to momentarily hold the object at the destination.

(iii) The worker has to carefully position or guide the load at the destination.

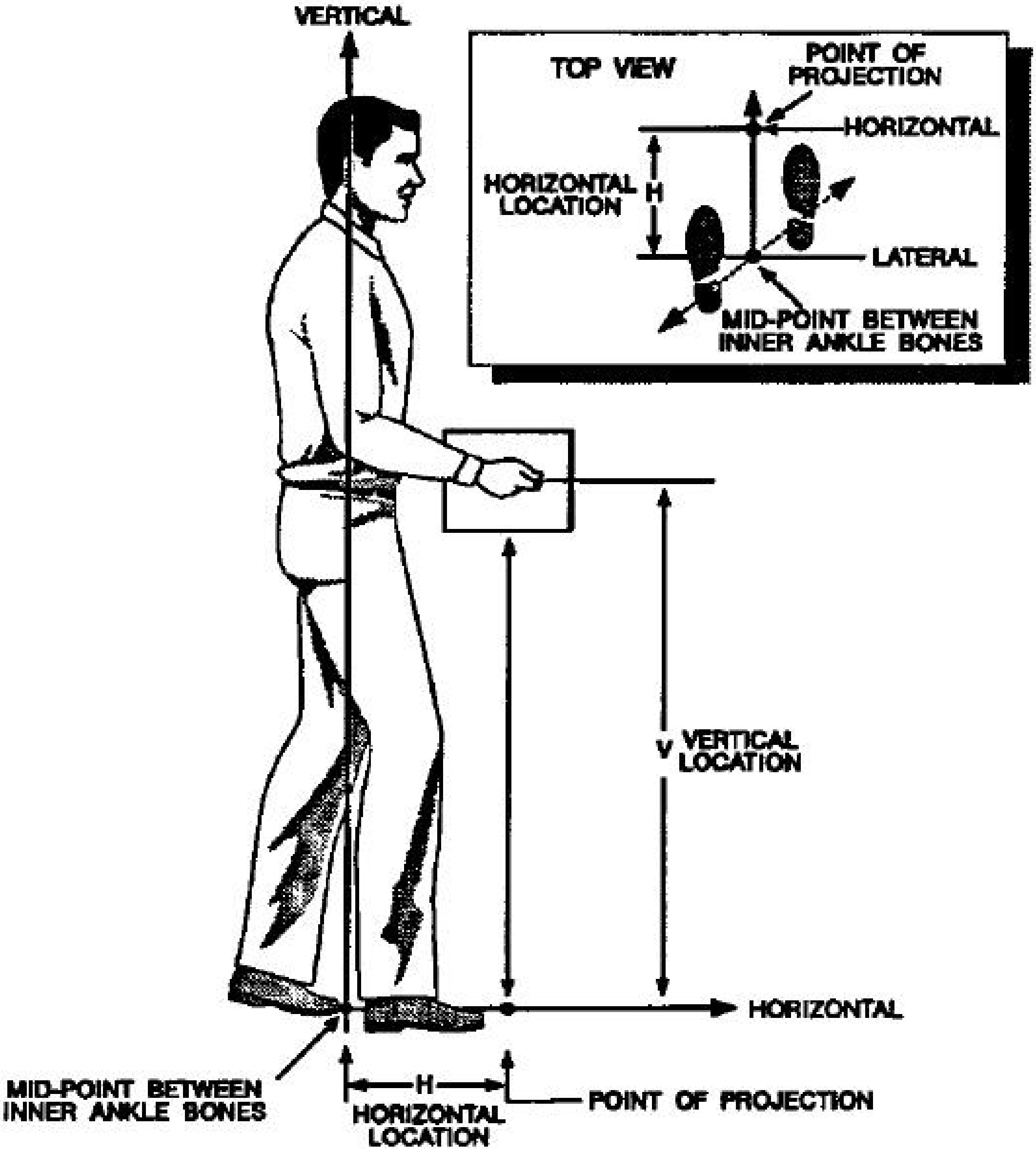


Figure 2.1 Graphic representation of hand location

Source: Waters et. al., 1994

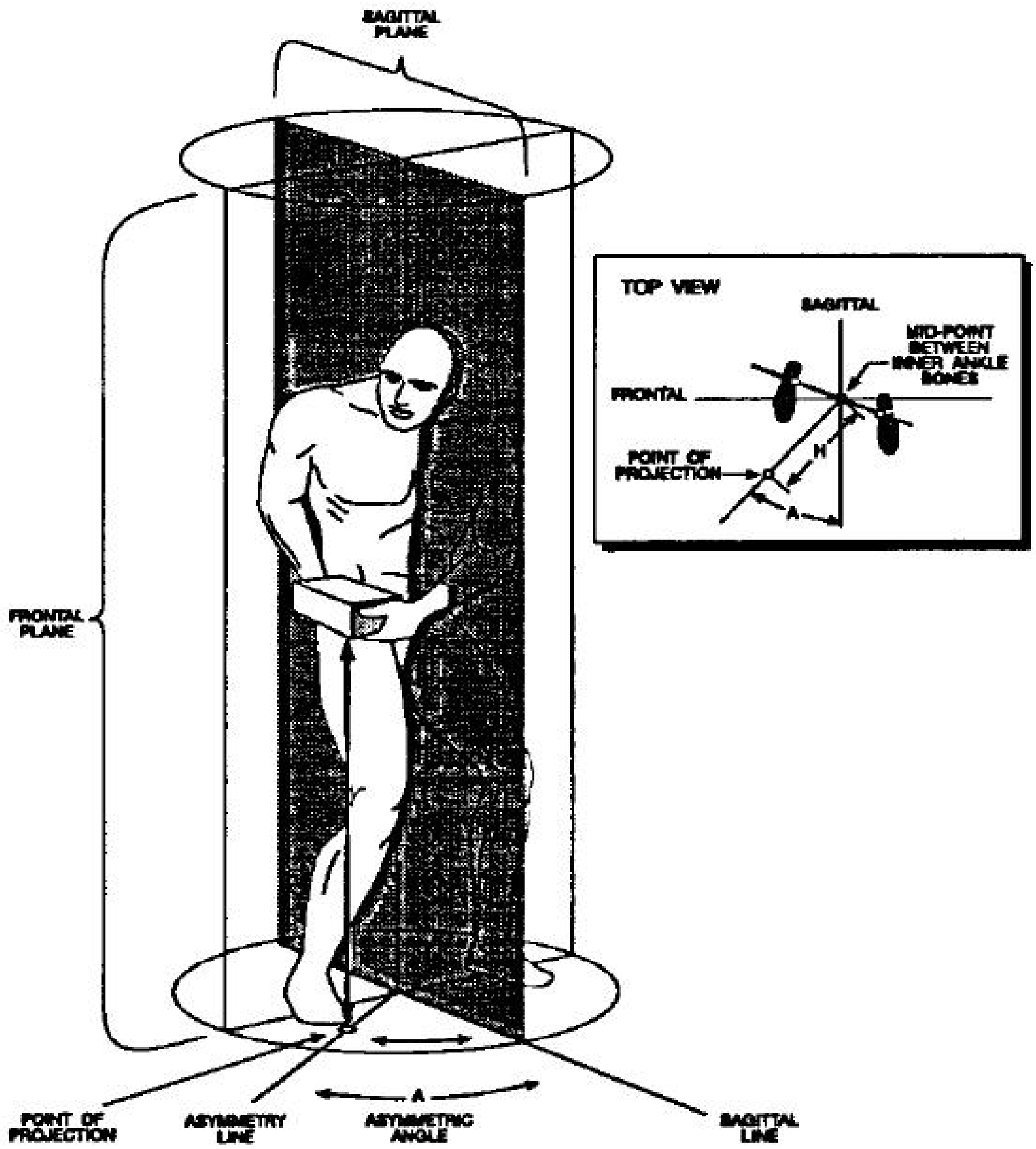


Figure 2.2 Graphic representation of angle asymmetry

Source: Waters et. al., 1994

2.8 LIFTING TASK LIMITATIONS

From the works of Waters et. al. (1994), it is mentioned that, the NIOSH Revised Lifting Equation does not apply if any of the following occur:

(i) Lifting/lowering with one hand

(ii) Lifting/lowering for over 8 hours
(iii) Lifting/lowering while seated or kneeling
(iv) Lifting/lowering in a restricted workspace
(v) Lifting/lowering unstable objects
(vi) Lifting/lowering while carrying, pushing, or pulling
(vii) Lifting/lowering with wheelbarrows or shovels
(viii) Lifting/lowering with high speed motion (faster than about 30 inches per second)
(ix) Lifting/lowering with unreasonable foot/floor coupling (<0.4 coefficient of friction between the sole and the floor)
(x) Lifting/lowering in an unfavorable environment (i.e., temperature significantly outside 19-26 ˚C (66-79 ˚F) range; relative humidity outside 35-50% range)

2.9 USING THE RWL AND LI TO GUIDE ERGONOMIC DESIGN

The ergonomic design can be guided in several ways based on Waters et. al. (1994) by using the recommended weight limit (RWL) and lifting index (LI):

2.9.1 The individual multipliers can be used to specific job-related problems. The relative magnitude of each multiplier indicates the relative contribution of each task factor (e.g., horizontal, vertical, frequency, etc).

2.9.2 The RWL can be used to guide the redesign of existing manual lifting jobs or to design new manual lifting jobs. For example, if the task variables are fixed, then the maximum weight of the load could be selected so as not to exceed the RWL; if the weight is fixed, the task variables could be optimized so as not to exceed the RWL.

2.9.3 The relative magnitude of physical stress for a task or job can be estimated by using the LI. The greater the LI, the smaller the fraction of workers capable of safely sustaining of the level of activity. As a result, two or more job designs could be compared.

2.9.4 Ergonomic redesign can be prioritized by using the LI. For example, a series of suspected jobs could be ranked ordered according to the LI and a control strategy could be developed according to the rank ordering (i.e., jobs with lifting indices over 1.0 or higher would benefit the most from redesign).

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

Work-related musculoskeletal disorders may be caused by prolonged static postures or biomechanical loading from external loads (Capodaglio et. al., 1995). The aim of this study is to investigate and improve an on-site work task by assessing all the criteria needed for improvements. The methods available for measuring physical work loads can be categorized as follows.

3.2 FLOW OF PROJECT

In this particular study, the flow of the project had been done by building flowcharts in order to achieve the goal for the objectives stated previously. These arranged sequences are planned to smoothen the study and that it would be performed in an appropriate manner. The brief description of each action is described as below in Flow Chart for Final Year Project 1 (Figure 3.1) and Flow Chart for Final Year Project 2 (Figure 3.2).

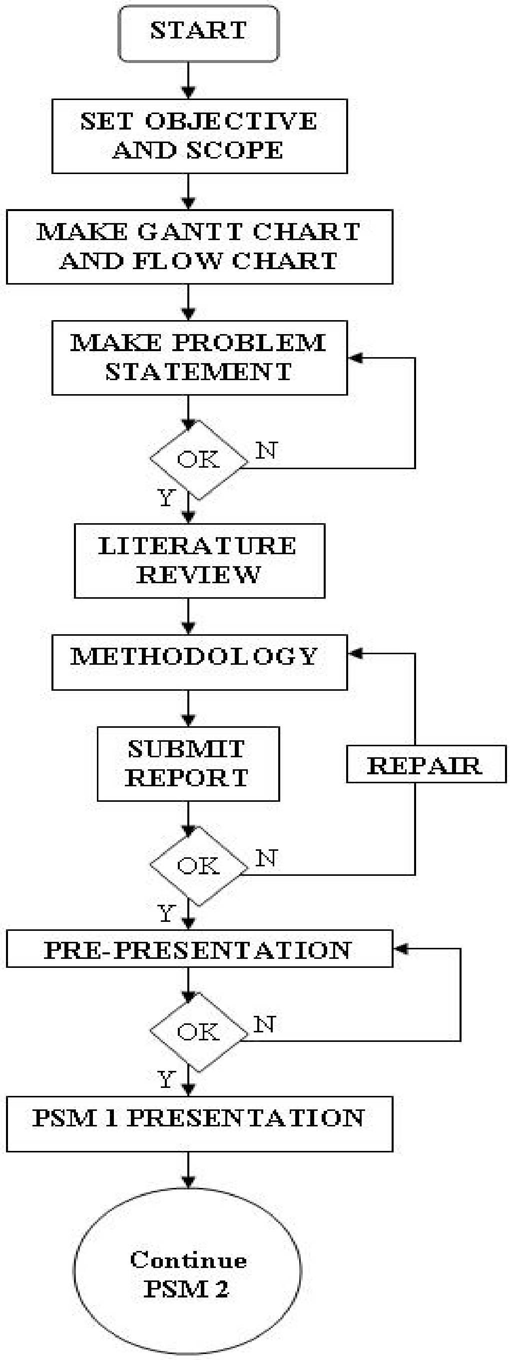


Figure 3.1 Flow chart for final year project 1

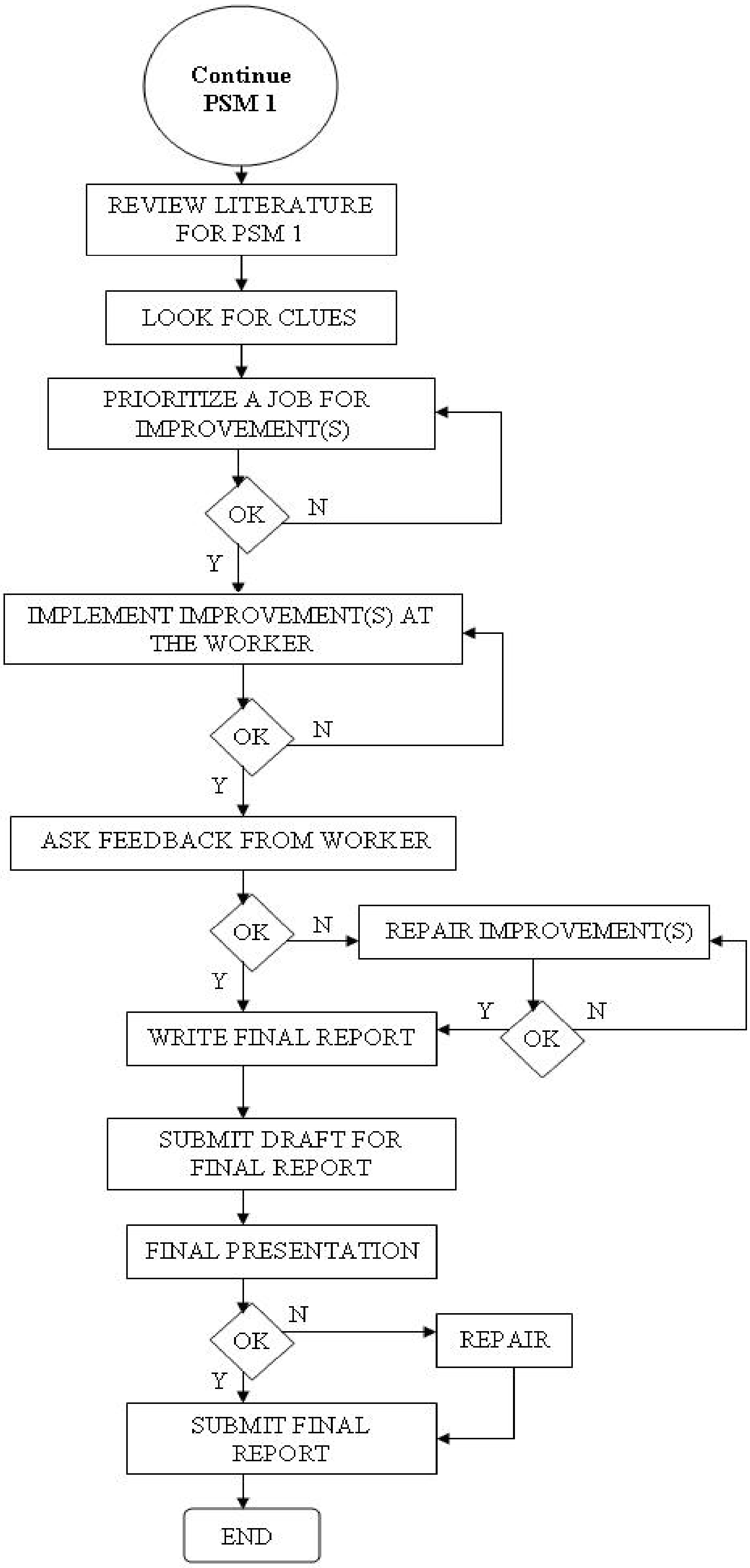


Figure 3.2 Flow chart for final year project 2

3.2.1 Set Objective and Scope

The objectives were made after the title was chose. These are the goals of the project and any actions made during this study are to fulfill the objectives made. The scope was done to narrow down the broadness of the title to ensure that only relevant matters are going to be brought into considerations.

3.2.2 Make Gantt Chart and Flow Chart

The Gantt Charts were made for Final Year Project 1 and Final Year Project 2 as to plan what will be done in a specific interval of time. The Flow Charts were also made for both final year projects and were as shown previously to ensure the smoothness of the workflow for the study to be carried out in an appropriate manner. For further information on Gantt Charts for both final year projects, interested readers please refer to the Appendix A and Appendix B.

3.2.3 Make Problem Statement

The problem statement was done based on the ergonomic problems that are being faced by a particular company. The problem statement states the actual issues that were happening that need to be tackled and solved while conducting this study. The company involved with this study is BI Technologies (Magnetic Component Division). A little bit of company background would be describe in the next sub number.

3.2.4 Literature Review

Preliminary study and review about the topic were required before any study could be performed. The literature reviews were mostly based from journals, technical papers, books, training manuals, and reliable websites. Relevant study matters were then gathered in order to perform the study. A little bit of company background were searched and BI Technologies have been running its business for 50 years.

BI Technologies product lines encompasses trimming potentiometers, precision potentiometers, position sensors, turns counting dials, resistor and resistor networks, integrated passive networks, transformers and inductors, hybrid and power hybrid microcircuits, and custom integration of these technologies. The particular branch of BI Technologies that was involved with this study is from the magnetic division and the product that was being evaluated (Figure 3.3) concerning its handling was one of the Power/Bias transformers with product code of HL00-00158 (9100-4848) which was produced for Agilent (HP).

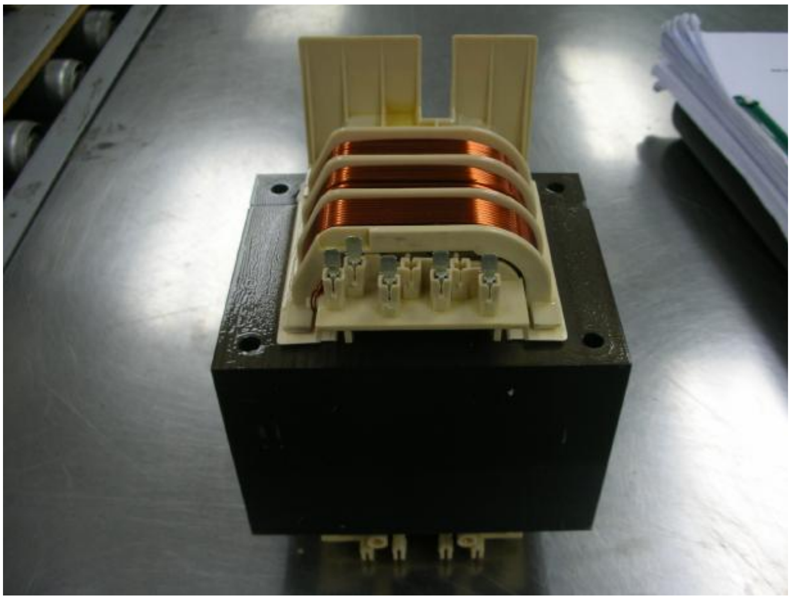


Figure 3.3 Power/bias transformer

3.2.5 Methodology

As stated previously, the methodology is based from NIOSH Ergonomic Guidelines for Manual Material Handling (2007) which offers information on effective ergonomic interventions. The sequences of work that need to be done were ensured for the study to have accurate and precise results. Basically, the higher the risk factors, the higher is the lifting index, and the higher is the potential of developing lower back pain. Achieving LI of 1.0 or less was targeted and briefly discussed on next chapters.

3.2.6 Draft, Report, and Pre-presentation Submissions

The draft submissions, report submission, and pre-presentation for Final Year Project 1 were required by the supervisor and failing to do so would result in no approval to proceed to the Final Year Project 1 Presentation and Final Year Project 2.

On the other hand, if candidates had completed and passed Final Year Project 1 and were able to proceed with Final Year Project 2, draft submissions, report submission, and pre-presentation will be still compulsory and being reluctant in doing so may affect candidates marks with the supervisor.

3.2.7 Repairments and Corrections

There are several verification actions in both of the flow charts for Final Year Project 1 and Final Year Project 2. These verification actions require either the supervisor or the person related during the study to decide that it is appropriate to proceed to the next precedence.

3.3 SEQUENCE OF METHODOLOGY

The methodology was based from NIOSH Ergonomic Guidelines for Manual Material Handling (2007) which offers information on effective ergonomic interventions. The sequences of work that had been done are stated below generally. Interested ergonomic readers should emphasize reading on how to obtain the clues in the next sub topic of 3.4 – Description of Packaging Work Task.

3.3.1 Look For Clues

(i) The first action that was done was by looking for clues through the manager by dialog sessions during a meeting to find out how the working environment is exactly. Through that meeting and a thorough site visit, certain areas of production lines were told to be prone of having problems of balancing the fit between the demands of work with the capabilities of the worker.

(ii) When the packaging section (Figure 3.4) was chosen, the work activities was first been observed. This also includes by talking to the production operator and the supervisor who was in charged. Conversations were done with those two individuals as they were the key to provide quick, relevant, and probably useful information of where the problems exist. There were a few warning signs or indications and those were considered is stated as below.

(a) Risk factors in work tasks which probably involved awkward postures, repetitive motions, forceful exertions, pressure points, or staying in the same position for a long time.

(b) Worker fatigue and discomfort complaints.

(c) Worker exhibition of pain behaviors by massaging her hands.

(d) Worker modified the workstations on her own.

(e) Packaging Bottlenecks

(f) Unnecessary handling and product movement.

(g) Decrease in employee morale.

Figure 3.4 Packaging section

(iii) Several assessment tools were used to establish where the problems might arise in specific work task.

(a) NIOSH Manual Material Handling Checklist

(b) NIOSH Hazard Evaluation Checklist for Lifting

(c) The Awareness Worksheet: Looking for Clues

(d) Ergonomics Checklist – Material Handling

(See example in Appendices C, D, E, and F respectively)

(iv) Detailed assessment such as Revised NIOSH Lifting Equation was used to evaluate and analyze the working condition. The results of the analysis were then used as guidelines to redesign a new work task that would probably fit the demands of the work task with the worker's capabilities.

3.3.2 Prioritizing A Job For Improvements

(i) The work task was identified by means of observing and evaluating the frequency of lifting. Some risk factors that were discussed earlier were taken into considerations as those factors may lead to injuries.

(ii) All of the complaints were taken into considerations and the reasoning for the severity of the complaints was made.

(iii) The impacts on technical and financial resources were not made as those two are off the scope of this project.

(iv) Conversations with the worker were done to identify if the worker has her own ideas on how to do the improvements.

(v) The degree of difficulty in implementing the improvements were taken into considerations in accordance to the improvement options discussed previously.

(vi) Planning and scheduling were also considered to make it easier to synchronize the timeframes for the improvements to be made.

3.3.3 Make The Improvements And Suggest It

(i) Considerations of the improvements were enhanced by talking to various personnel such as production operator, supervisor, and even managers.

(ii) The operations and processes were combined whenever possible to reduce and eliminate unnecessary manual handling of materials and products.

3.3.4 Follow Up Actions

(i) Check if the fatigue, discomfort, symptoms, and/or injuries reduced or eliminated.

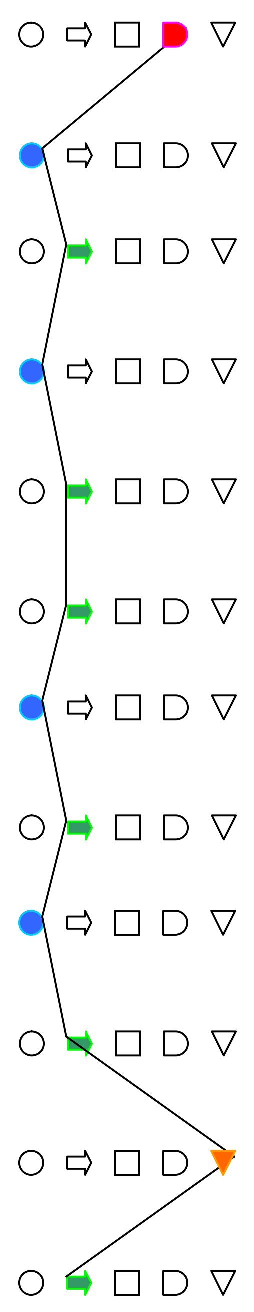
(ii) Check if the improvements accepted by the worker.

(iii) Check if the new improvements create any new problems.

3.4 DESCRIPTION OF PACKAGING WORK TASK

The sequences of the packaging work task performed at BI Technologies (Magnetic Component Division) are represented below in the form of Process Chart (Table 3.1). As it is shown in the table, the work task was broken down into greater details comprehensively. There are columns for distance, time, chart symbols, and process descriptions. The chart symbol shows the work that was done with respect to its actual sequences. On the other hand, the process descriptions provides remarks and information of what the current process is all about whether it involves operation, transportation, inspection, delay, or storage.

Table 3.1: Process chart for packaging work task

Distance in centimeters (cm)	Time in seconds (sec.)	Chart Symbols	Process Description
30	Idle		The agilents are supplied through the conveyor.
40	3		Operation at packaging table.
125	1		Move to strapping machine.
35	2		Operation at strapping machine.
68	1		Move to conveyor.
68	3		Transport agilent from conveyor to strapping machine.
35	22		Operation at strapping machine.
120	3		Transport agilent to packaging table.
40	34		Operation at packaging table.
270	7		Transport packaging to pallet area.
15	3		Storage at pallet area.
270	4		Move to packaging table.
1116	83		TOTAL

= Operation; = Transportation; = Inspection; = Delay; = Storage

3.5 MULTITASK PACKAGING WORK ANALYSIS PROCEDURE

After thorough work of problem detections, the specific tasks that was improved within the multitask packaging work were decided and set their priorities significantly. This was done by thorough evaluation by using Revised NIOSH Lifting Equation. The Revised NIOSH Lifting Equation provides guidelines for evaluating the multitask packaging work which defines a recommended weight limit as the weight of the load that nearly all healthy workers can lift over a substantial period of time without an increased risk of developing lower back pain. The procedure of it was designed to determine the collective effects of all the tasks. For interested ergonomic readers, some of the procedures conducted that required special procedures were described as below, on-site measuring procedures that were considered as simple is to be referred to Chapter 2 – Literature Review.

(i) Frequency Adjustment Procedure

The worker did not lift continuously during the 15 minutes sampling period. This is because the work pattern did not require the worker to do such. The actual work demands the worker to lift repetitively for a short time and then performs light task for also a short time before starting the same cycle over and over again. Since the actual lifting frequency does not exceed 15 lifts per minute, the total number of lifts performed for the 15 minute period were recorded and then being divided by the value of 15. The resulting value was considered as the actual frequency (F) and then was determined its multiplier from the Frequency Multiplier (Appendix G-Table 5).

(ii) Coupling Classification Procedure

The entire range of the lift was considered when hand to object coupling was classified. This was because the effectiveness of coupling is not static, but may vary with the distance of the object from the ground. In order to determine the appropriate classification type, the Decision Tree for Coupling Quality (Figure 3.5) was used as a tool to help in the decision making. After that, the decision was referred to (Appendix G-Table 7) and the coupling multiplier was obtained.

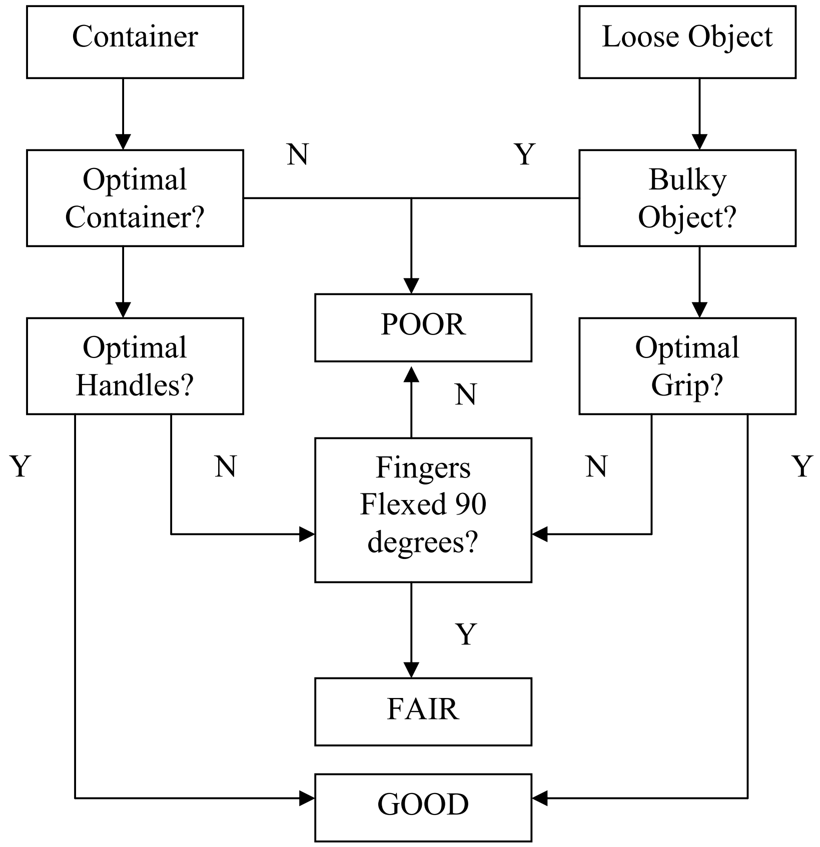


Figure 3.5 Decision tree for coupling quality

(iii) **Compute FIRWL**

The Frequency Independent Weight Limit (FIRWL) value was computed for each task by using the respective task variables The FIRWL for each task reflected the compressive force and muscle strength demands for a single repetition of that task. A significant control was required at one of the destination for one of the individual task, the FIRWL must be computed was then computed at both the origin and the destination of the lift.

(iv) **Compute STRWL**

The Single-Task Recommended Weight Limit (STRWL) was computed for each task by multiplying its FIRWL by its appropriate Frequency Multiplier (FM).

The STRWL for a task reflects the overall demands of that task, assuming it was the only task being performed. This value was helpful in determining the extent of excessive physical stress for an individual task.

(v) **Compute FILI**

The Frequency-Independent Lifting Index (FILI) was computed for each of the task by dividing the maximum load weight (L) for that task by the respective FIRWL. The maximum weight was used to compute the FILI because the maximum weight determines the maximum biomechanical loads to which the body will be exposed, regardless of the frequency of occurrence. The FILI was used to identify individual tasks with potential strength problems for infrequent lifts. If any of the values exceed a value of 1.0, then ergonomic changes may be needed to decrease the strength demands.

(vi) **Compute STLI**

The Single-Task Lifting Index (STLI) were calculated for each task by dividing the average load weight (L) for that task by the respective STRWL. The average weight was used to compute the STLI because the average weight provides better representation of the metabolic demands, which in this case were not visible because the weight were constant and the same. The STLI was used to identify individual tasks with excessive physical demands as for example is a task that would result in fatigue. If any of the STLI values exceed a value of 1.0, then ergonomic changes may be needed to decrease the overall physical demands of the task.

(vii) **Compute CLI**

The assessment was completed on the multi-task worksheet when the Composite Lifting Index (CLI) as shown in the Equation 3.1 was determined for the overall job. The CLI was computed by first having the tasks renumbered in order of decreasing physical stress. It began with the task with the greatest STLI down to the task with the smallest STLI. The tasks were then renumbered in this way so that the more difficult tasks were considered first. The CLI for the job were then computed according to the following formula.

$$CLI = STLI_1 + \sum \Delta LI \qquad (3.1)$$

Where:

$$\begin{aligned}\sum \Delta LI = & \left(FILI_2 \times \left(\frac{1}{FM_{1,2}} - \frac{1}{FM_1} \right) \right) \\ & + \left(FILI_3 \times \left(\frac{1}{FM_{1,2,3}} - \frac{1}{FM_{1,2}} \right) \right) \\ & + \left(FILI_2 \times \left(\frac{1}{FM_{1,2}} - \frac{1}{FM_1} \right) \right) \\ & + \left(FILI_n \times \left(\frac{1}{FM_{1,2,\ldots,n}} - \frac{1}{FM_{1,\ldots,n}} \right) \right) \qquad (3.2)\end{aligned}$$

Note that the numbers in the subscripts in Equation 3.2 refer to the new task numbers and the FM values are determined from (Appendix G-Table 5), based on the sum of the frequencies for the tasks listed in the subscripts.

3.6 IMPROVEMENTS FOR THE MULTITASK PACKAGING WORK

The goal of making changes is to improve the fit between the demands of the work task and the capabilities of the workers. In this case, certain operations and processes were combined and rearranged significantly whenever possible to reduce or eliminate unnecessary manual handling and to improve the work so that it is done in accordance to the worker's power zone.

Other than Appendix D, the improvements were made by talking to various employees from a production operator leveled worker, to a supervisor leveled worker, to even a manager. This was done by having some brainstorming sessions which is a great way to generate ideas. Other improvements were discussed with Final Year Project supervisor which gave great solutions that could also be applied to this case which saved time, money, and effort. Some improvements were found through the Internet which is an excellent place to share ideas from other operations similar to this case and how to solve with the problems that were dealt with.

3.7 FOLLOW UP ACTIONS THAT WERE TOOK

A number of important follow up actions were put to order to evaluate whether the improvements made worked or did not worked. After a reasonable adjustment period, a date was set with BI Technologies and certain follow up actions were made to evaluate each improvement separately for their own effectiveness. The improvements were evaluated by finding out the reduction or elimination of fatigue, discomfort, or any related symptoms of injuries.

The improvements made were also checked with the worker for her suitability and acceptance. Reduction or elimination of most of the risk factors were also found out and whether the improvements made caused some new risk factors, hazards, or problems. The improvements are also evaluated whether it had caused a decrease in productivity and efficiency as well ass product or service quality.

There were improvements that have not worked and accepted by the company due to multiple of reasons. It is further discussed in Chapter 4 – Results and Discussion where the improvements that have not worked or not accepted will be left for further studies by trying a different approach or something different until the risk factors have been reduced or eliminated.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 INTRODUCTION

This chapter provides the results achieved from performing and conducting the methodology discussed earlier in Chapter 3 – Methodology. The findings from performing the methodologies are stated in the forms of tables and numerical figures. Further discussions are also provided in relevant to the findings obtained. The assessments of these discussions were then converted into improvements and being firstly reviewed then organized in their own significant manner to offer insight on how to improve the multitask packaging work. Interested ergonomic readers should emphasize on reading this chapter thoroughly.

4.2 RESULTS BY USING NIOSH ERGONOMIC GUIDELINES

Several findings information was gathered while following NIOSH Ergonomic Guidelines to evaluate the multitasking packaging work. Please refer to Chapter 3 to recall the sequence of methodology if the descriptions here are not detailed and thorough. The findings are as discussed as given:

4.2.1 Clues Obtained

(i) Please recall that the clues are obtained by having dialog sessions with the worker, supervisor, and manager. It was told that there were certain lines that are prone of having problems of balancing the fit between the demands of work and the capabilities of the worker. Other than Vacuum Varnishing and

Curing operations, packing operations was also said to be prone of having ergonomic problems. It was told that there were no written records of past worker reports or complaints. The worker's compensation reports were available but were not allowed to be viewed by outsiders. Further negotiations to retrieve the relevant information were also failed, so that particular information area was left untouched and undisturbed.

(ii) When the packaging section was chosen, the work activities were observed. This also includes by having conversations to the operator and the supervisor who was in charged. The work task sequences for packaging work were briefly explained and describe as follows.

(a) The product weighing 11 kg each is supplied to the packaging workstation, right beside the packaging table.

(b) A cardboard box is prepared on the packaging table and the cardboard pads for the top and bottom region of the product are prepared at the Manual Strapping machine.

(c) The product is then lifted from the conveyor section by having a step turn to the Manual Strapping machine with no significant control over the product handled.

(d) The product is then reoriented to accommodate the exact slot section on the bottom cardboard pad.

(e) The top cardboard pad served as the cover is placed at the top region of the product also with respect to the slots provided.

(f) A strapping cable is then wrapped over the covered product and the end tip of the cable is inserted to the pulling and heating slot at the machine which made the cable tightened and secured.

(g) Once the cable is tightened, it is lifted to the packaging table **with significant control** so that it would be placed directly into the box.

(h) The box is then closed, secured, and taped.

(i) The box is then lifted and arranged to a pallet at the pallet area.

(j) The worker then will go straight to the workstation to perform the same sequence over again.

Conversations were done with the worker as it is believed she was the key to provide quick, relevant, and probably useful information of where the problems exist. Stated as follows is a little background check made for the particular operator who works at the packaging section.

Name	**:** Mariam Binti Mohd Zain
Age	**:** 42 years old
Experience of working	**:** 18 years

But unfortunately, the conversations that were made to view her ideas for altering the work processes or the job sequences were not relevant and are not useful for the purpose of improvements. Although the conversations made were not useful, the worker did show several warning signs or indications that were significantly important and those signs are discussed as below.

(iii) Several risk factors were encountered by observing the worker's movement. The worker has awkward movements and postures while conducting the work activities. Furthermore, the work activities not only have repetitive motions but also forceful exertions especially while lifting the product to be inserted inside its packaging box. Not to mention that the product being handled resulted in pressure points at some region of the hand due to poor coupling. The worker does not stay in a specialization position for a long period of time as the worker is also required to perform few other light tasks.

(iv) The worker complaints that sometimes she suffered discomfort due to back pain. The worker also informed that it was because of the weight of the load that is too heavy for her to handle. It was observed that the worker was not working in a rapid and fast manner. It can be stated that, after a full shift observation, the worker works in a normal pace based on her own capabilities. This reduces the demands of the work task and automatically reduces the risk factors that were discussed on earlier. But still, the worker complaints of having fatigue that probably resulted from the muscle pain in some areas of the subject's upper body that were involved with the lifting task.

(v) In between the work task, there is a very short interval time where it was observed that the worker massaged her hands in the manner of easing the pain due to pressure points cause by the product. The pain behavior exhibited was definitely because of the work task movement while handling the product.

(vi) For the packaging work station, some of the equipments used do not have a standard specific layout. The worker required to arrange the workstation by herself to start the packaging work and rearrange the equipments used to its initial position after the packaging work is finished. There were no other tools or equipment that was modified or altered by the worker.

(vii) The worker was very careful in performing her lifting work. It could be said that she was lacking in confidence while performing her work. This was due to the fact of past lifting that was painful thus resulted in the decrease of the worker's morale.

(viii) Due to frequent heavy lifting, the worker was prone to fatigue, and this resulted in a production bottleneck where the amount of production produced got obstructed by the worker's normal pace. If production bottleneck did not happen, valuable production time is wasted which could be utilized for other working operations.

(ix) It was observed that the worker very seldom uses the scissor lift trolley. Instead, she handled the product herself from the packaging section to the pallet at the storage area. This was a good example of unnecessary handling to move the product from one point to another.

4.2.2 Results of Assessments Tools

(a) NIOSH Manual Material Handling Checklist

The checklist shown on Table 4.1 had been used as a tool and potential problem jobs were identified quickly. Note that the "No" indication that is showed at the table pointed out potential problem areas that were investigated in this study.

Table 4.1: NIOSH manual material handling checklist results

1. Are the weights of loads to be lifted judged acceptable by the workforce?	Yes	**No**
2. Are the materials moved over minimum distances?	Yes	No
3. Is the distance between the object load and the body minimized?	Yes	No
4. Are walking surfaces level?	Yes	No
wide enough?	Yes	No
clean and dry?	Yes	No
5. Are objects easy to grasp?	Yes	No
stable?	Yes	No
able to be held without slipping?	Yes	No
6. Are there handholds on these objects?	Yes	**No**
7. When required, do gloves fit properly?	Yes	No
8. Is the proper footwear worn?	Yes	No
9. Is there enough room to maneuver?	Yes	No
10. Are mechanical aids used whenever possible?	Yes	No
11. Are working surfaces adjustable to the best handling heights?	Yes	No
12. Does material handling avoid:		
Movement below knuckle height and above shoulder height?	Yes	No
Static muscle loading?	Yes	No
Sudden movements during handling?	Yes	No
Twisting at the waist?	Yes	**No**
Extended reaching?	Yes	No
13. Is help available for heavy awkward lifts?	Yes	**No**
14. Are high rates of repetition avoided by job rotation?	Yes	No
Self-pacing?	Yes	No

Sufficient pauses?	Yes	No
15. Are pushing or pulling forces reduced or eliminated?	Yes	No
16. Does the employee have no obstructed view of handling the task?	Yes	No
17. Is there a preventive maintenance program for equipment?	Yes	No
18. Are workers trained in correct handling and lifting procedures?	Yes	No

From the results obtained by conducting the assessment, four potential problems were identified. The problems were mainly regarding whether the weight of loads lifted were accepted by the worker, whether there were handholds on the object being handled, whether there were twisting movements at the waist, or whether help was available for heavy awkward lifts. The "No" indications were taken note to be accumulated with other findings from other assessment tools.

(b) NIOSH Hazard Evaluation Checklist for Lifting

The checklist shown on Table 4.2 had been used as a tool and potential problem jobs were identified quickly. Note that the "Yes" indication that is showed at the table pointed out conditions that have the tendency of developing low back pain.

Table 4.2: NIOSH hazard evaluation checklist for lifting results

Risk Factors		
1.0 General		
1.1 Does the load handled exceed 50lb.?	Yes	No
1.2 Is the object difficult to bring close to the body because of its size, bulk, or shape?	Yes	No
1.3 Is the load hard to handle because it lacks handles or cutouts for handles, or does it have slippery surfaces or sharp edges?	**Yes**	No
1.5 Is the footing unsafe? For example, are the floors slippery, inclined, or uneven?	Yes	No
1.5 Does the task require fast movement such as throwing, swinging, or rapid walking?	**Yes**	No
1.6 Does the task require stressful body postures such as stooping to the floor, twisting, reaching overhead, or excessive lateral bending?	**Yes**	No
1.7 Is most of the load handled by only one hand, arm, or shoulder?	Yes	No
1.8 Does the task require working in extreme temperatures, with noise, vibration, poor lighting, or airborne contaminants?	Yes	No
1.9 Does the task require working in a confined area?	Yes	No
2.0 Specific		

2.1 Does lifting frequency exceed 5 lifts per minute?	Yes	No
2.2 Does the vertical lifting distance exceed 3 feet?	Yes	No
2.3 Does carrying work last longer than 1 minute?	Yes	No
2.4 Do tasks that require large sustained pushing or pulling forces exceed 30 seconds duration?	Yes	No
2.5 Do extended reaching reach static holding tasks exceed 1 minute?	Yes	No

From the results obtained by conducting the assessment, three conditions that had the tendency of developing low back pain were identified. The indication points were mainly regarding the coupling issues of the load being handled because the product being handled had very little coupling region that it is considered as poor, whether the task required fast movement due to the multitasking scope of the work task itself, and whether the task required stressful body postures by means of stooping to the floor. The "Yes" indications were taken note to be accumulated with other findings from other assessment tools.

(c) The Awareness Worksheet: Looking For Clues

The worksheet shown in the Table 4.3 was used as a tool and clues was looked and potential problems were pointed out for the associated work task that was being evaluated. This worksheet provides clues on where to make the redesign so that the improvements would be effective.

Table 4.3: The awareness worksheet: looking for clues results

Risk Factors	Other Clues	Reasons for Problems
Observation 1: *Possible Awkward Postures*	Observation 1: *Possible Awkward Postures*	Observation 1: *Possible Awkward Postures*
Multiple task requires the worker to move from one station to the other to complete the work, thus involves twisting and few bending.	Eventhough the worker uses a step turn to complete a lift, the worker still twist even a little bit.	It was assumed that no step turn occurs and the worker twists while performing the work.
Observation 2: *Repetitive Motions*	Observation 2: *Repetitive Motions*	Observation 2: *Repetitive Motions*
Obviously packaging work involves a lot of repetitions due to many	Eventhough the worker's workload was highly repetitive; it was switched	Production bottleneck and many pending products made the work to be

production rates.	to light works while waited for product arrivals.	highly repetitive with seldom short breaks or light works.
Observation 3: *Forceful Exertions*	Observation 3: *Forceful Exertions*	Observation 3: *Forceful Exertions*
One of the task required to package the product is to bring the strapped product from the machine to the box at packaging table.	The worker required to lift the product to be packaged almost at the height level of her shoulder.	The table height was a bit high for the worker to insert the strapped product into the packaging box.
Observation 4: *Pressure Points*	Observation 4: *Pressure Points*	Observation 4: *Pressure Points*
The product has pointy corners and sharp edges that would result in pressure points at the worker's palms	Other possible pressure points could be the lower back or the worker's feet	Resulted from lifting of the load demanded by the work task.
Observation 5: *Static Postures*	Observation 5: *Static Postures*	Observation 5: *Static Postures*
No static postures were in presence or demanded by the work task.	The worker does not stay in the same position for a very long time.	No reasons or evidence to support the static posture assumption.

The assessment made was based on several observations for whole shift duration. The observations made were distinguished from each other according to its own classification of risk factors which were broke down into greater details concerning awkward postures, repetitive motions, forceful exertions, pressure points, or static postures. Eventhough there were some assumptions that was drastically made such as the worker only had twisting motions and did not use step turns would be pointed more to overestimation and it would make the result vary significantly, the goal of reducing exposure for stressful body movements would be achieved because this assumption provides the greatest protection for the worker.

(d) Ergonomic Checklist for Material Handling

The Ergonomic Checklist for material handling in Table 4.4 was used as a tool and it pointed out some job risk factors that presented in the work task. Eventhough the table is originally included not only lifting and lowering, but also carrying, pushing, and pulling conditions, those were not considered as it went of the original scope which is evaluations for lifting tasks only.

Table 4.4: The ergonomic checklist – material handling results

Condition	X if a concern	Comments
REPETITION		
High-speed process line or work presentation rates	**X**	Have to achieve target
Similar motions every few seconds		
Observed signs of fatigue	**X**	Worker complaints
WORKSTATION DESIGN		
Work surface too high or low		
Location of materials promotes reaching		
Angle/orientation of containers promotes non-neutral positions	**X**	No standardized layout
Spacing between adjacent transfer surfaces promotes twisting		
Obstructions prevent direct access to load/unload points		
Floor surfaces are uneven, slippery, or sloping		
Hoists or other lifting devices are needed but not available	**X**	Scissor lift were not used
LIFTING		
Heavy objects need to be handled	**X**	11kg product
Handling bulky or difficult-to-grasp objects	**X**	Lacking of grip area
Handling above the shoulders or below the knees		
Lifting to the side or unbalanced lifting	**X**	Twisting motion
Placing objects accurately/precisely	**X**	Significantly
Sudden, jerky movements during handling		
One-handed lifting		
Long-duration exertions (static work)		

After the assessment was done, seven concerned conditions of working were taken note of and marked with 'X' and marked with respective comments.

(e) Revised NIOSH Lifting Equation

The Revised NIOSH Lifting Equation was used as a tool to identify ergonomic problems and evaluate the ergonomic redesign solutions. The penalties associated with each risk factor were evaluated and the task factors that cause the greatest reduction in the load constant should be considered for job redesign. Please see next page for further details.

MULTITASK JOB ANALYSIS WORKSHEET

DEPARTMENT : Production Department JOB TITLE : Production Operator ANALYST'S NAME : Muhammad Thaqib Bin Kamaruzzaman DATE : 8 August 2008	JOB DESCRIPTION: Packaging work done by a female production operator who multitask jobs such as wrapping, packaging, and organizing. Task 1 is lowering. Task 2 is lifting. Task 3 is lowering.

MEASURE AND RECORD TASK VARIABLE DATA

Task No.	Object Weight (kg)		Hand Location (cm)				V-V Distance (cm)	Asymmetric Angle (deg.)		Frequency Rate	Duration	Coupling
			Orig.		Dest.			Orig.	Dest.	Lifts/min	Hrs.	
	L (Avg.)	L (Max)	H	V	H	V	D	A	A	F		C
1	11	11	40	87	35	80	7	63	0	0.6	8	Poor
2	11	11	35	91	40	104	13	45	90	0.6	8	Fair
3	11	11	40	78	27	36	42	90	0	0.6	8	Fair
-	-	-	-	-	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	-	-	-	-

COMPUTE MULTIPLIERS AND FIRWL, STRWL, FILI, AND STLI FOR EACH TASK

Task No.	LC x	HM x	VM x	DM x	AM x	CM	FIRWL x	FM	STRWL	FILI = L/FIRWL	STLI = L/STRWL	New Task No.	F
1	23	0.63	0.97	1.0	0.73	0.8	10.12	0.78	7.89	1.09	1.39	3	0.6
2a	23	0.72	0.96	1.0	0.81	0.86	13.67	0.78	10.66	0.80	1.03	-	0.6
2b	23	0.63	0.92	1.0	0.82	0.71	9.46	0.78	7.38	1.16279	1.490515	1	0.6
3	23	0.63	0.99	0.93	0.77	0.71	9.47	0.78	7.39	1.16156	1.488497	2	0.6
-	23	-	-	-	-	-	-	-	-	-	-	-	-

COMPUTE THE COMPOSITE LIFTING INDEX FOR THE JOB (After renumbering tasks)

	$STLI_1$ +	$\Delta FILI_2$ +	$\Delta FILI_3$ +	$\Delta FILI_4$ +	$\Delta FILI_5$
CLI =		$FILI_2(1/FM_{1+2} - 1/FM_1)$	$FILI_3(1/FM_{1+2+3} - 1\text{-}/FM_{1+2})$	$FILI_4(1/FM_{1+2+3+4} - 1/FM_{1+2+3})$	$FILI_3(1/FM_{1+2+3+4+5} - 1/FM_{1+2+3+4})$
CLI =	1.49	1.1616(1/0.73 – 1/0.78)	1.09(1/0.67 – 1/0.73)	-	-
	1.49	0.102	0.133	-	-

Total: **1.7**

The packaging work that was done was from multitask category, thus the Multi-task Job Analysis Worksheet (Appendix H) was used. The heaviest product was weighted which yielded the value of 11kg and the duration of lifting was 7 hours and 35 minutes which is less than 8 hours. After the data for hand location, vertical to vertical distance, asymmetric angle, and frequency rate were measured and recorded at task variable data, the coupling classification was then determined from Hand-to-Object Coupling Decision Tree (Figure 3.5). The job evaluated has three tasks, Task 1, Task 2, and Task 3 which were evaluated into four tasks of Task 1, Task 2a, Task 2b, and Task 3.

The Task 1 was the movement from conveyor to the manual strapping machine. The hand location for horizontal and vertical distance at the origin of the lift was 40cm and 87cm respectively. The vertical travel distance was 7cm. The asymmetric angle at the origin is 63˚. The frequency rate is 0.6lifts/min. The coupling classification is poor because there was very little of gripping area at the product.

The Task 2 was the movement from the manual strapping machine to the packaging table. The hand location for horizontal and vertical distance at the origin of the lift was 35cm and 91cm respectively. The hand location for horizontal and vertical distance at the destination of the lift was 40cm and 104cm. Task two was evaluated from both origin and destination of lifts because Task 2 required significant control at the destination of the lift by means of inserting the strapped product inside the packaging box, so the worker must apply a significant upward force to decelerate object. The vertical travel distance was 13cm. The asymmetric angle for origin and destination of lifts was 45˚ and 90˚. The frequency rate was 0.6 and the coupling classification is fair because the fingers can almost be flexed 90˚ at the strapped product.

The Task 3 was the movement of packaging table to the scissor lift trolley. The hand location for horizontal and vertical distance at the origin of the lift was 40cm and 78cm respectively. The vertical travel distance was 42cm and the asymmetric angle was 90˚. The frequency rate and coupling classification was also 0.6lifts/min and fair, respectively.

The multipliers was then determined from the values of data obtained from the on-site measurements. The value of Load Constant (LC) is 23kg and was fixed because this is the maximum weight to be lifted with two hands under ideal conditions. For Task 1, the horizontal multiplier (HM) of 40cm yielded 0.63 and the vertical multiplier (VM) for 87cm is 0.97 by interpolation. The vertical travel distance (DM) was 7cm, this value is less than 25 cm so a default value of 1.0 was given. The asymmetric multiplier (AM) for 63˚ was 0.8 and the coupling classification of poor yielded 0.90 as coupling multiplier (CM).

The Frequency Independent Recommended Weight Limit (FIRWL) was calculated by multiplying the LC, HM, VM, DM, AM, and CM. The FIRWL value yielded 10.12 and then after multiplied by 0.78 which is the frequency multiplier (FM), it yielded the single task recommended weight limit (STRWL) which is 7.89. Then the frequency independent lifting index (FILI) was calculated by having the 11kg load being divided by the value of FIRWL which yielded 1.09. On the other hand, the single task lifting index (STLI) was calculated by dividing the 11kg value of load with the value of STRWL which yielded 1.39. For

Task 2a, the HM value for 35cm was 0.72, VM value for 91cm was 0.96, DM value for 13cm was 1.0, AM value for 45˚ was 0.86, and CM value for fair was 1.0. The FIRWL was calculated and yielded 13.67, it is then multiplied by the FM value and yielded 10.66 for the STRWL value. The FILI value was then calculated by dividing the load of 11kg with the FIRWL value of 13.67 and yielded 0.80. The STLI was then calculated by dividing the load value of 11 kg with STRWL value of 10.66 which yielded 1.03.

For Task 2b, the HM value for 40cm was 0.63, VM value for 104cm was 0.92, DM value for 13cm was the same as Task 2a which is 1.0, AM value for 90˚ was 0.71, and CM value for fair was 1.0. The FIRWL was calculated and yielded 9.46, it is then multiplied by the FM value of 0.78 and yielded 7.38 for the STRWL value. The FILI value was then calculated by dividing the load of 11kg with the FIRWL value of 9.46 and yielded 1.16279. The STLI was then calculated by dividing the load value of 11 kg with STRWL value of 7.38 which yielded 1.490515.

For Task 3, the HM value for 40cm was 0.63, VM value for 78cm was 0.99, DM value for 42cm was 0.93, AM value for 90˚ was 0.71, and CM value for fair was 1.0. The FIRWL was calculated and yielded 9.47, it is then multiplied by the FM value of 0.78 and yielded 7.39 for the STRWL value. The FILI value was then calculated by dividing the load of 11kg with the FIRWL value of 9.47 and yielded 1.16156. The STLI was then calculated by dividing the load value of 11 kg with STRWL value of 7.39 which yielded 1.488497.

All of the task were then rearranged and renumbered according to its value of STLI. It was rearranged according to the greatest value of STLI down to the task with the smallest STLI. The tasks were renumbered this way so that more difficult tasks were considered first. All of them had the same frequency rate so the rearranging of the task was not made based on that detail. Then, the Composite Lifting Index (CLI) was computed for this work task according to the formula shown in Equation 3.1.

The task with the greatest CLI after rearranged and renumbered is Task 1 (STLI = 1.49). The sum of the frequencies for Task 1 and Task 2 is 0.6 + 0.6 or 1.2, and the sum of the frequencies Task 1, Task 2, and Task 3 is 0.6 + 0.6 + 0.6 or 1.8. Then from Appendix G-Table 5, FM_1 is 0.78, $FM_{1,2}$ is 0.73, and $FM_{1,2,3}$ is 0.67. Finally, the CLI = 1.49 + 1.1616(1/0.73 – 1/0.78) + 1.09(1/0.67 – 1/0.73) = 1.49 + 0.102 + 0.133 = 1.72.

Noted that the FM values were based on the sum of the frequencies for the subscripts, the vertical height, and the duration of lifting.

4.3 DISCUSSION OF THE RESULTS OBTAINED

When the outcome of the analysis had been obtained, the results were then interpreted and studied for the ease of altering and redesigning the existing work task successfully. In order to redesign, these few things need to be considered such as physical changes in the layout of the work task, reductions in the lifting frequency rate, the duration of the work period, or modifications of the physical properties of the object lifted, such as type, size, or weight, or improvement of hand-to-object coupling.

(i) From the value of Horizontal Multiplier (HM), the entire work task showed the penalties applied had decreased the multiplier values up to 37%. This means that the values of HM is less than 1.0 and the load should be redesigned to be closer to the worker for the multiplier value to be 1.0 or close to 1.0.

(ii) From the value of Vertical Multiplier (VM), the entire work task showed the penalties applied had decreased only up to 8%. This means that the value of VM is close to 1.0 and any redesign suggestion should raise or lower a bit the origin or destination of the lift where it is appropriate.

(iii) From the value of Vertical Travel Distance Multiplier (DM), the entire work task shows tremendous values of decrement of the multiplier. The penalties applied only had decreased the multiplier at 7% for Task 3. For the rest of Task 1, 2a, and 2b, the distance is excellent enough. Any redesign suggestion should only alter the DM for Task 3 by reducing the vertical travel distance between the origin and the destination of the lift.

(iv) From the value of Asymmetric Multiplier (AM), the entire work task showed quite a number of percentage decrement up to 27%. This means that the values of AM is less than 1.0 and the origin and destination of the lift should be moved closer together to reduce the angle of twist.

(v) From the value of Coupling Multiplier (CM), the penalties had made 10% decrements from the ideal value for Task 1. This means that the values of CM for Task 2a, 2b, and Task 3 would not have to be considered in redesign affairs.

(vi) From the value of Frequency Multiplier (FM), since the frequency rates were all the same, the penalties percentage decrements were also the same which was 22%. This means that the value of FM was less than 1.0 and any redesign suggestion should consider reducing the lifting frequency rate or reducing the lifting duration, or provide longer recovery periods.

(vii) From the value of Single Task Recommended Weight Limit (STRWL), the value for Task 2a represented the lifting from the origin and Task 2b represented the lifting to destination. The penalties applied to the values yielded the values for Frequency Independent Recommended Weight Limit (FIRWL) and then each of them was multiplied by the FM value and yielded each STRWL values that had decrements up to 34% less than the actual load weight. Any redesign considerations should include the elimination of the need for significant control of the object at the destination by redesigning the work task or modifying the object characteristics.

4.4 REDESIGN SUGGESTIONS

The product being evaluated has no handles, it is heavy and hard to grip, and also it has sharp edges that would result in pressure markings on the hand palms if being handled often. From the worker's complaints, the worker did stated that it hurts when there is no gloves but the varnished surfaces would make it slippery to handle the product if gloves were used. According to NIOSH Ergonomic Guidelines For Manual Material Handling (2007), gloves can reduce the grip strength up to 60% depending on the material they are made of or how many pairs you wear at once. This is considered as one of the major problems, but straight away, the modifications of the physical properties of the object were considered as impossible, improving the grip, reducing the palm pressures, and increasing the CM value for it to be close to

1.0 were neglected. This was because the alterations of the product would be very lengthy, time consuming, and way beyond the scope of study.

So, there are a few other suggestions that were concerned of such as those of reducing reaching and bending, reducing the stress on the worker's back and shoulders, and also reducing the effort and force needed to perform the work task. Those guidelines established are stated briefly as follows.

(i) The worker should first acknowledge the weight that will be lifted. If the worker knows the exact weight or load, mind and body muscles will be prepared to lift that certain amount of load and thus reduces the exposure to risk factors. The worker must also know own capabilities and the acceptable weight limit. To implement this, load tags should be indicated at the Quality Plan sheets or the designated pallets that were being used on the conveyor or however possible to ensure that the load information reaches the worker.

(ii) In terms of the layout of the workplace, the workstation must have a fixed appropriate and designated place to work in. Fixed stations are preferred over stations that can be altered randomly. As for what had been studied, the manual strapping machine should be set in a fix angle of 30˚ or less to make sure that the worker does not use twisting motions to carry out the task. The scissor lift's designated place should also be marked on the floor even though the lift does not require any particular angle to be worked with. The same reason also applies for the scissor lift. This can be done by having to put markings or indications by using colored tapes fixed in a specific angle mentioned above.

(iii) The main redesign of the workplace is stated briefly in points broken down below. Note that the suggestions made were based on reducing the penalties of each of the multipliers.

(a) To increase the value of HM for it to be 1.0 or close to that value, during Task 1, the worker needs to first manipulate the product for it to be close to the worker before lifting the product to the strapping machine. This will remove any gap horizontally thus induces lifting within power zone. During Task 2a, the horizontal barrier at the manual strapping machine that serves as the strapping barricade could not be adjusted, so in order to improve this, the worker should first place the packaging box near the edge of the table so that when performing the Task 2b, the HM value can be increased close to 1.0. For Task 3, the usage of scissor lift would promote the best working practice as none of lifting would be required if the lifting movements are converted to pushing movements.

(b) Task 1, 2b and 3 shows very little penalty were given to those tasks as the vertical distance of them were at their best already. To increase the value of VM for it to be 1.0 or close to that value, during Task 2b, a portable work platform should be used to increase the height of the worker so that the worker could insert the strapped product without having to exert any stressful force to the lower back. In order for this suggestion to work smoothly with the previous suggestion, divide the standing region of the packaging table into sections that has portable work platform and no work platform. The worker will still have room to maneuver or manipulate the product for it to be pushed to the scissor lift next to the packaging table.

(c) If both of the above suggestions were implemented, the DM value would certainly be cancelled off as there were no lifting conducted. The ideal value of vertical distance is equal to 25cm or less. If the worker pushes the packaging box near to the edge of the table and then lifts the box to the scissor lift, as long as the distance would not exceed 25cm, the work task is at its ideal state already.

(d) To increase the value of AM to be 1.0 or close to 1.0, in this case, instead of moving the origin and destination of lift closer together, which is impossible, and there would be insufficient room for the worker to maneuver, the origin and destination of the lift should be moved further apart to force the worker to turn the feet and step, rather than twist the body. But this has to be made with respect to the DM which any distance that exceeds 25cm would apply penalties that would decrease the DM.

(iv) The packaging section should have one scissor lift designated for the packaging worker as most of the workload requires manual material handling. This would avoid the sharing of the scissor lift that would make it unavailable for the usage of the worker whenever the scissor lift is required to transfer the load to the pallet area.

(v) The equipments and appliances which are present at the packaging section such as the manual strapping machine, conveyor, and scissor lift should be inspected and maintained according manufacturer's recommendation to ensure high level of safety and also reduces exposure to other risk factors.

(vi) The proper usage of equipments and appliances mentioned should also be heed to ensure proper equipment use.

(vii) A cutout work surface should really be implemented between Task 1 and Task 2a to reduce the travel distance involved. The worker would then could easily manipulate products and does not require any walking movements.

(viii) Eventhough training is not considered as an improvement according to NIOSH (2007), training employees to be concerned with proper equipment usage and appropriate work practices ensures the optimum worker efficiency and hinders any exposures towards hazardous working methods.

(ix) The management division could also increase the worker wages or salaries. This would increase worker's morale while performing the work. When worker's spirits are high, this would result to a happy worker, and a happy worker is a healthy worker.

CHAPTER 5

CONCLUSION

5.1 INTRODUCTION

There were several approaches for assessing and evaluating the manual lifting task which was the packaging work task. One approach that was done was by using Revised NIOSH Lifting Equation. Other approaches to eliminate the manual requirements and the demands of the work task were by using appropriate equipments such as scissor lifts. If the manual requirement or demands of the work task cannot be eliminated, the demands were reduced by ergonomic redesign approaches. If it requires further and advance alterations such as altering the shape, size, or features of the product being handled, those matters were neglected as a last resort because redesign were not feasible.

5.2 ASPECTS OF IMPROVEMENTS MADE

(i) The load should be kept close to the body and one of the lifting tasks was shifted to sliding instead of lifting as one of the improvements.

(ii) The scissor lifts should be used to raise or lower the load so that it is level with the packaging table work surface. (Follows previous improvement).

(iii) Use a portable work platform and adjust it to the height of the worker. Multiple work platforms also can be used to adjust the height to an appropriate level depending on the worker.

(iv) Use a cutout work surface so that the worker can get closer to the container.

(v) Increase the worker's wages or salaries to increase morale.

5.3 MANAGEMENT GUIDELINES FOR SAFER LIFTING

(i) Plan the workflow to eliminate unnecessary lifts.

(ii) Organize work so that the physical demands and work pace increase gradually.

(iii) Minimize the distances loads are lifted and lowered.

(iv) Position loads of products at a height that allows the worker to lift and lower within her power zones.

(v) Avoid manually lifting or lowering loads to or from the floor.

  (a) Store items and/or products off the floors

  (b) Use mechanical devices whenever possible. Use a scissor lift trolley to lift or lower the entire pallet of the material instead of lifting or lowering the material individually.

  (c) Arrange to have material off-loaded directly onto shelves. Store only lightweight on the floor.

  (d) Avoid designing jobs that require the worker to lift and lower the materials to or from floor level.

(vi) For loads that are unstable and/or heavy

  (a) Tag the load to alert the worker.

  (b) Test the load for stability and weigh before carrying the load.

  (c) Use mechanical devices or equipment to lift the load.

(vii) Reduce the frequency of lifting and the amount of time employees perform lifting tasks by having workers alternate lifting tasks with non-lifting tasks.

(viii) Clear spaces to improve access to materials or products being handled. Easy access allows the worker to get closer and reduces reaching, bending, and twisting.

5.4 EMPLOYEE GUIDELINES FOR SAFER LIFTING

(i) The use of stretching is appropriate as a part of a comprehensive ergonomic program.

(ii) Check for tags on loads.

(iii) Before lifting, always test the load for stability and weight.

(iv) Plan the lift

(a) Wear appropriate shoes to avoid slips, trips, or falls.

(b) If you wear gloves, choose the size that fits properly. Depending on the material the gloves are made of and the number of pairs worn at once, more force may be needed to grasp and hold objects.(Wearing a thick glove can reduce the worker grip strength up to 60% - Ergonomic Guidelines for MMH, 2007)

(c) Lift only as much as the worker can handle by herself.

(d) Keep the lifts in the worker power zone (i.e., above the knees, below the shoulders, and close to the body), if possible.

(e) Use extra caution when lifting loads that may be unstable.

(v) When lifting

(a) Get a secure grip

(b) Use both hands whenever possible

(c) Avoid jerking by using smooth, even motions.

(d) Keep the load as close to the body as possible.

(e) Do not twist body. Step to one side or the other to turn.

(f) Alternate heavy lifting or forceful exertion tasks with less physically demanding tasks.

(g) Take rest breaks.

5.5 RECOMMENDATIONS FOR FURTHER STUDY

There were several recommendations for further study that were considered at the end of this study. Those recommendations are described as below.

(i) The study should include pushing and pulling activities.

(ii) The results should be compared with appropriate software.

(iii) The subjects should be evaluated in a number of samples.

(iv) The study should include male gender.

(v) The proposed guidelines could be used anywhere in the industry.

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APPENDIX A

GANTT CHART FOR FINAL YEAR PROJECT 1

APPENDIX B

GANTT CHART FOR FINAL YEAR PROJECT 2

APPENDIX C

NIOSH MANUAL MATERIAL HANDLING CHECKLIST

Appendix C

NIOSH Manual Material Handling Checklist

This checklist is used as a tool to identify potential problem jobs quickly. It is not designed as a comprehensive risk assessment technique. Additional risk factors may not include in this checklist. More precise techniques need to be performed as follow up actions to this checklist observation.

1. Are the weights of loads to be lifted judged acceptable by the workforce?	Yes	No
2. Are the materials moved over minimum distances?	Yes	No
3. Is the distance between the object load and the body minimized?	Yes	No
4. Are walking surfaces level? wide enough? clean and dry?	Yes Yes Yes	No No No
5. Are objects easy to grasp? stable? able to be held without slipping?	Yes Yes Yes	No No No
6. Are there handholds on these objects?	Yes	No
7. When required, do gloves fit properly?	Yes	No
8. Is the proper footwear worn?	Yes	No
9. Is there enough room to maneuver?	Yes	No
10. Are mechanical aids used whenever possible?	Yes	No
11. Are working surfaces adjustable to the best handling heights?	Yes	No
12. Does material handling avoid: Movement below knuckle height and above shoulder height? Static muscle loading? Sudden movements during handling? Twisting at the waist? Extended reaching?	 Yes Yes Yes Yes Yes	 No No No No No
13. Is help available for heavy awkward lifts?	Yes	No
14. Are high rates of repetition avoided by job rotation? Self-pacing? Sufficient pauses?	Yes Yes Yes	No No No
15. Are pushing or pulling forces reduced or eliminated?	Yes	No
16. Does the employee have an obstructed view of handling the task?	Yes	No
17. Is there a preventive maintenance program for equipment?	Yes	No
18. Are workers trained in correct handling and lifting procedures?	Yes	No

Note that the “No” indication points out potential problem areas that should be investigated.

Source: Cheung (2007)

APPENDIX D

NIOSH HAZARD EVALUATION CHECKLIST FOR LIFTING PUSHING OR PULLING

Appendix D

NIOSH Hazard Evaluation Checklist for Lifting, Pushing, or Pulling.

This checklist is used as a tool to identify potential problem jobs quickly. It is not designed as a comprehensive risk assessment technique. Additional risk factors may not include in this checklist. More precise techniques need to be performed as follow up actions to this checklist observation.

Risk Factors		
1.0 General		
1.1 Does the load handled exceed 50lb.?	Yes	No
1.2 Is the object difficult to bring close to the body because of its size, bulk, or shape?	Yes	No
1.3 Is the load hard to handle because it lacks handles or cutouts for handles, or does it have slippery surfaces or sharp edges?	Yes	No
1.4 Is the footing unsafe? For example, are the floors slippery, inclined, or uneven?	Yes	No
1.5 Does the task require fast movement such as throwing, swinging, or rapid walking?	Yes	No
1.6 Does the task require stressful body postures such as stooping to the floor, twisting, reaching overhead, or excessive lateral bending?	Yes	No
1.7 Is most of the load handled by only one hand, arm, or shoulder?	Yes	No
1.8 Does the task require working in extreme temperatures, with noise, vibration, poor lighting, or airborne contaminants?	Yes	No
1.9 Does the task require working in a confined area?	Yes	No
2.0 Specific		
2.1 Does lifting frequency exceed 5 lifts per minute?	Yes	No
2.2 Does the vertical lifting distance exceed 3 feet?	Yes	No
2.3 Does carrying work last longer than 1 minute?	Yes	No
2.4 Do tasks that require large sustained pushing or pulling forces exceed 30 seconds duration?	Yes	No
2.5 Do extended reaching reach static holding tasks exceed 1 minute?	Yes	No

The "Yes" indication points out conditions that have the tendency of developing low back pain. The larger the percentage of "Yes" responses, the greater the possible of risk.

Source: Cheung (2007)

APPENDIX E

ERGONOMICS AWARENESS WORKSHEET

Appendix E

Ergonomics Awareness Worksheet

The objective of the worksheet is to increase basic awareness of potential problems associated with jobs and tasks. This awareness can help provide clues on how to make effective improvements.

Job Title:___________________________ Job Location:___________________________

Name of Employee:____

Name of Observer:_______________________________________ Date:_____________

Risk Factors	Other Clues	Reasons for Problems
Task 1:		

Note that more tasks will be added if there are more potential problems in presence.

Source: Cheung (2007)

APPENDIX F

ERGONOMICS CHECKLIST – MATERIAL HANDLING

Appendix F

Ergonomics Checklist – Material Handling

The checklist presented below would help users to identify any job risk factors that may be present in the job. This checklist is applicable to jobs requiring the routine handling of objects of 10 pounds or more.

Job/Task:________________ Dept:_____________ Date:_________ Analyst:_____________

Before__________________________ After (Controls Implemented)___________________

Directions: Review each condition for the job/task of interest and for each condition that frequently occurs, place an X in the "Concern" column as appropriate. Add comments as appropriate.

Condition	X if a concern	Comments
REPETITION		
High-speed process line or work presentation rates		
Similar motions every few seconds		
Observed signs of fatigue		
WORKSTATION DESIGN		
Work surface too high or low		
Location of materials promotes reaching		
Angle/orientation of containers promotes non-neutral positions		
Spacing between adjacent transfer surfaces promotes twisting		
Obstructions prevent direct access to load/unload points		
Floor surfaces are uneven, slippery, or sloping		
Hoists or other power lifting devices are needed but not available		
LIFTING AND LOWERING		
Heavy objects need to be handled		
Handling bulky or difficult-to-grasp objects		
Handling above the shoulders or below the knees		
Lifting to the side or unbalanced lifting		
Placing objects accurately/precisely		
Sudden, jerky movements during handling		
One-handed lifting		
Long-duration exertions (static work)		

Condition	X if a concern	Comments
PUSHING/PULLING/CARRYING		
Forceful pushing/pulling of carts or equipment required		
Brakes for stopping hand carts/handling aids are needed but not available		
Carts or equipment design promotes non-neutral postures		
Long-distances carrying (carts not available)		
CONTAINER/MATERIALS		
Lack adequate handles or gripping surfaces		
Are unbalanced, unstable, or contents shift		
Obstructs leg movement when being carried		
OTHER		
Inappropriate work techniques used		
Buildup of process material/product increases worker effort		
Personal protective equipment needed but not available/used		
TOTAL SCORE (Optional)		***To score, add up the total number of Xs identified***

Source: Cheung (2007)

APPENDIX G

REVISED NIOSH LIFTING EQUATION RWL TABLES

APPENDIX G

Table 1: Horizontal Multiplier

H	HM	H	HM
in	Index	cm	Index
≤10	1.00	≤25	1.00
11	0.91	28	0.89
12	0.83	30	0.83
13	0.77	32	0.78
14	0.71	34	0.74
15	0.67	36	0.69
16	0.63	38	0.86
17	0.59	40	0.63
18	0.56	42	0.60
19	0.53	44	0.57
20	0.50	46	0.54
21	0.48	48	0.52
22	0.46	50	0.50
23	0.44	52	0.48
24	0.42	54	0.46
25	0.40	56	0.45
>25	0.00	58	0.43
		60	0.42
		63	0.40
		>63	0.00

Table 2: Vertical Multiplier

V	VM	V	VM
in	Index	cm	Index
0	0.78	0	0.78
5	0.81	10	0.81
10	0.85	20	0.84
15	0.89	30	0.87
20	0.93	40	0.90
25	0.96	50	0.93
30	1.00	60	0.96
35	0.96	70	0.99
40	0.93	80	0.99
45	0.89	90	0.96
50	0.85	100	0.93
55	0.81	110	0.90
60	0.78	120	0.87
65	0.74	130	0.84
70	0.70	140	0.81
>70	0.00	150	0.78
		160	0.75
		170	0.72
		175	0.70
		>175	0.00

Table 3: Distance Multiplier

D	DM	D	DM
in	Index	cm	Index
≤10	1.00	≤25	1.00
15	0.94	40	0.93
20	0.91	55	0.90
25	0.89	70	0.88
30	0.88	85	0.87
35	0.87	100	0.87
40	0.87	115	0.86
45	0.86	130	0.86
50	0.86	145	0.85
55	0.85	160	0.85
60	0.85	175	0.85
70	0.85	≤175	0.00
>70	0.00		

Table 4: Asymmetric Multiplier

A	AM
deg	Index
0	1.00
15	0.95
30	0.90
45	0.86
60	0.81
75	0.76
90	0.71
105	0.66
120	0.62
135	0.57
>135	0.00

Table 5: Frequency Multiplier

F Lifts/min	Duration					
	<1 hour		1-2 hours		2-8 hours	
	V< 30in	V≥ 30in	V< 30in	V≥ 30in	V< 30in	V≥ 30in
≤0.2	1.00	1.00	0.95	0.95	0.85	0.85
0.5	0.97	0.97	0.92	0.92	0.81	0.81
1	0.94	0.94	0.88	0.88	0.75	0.75
2	0.91	0.91	0.84	0.84	0.65	0.65
3	0.88	0.88	0.79	0.79	0.55	0.55
4	0.84	0.84	0.72	0.72	0.45	0.45
5	0.80	0.80	0.60	0.60	0.35	0.35
6	0.75	0.75	0.50	0.50	0.27	0.27
7	0.70	0.70	0.42	0.42	0.22	0.22
8	0.60	0.60	0.35	0.35	0.18	0.18
9	0.52	0.52	0.30	0.30	0.00	0.15
10	0.45	0.45	0.26	0.26	0.00	0.13
11	0.41	0.41	0.00	0.23	0.00	0.00
12	0.37	0.37	0.00	0.21	0.00	0.00
13	0.00	0.34	0.00	0.00	0.00	0.00
14	0.00	0.31	0.00	0.00	0.00	0.00
15	0.00	0.28	0.00	0.00	0.00	0.00
>15	0.00	0.00	0.00	0.00	0.00	0.00

Table 7: Coupling Multiplier

Coupling Type	CM	
	V<30 in	V≥30in
GOOD	1.00	1.00
FAIR	0.95	1.00
POOR	0.90	0.90

Source: Waters (1994)

APPENDIX H

MULTITASK JOB ANALYSIS WORKSHEET

APPENDIX H

MULTI-TASK JOB ANALYSIS WORKSHEET

DEPARTMENT : ____________________
JOB TITLE : ____________________
ANALYST'S NAME : ____________________
DATE : ____________________

JOB DESCRIPTION: ____________________

MEASURE AND RECORD TASK VARIABLE DATA

Task No.	Object Weight (kg)		Hand Location (cm)				V-V Distance (cm)	Asymmetric Angle (deg.)		Frequency Rate	Duration	Coupling
			Orig.		Dest.			Orig.	Dest.	Lifts/min	Hrs.	
	L (Avg.)	L (Max)	H	V	H	V	D	A	A	F		C
____												
____												
____												
____												
____												

COMPUTE MULTIPLIERS AND FIRWL, STRWL, FILI, AND STLI FOR EACH TASK

Task No.	LC x	HM x	VM x	DM x	AM x	CM	FIRWL x	FM	STRWL	FILI = L/FIRWL	STLI = L/STRWL	New Task No.	F

COMPUTE THE COMPOSITE LIFTING INDEX FOR THE JOB (After renumbering tasks)

	$STLI_1$ +	$\Delta FILI_2$ +	$\Delta FILI_3$ +	$\Delta FILI_4$ +	$\Delta FILI_5$
CLI =		$FILI_2(1/ FM_{1+2} – 1/ FM_1)$	$FILI_3(1/ FM_{1+2+3}$ – 1-$/ FM_{1+2})$	$FILI_4(1/ FM_{1+2+3+4}$ – $1/ FM_{1+2+3})$	$FILI_3(1/ FM_{1+2+3+4+5}$ – $1/ FM_{1+2+3+4})$
CLI =					

Total:

Source: Waters (1994)