ADDIS ABABA UNIVERSITY

ADDIS ABABA INSTITUTE OF TECHNOLOGY

SCHOOL OF MECHANICAL AND INDUSTRIAL ENGINEERING

Work place Ergonomic burden on printing industry:
a case of Birhan and Selam printing enterprise

Thesis submitted to school of mechanical and Industrial Engineering for the partial fulfillment for the degree of Master of Science (M.Sc.) in Industrial Engineering, Addis Ababa University faculty of Technology, School of Mechanical and Industrial

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Ergonomic assessment and impact on the current packaging process: a case of Birhan and Selam printing enterprise

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DECLARATION

I hereby declare that the work which is being presented in this thesis entitled ***Work place Ergonomic burden on printing industry: a case of Birhan and Selam printing enterprise*** is original work of my own, has not been presented for a degree of any other university and all the resources of materials used for this thesis have been dually acknowledge.

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Abstract

All around the world, occupational health and safety is a major concern with in all economic sectors particularly in industries and ergonomics is the study of the design of a workplace, equipment, machine, tool, product, environment, and system which takes into consideration human being's physical, physiological, biomechanical, and psychological capabilities and optimizes the effectiveness and productivity of work systems while assuring the safety, health, and wellbeing of the workers. In general, the goal of ergonomics is to fit the task to the individual, not the individual to the task.

Hence, the purpose of this study is to evaluate the work practice regarding ergonomics in the case company Birhan and Selam printing enterprise and determine ergonomic risk factors to an employee working in the company.

To undertake this research, primary and secondary data are collected through a survey questionnaire, interviews (in the form of discussion) and physical observation in the case company Birhan and Selam printing , as well as referring previous research works and case company records. To analyze and present the data, pie charts, bar graphs, and cause and effect diagram are used. In addition to that, to see whether or not the workers are at risk RULA analysis is done.

From the research, it is concluded that there is a high risk for the employees to get exposed to work related ergonomic injury and the risk factors which leads to ergonomic injury are awkward posture, poor work place design, repetitive task, lighting, dust and temperature. In addition improvement approach is forwarded towards the existing problem of the company. In order to do these there have been three factors that were considered in this study as improvement method; they are enterprise community involvement, the psychosocial work environment and the physical work environment. The enterprise community involvements include top management commitment and training the workers. The psychological work environment includes improvement direction in lighting and temperature. The physical work environment forward improvement model on modifying workstation design. Finally, the overall conclusion and recommendation were developed.

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List of Acronym

MSD: Musculoskeletal disorder

MMH: Manual Material Handling

CTD: Cumulative trauma Disorder

RULA: Rapid Upper Limb Assessment

REBA: Rapid Entire Body Assessment

IEA: International Ergonomic Association

ILO: International Labor Organization

WHO: World Health Organization

OSHA: Occupational safety & Health Administration

MOH: Ministry Of Health

IAC: Industrial Advanced Country

IDC: Industrial Developed Countries

OSH: Occupational safely Health

MOLSA: Ministry Of Labor and Social Affairs

BSPE: Birhan And Selam printing enterprise

Chapter One

1.1. Introduction

The International Labor Organization estimates that each year around 2.78 million workers die as a result of occupational accidents and work-related diseases (ILO, 2019). Occupational injury is a global public health burden in terms of disability adjusted life year which contributed to 1.5% of all causes with estimated economic loss of 5% - 10% GDP (Nyguyent, 2009).

Ergonomics can be defined as the branch of science that aims at achieving an optimal fitting of the working environment and job activities to the worker, the work environment can affect a workers performance in many different ways by damaging health therefore the scope of ergonomics include physical work load, posture at work, lifting and carrying, machine-human system interaction, and also lighting, thermal comfort and noise (Ana suarez,2014).

Ergonomics can also be defined as a study of people and their interaction with the elements of their job or task including equipment, tools, facilities, processes, and environment. It is a multidisciplinary field of study integrating industrial psychology, engineering, medicine, and design (Ferreira, Elvis et al, 2015).

In previous studies like Allina (2017) has generally identified that musculoskeletal disorders which caused by awkward postures, excessive force and repetition because of the limited work area, standing for prolonged periods and operating heavy equipment.

Ergonomic practices within the workplace can alleviate these and minimize the potential risks for any eventual reoccurrence of a musculoskeletal disorder. These practices can help improve the workplace by reorganizing or redesigning workstation, by allowing employees to rotate within the line, decreasing the number of repetitions required in the task, reducing the force required in the task, providing education training on correct posture for the task and encouraging stretches during break times (Hennery,2014).

A study showed that in the printing industry, production workers are tending to have greater work demands placed on them, some of the physically demanding tasks undertaken by workers include masking film and exposing plates, operating power tools, tending to machines, loading

and unloading materials, as well as mixing and placing ink, alcohol, water, paper and gummer, these activities expose workers to ergonomic risk factors, such as awkward posture, frequent heavy lifting, repetitive motions, and hand/arm and whole body vibration(Niu, 2010cited in Mohammed , 2016).

In developing countries including Ethiopia workplace safety and health issues remain a neglected socio-economic development priority In Ethiopia and Occupational safety and health service has very low coverage with respect to injury recording system, basic occupational health, safety services, safety issues, research on occupational health and prevention strategy (Kassu ,2017).

Ergonomics and management style in our country is a new science that awareness about the ergonomics and management style needed strongly by the top managements, ministries, and other Head Quarters of the country (Kassu , 2015).

In Addis Ababa alone; more than 400 printing enterprises are available and more than 900 when considering national level. This list incorporates all categories of printing companies (i.e. micro, small, medium and large) functioning in printing license (Ftsum , Amha , Danil , Eshete , 2017).

there is high increasing demand for printing service in Ethiopia but the dearth of row material, the absence of foreign currency to import raw materials, shortage of skilled manpower are a bottle neck for the sector (Girmachew , Tsegaye ,2018).

Among printing industries, public government enterprises in Ethiopia are the oldest and are still functioning at higher level, though they are few in number, the governmental printing enterprises are the major printing ones for addressing most of the huge governmental and other business organizations' printing needs locally. Yet, the capacity of these governmental printing enterprises and existing demand of printing is way beyond comparable (Firehiwet , 2017).

This study has been carried out at Birhan and Selam printing enterprise, Birhan and Selam printing enterprise is a public enterprises in Ethiopia and its one of the oldest established in September 14/1922 and BSPE is still functional at higher level meeting the printing demand of the government and other local customers and it is the only in secret printing sector in Ethiopia. It has nine customer based services and known by on time deliver and quality. However there is a high hazard of ergonomic injury in the company because less attention is given to work place

safety and occupational health. The company has 861 permanent employees 306 of them are female employees and 555 are male employees.

The purpose of this study is to assist the company by assessing work related ergonomic injury which exists in a company and to recommend corrective measures which can help improve the situation.

1.2. Statement of the problem

Ergonomics is an important topic in Ethiopia because of the fast growing of industries in the country. However studies revealed, parallel with the expansion of manufacturing industries at global, at national, at the enterprise level and at individual level, all parties are suffering from workplace accidents, hazards and diseases (Kassu, 2017). MSDs are the most common injuries related to poor ergonomics, if these injuries are taken lightly, it will progress to permanent problems (Sain, Meena, 2016). Musculoskeletal disorders and the pathologies caused by biomechanical overload are occupational diseases which affect the vertebral column, the tendons, the nerves and the muscular as well as the circulatory system. They can be ascribed to incorrect and compulsory postures, prolonged exposure to repeated micro-traumas and functional stress, or to overloads which might occur while working (Lauren , 2014. Information that shows the magnitude and predictors of musculoskeletal disorders in most risky work places in Ethiopia such as industries is indispensable for proper health intervention programs Nyguyen (2009).

BSPE is the major printing enterprise works in full capacity for addressing most of the huge governmental and other business organization printing needs, yet the capacity of the company and the existing demand is way beyond comparable. Due to this the workers and the management of the company are always in a rush of meeting the customer order given, they focus on fulfilling of their task and giving almost no consideration about ergonomic injury and MSD. Because of this reason the employees are exposed to fatigue and ergonomic injuries, which lowers the company's productivity by increasing cost through absenteeism and medical cost.

The data from the company's record (Table1.1), shows the direct and the indirect cost due to occupational injury.

The reason BSPE is chosen for the purpose of this study is as mentioned earlier the company has higher customer demand and the company strives to satisfy the customers through quality and on time delivery, both the management and the employees work with higher determination to satisfy their customers but give less consideration to work place safety and occupational injury. Therefore, it was believed doing this ergonomic assessment on the company better assist the management for taking Corrective action to implement ergonomics which will increase productivity by cutting

Unnecessary injury case costs.

Table 1. 1 Direct and Indirect cost of a year 2016, 2017 and 2018

No	Year	Lost time	Direct cost	Indirect cost	Total
1	2016	251	122,559.64	167,678.93	290,238.57
2	2017	317	146,162.09	238,486.27	384,648.36
3	2018	379	163,095.62	289,286.86	452,382.48

The costs in Table1.1 come from the lack of safety in the work place of the organization. Direct costs are those directly associated with the claim and include Medical treatment, Prescription costs and Insurance premiums. The **Indirect costs** associated with the injury can include overtime due to staff coverage during absence of injured worker, accommodation for modified duty, increased absenteeism, decreased morale, legal and investigation costs, presenteeism(when an employee comes back to work too early and is less productive than in a healthy state) replacement worker costs, advertising and recruiting if employee doesn't return to work, orientation and training costs.

"Indirect costs are estimated to be 3-5 times more expensive than the direct costs of that claim" (Hailye , 2016). These factors at the company's workplace are the reasons to conduct this study.

BSPE a big enterprise with a huge number of employees and it plays a big role in county's economy. For the purpose of this study it was appropriate to focus in specific area of the company to be effective because, it has different job and different type of occupational injury. To select that specific area of study, it has been assessed to determine the department with the highest number of occupational injury. By doing so packaging line is found to be the highest in ergonomic injury, the following section shows evidence for this.

Data collected from the company's safety office explained that out of 127 injuries occurred in the year 2017/2018 in different departments 13 of them are laborers, 25 workers were messenger, maintenance and civil workers and 20 of them are printing workers but 69 of them are packaging line workers which is more than half (54%) of the total number.

Length of absence work day

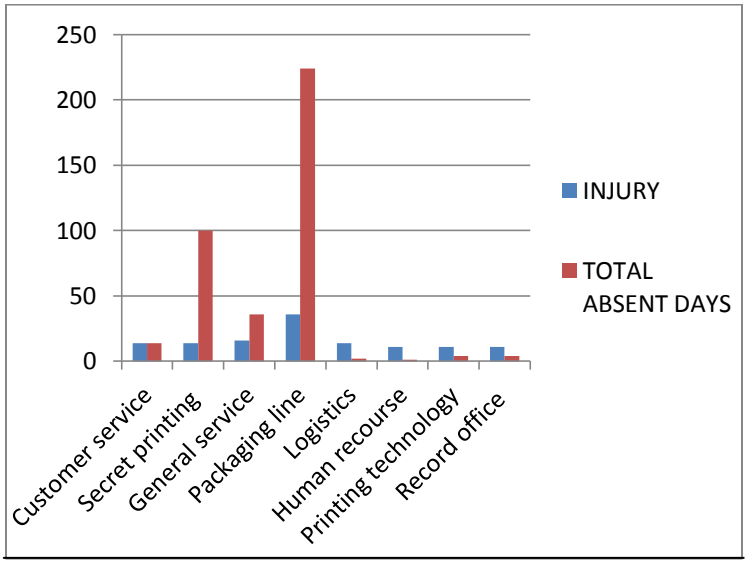


Figure 1. 1 absent work days

As a data collected from the company's safety office, in packaging line 36 workers has been injured and it's the highest number comparing to others in survey and absenteeism in work days is 224 days for packaging line workers. By taking this in to account and in addition to that by discussing with the enterprises safety officer and management, it was able to understand the packaging line is a department found with higher number of ergonomic injuries and improvement priority area. Therefore, packaging line workers are the target groups to this study.

1.3. Research question

1. What are the Ergonomics Risk Factors (ERF) affecting workers in the industry?
2. What workplace design and areas exposed workers to musculoskeletal disorders in the printing industry?
3. How to develop an improvement method for ergonomic risk of the printing industry?

1.4. Objective

1.4.1. General objective

The purpose of this study is to assess the ergonomic-based risk factors and its impact on Brhan and Selam printing enterprise employees exposed to and to develop controls that prevents risks of musculoskeletal disorders.

1.4.2. Specific objective

- To identify ergonomic risk factors which affect workers of the manufacturing industry.
- To asses and identify which workplace design areas that exposed workers to musculoskeletal in printing industry.
- To develop a design which can make a packaging line safe work place.
- To in place workplace improvement strategies of printing industry.

1.5. Scope

This study evaluates task functions, production demands, and workstation characteristics of the packaging line of Birhan and Selam that contribute to the occurrence of musculoskeletal disorders. This study includes the assessment of specific work environments to identify the magnitude of the potential ergonomic risk factors present.

1.6. Significance of the Study

A study conducted on packaging line of birhan and selam printing enterprise is essential in order to identify ergonomic risk factors which could result in musculoskeletal disorders. This study is necessary to identify ergonomic risk factors which possess the potential lead to musculoskeletal disorders in the associated employees. Inadequate resources and workspace layout that is not designed to accommodate the majority of employees on the line has the potential to cause injury. This study assist the company to determine controls that will prevent ergonomic injuries or reduce the risk exposure that may lead to financial loss and quality loss due to the processes involved in the packaging line.

1.7. Limitation

In Ethiopia ergonomics doesn't get much attention in many industries because of this reason it's difficult to get well organized data of workers injury and the injury causes. In this research the absence of well documented data and lack of cooperativeness of the workers to give appropriate

information were among the limitations faced. However these problems have been solved by the use of systematic data gathering and by clarifying the purpose of the research.

1.8. Organization of the Study

The study is organized in six chapters. The first chapter deals with the background and problem justification. Chapter two evaluates the literature review of previous works. Chapter three focuses on the research design and methodology of the study. In chapter four data collected from the industry and analyzed. Chapter five discusses the results obtained under the data analysis and develops improvement models based on the previous results, and chapter six presents the conclusion and recommendation of the study.

Chapter Two

Literature Review

2.1 introductions

The purpose of this chapter is to introduce literature surrounding the topic and a comprehensive overview of prior research regarding the topic. An overview includes all of the main theme and subthemes found within the general topic of the study. It also uses to identify and discuss/explain all of the main points or findings of the topic.

The sources to draw upon and use as evidence in a review of a topic are articles found in academic journals, books and also governmental publications, recent studies are used to demonstrate an in-depth understanding of the topic.

The literature review has attempted to identify related article with ergonomic injury and MSD. Most of the obtained materials were gathered from the internet. Thousands of articles, policies, books and manuals were obtained from different sources. abstract and keyword screening operation was done to know the importance of the material and after this the screening continues to select only the recent publication.

2.2. Definition

According to International Ergonomics Association (IEA), ergonomic is the scientific discipline concerned with the understanding of the interactions among humans and other elements of a system, and the profession that applies theoretical principles, data and methods to design in order to optimize human well being and overall system.

(Pandeve, 2012) says ergonomics is derived from the Greek ergon (work) and nomos (laws) to denote the science of work, ergonomics is a systems-oriented discipline, which now applies to all aspects of human activity.

Optimal ergonomic design is achieved through evaluation and design of workplaces, environments, job tasks, equipment, and processes in relation to human capabilities. Due to the lack of adjustability of most workstations, it is difficult to accommodate differences in the height or arm length of personnel (Biniyam ,2015).

Ergonomics is also defined as the study of the design of a workplace, equipment, machine, tool, product, environment, and system which takes into consideration human being's physical, physiological, biomechanical, and psychological capabilities and optimizes the effectiveness and

productivity of work systems while assuring the safety, health, and well being of the workers (Fernandez and Marley, 1998).

In general, the goal of ergonomics is to fit the task to the individual, not the individual to the task Practicing good ergonomics achieves increased productivity, improved health and safety of workers, higher job satisfaction and better compliance with government regulations.

Musculoskeletal Disorders (MSDs)

As European foundation for the improvement of living and working condition the term "musculoskeletal disorders" and its abbreviation "MSDs" are used to mean "any affliction of the musculoskeletal system that appears at work and causes discomfort, difficulty or pain when performing work", the definition applies to any disorder of the musculoskeletal system, i.e., the structures that make the body move or allow it to be kept in the different static positions upright, seated and variants which we call postures (Boococket al., 2009).

As Christopher, 2014 musculoskeletal Disorder (MSDs) is one of the most common occupational health problems, and workers in the industry are at higher risk of MSDs. In addition, MSDs constitute a major health challenge for workers and the general population. MSDs include injuries affecting muscles, tendons, ligaments, joint, nerves, and blood vessels. MSD refers to conditions that involve the nerves, tendons, muscles and supporting structures of the body and also known as ergonomic injuries and illnesses. Symptoms of MSDs include numbness, tingling, aches and pain, localized inflammation, weakness, and/or difficulty in moving joints, which can significantly reduce the ability to do work or carry out daily activities (Rachel, 2012). these disorders have caused a considerable human suffering and are also economically very costly because of reduced working capacity and lessen production. High incidence rate for MSD of the upper extremities have been reported for workers in office work, manufacturing and agriculture which includes numerous material handling occupation in various factories (Faucet et al., 2002;Allina, Nik et al,2017).

The poor posture and movement can lead to local mechanical stress on the muscles, tendons, ligaments and joints resulting in discomfort in the neck, back, shoulder, wrist and other parts of the musculoskeletal system. This is because when maintaining a posture, the joints must be kept in a neutral position with the limbs, as far as possible, close to the body, thus enabling the muscles to deliver the greatest force (David, 2005; Chowdury et al., 2015)

MSDs may be characterized in two different methods. The first may occur from a single event such as a strain or a sprain or it may occur from numerous continuous events that gradually increase tissue damage from an accumulation of smaller injuries. These injuries may develop over periods of weeks, months, or years. It is difficult to identify symptoms of these injuries in their early stages, but the symptoms become pronounced after repeated occurrences. The causes of MSDs are not restricted only to the work environment, but may also originate from the home or while performing recreational activities. The severity of MSDs may vary significantly among employees performing the task (Garg, 2012).

studies of prevalence of MSD among workers who perform the Manual Material Handling task in an automotive manufacturing plant by Deros et al. (2010) investigated that the lower back is the highest pain of MSD problems followed by pain at feet/ankle and pain at upper back regions. It was concluded that the back pain the workers are experiencing may be a result of their ignorance in the correct and ergonomic techniques in materials handling (Allina, Nik et.al,2017).

In general Musculoskeletal disorder (MSD) is term applied to disorders and injuries of the musculoskeletal system. They occur when the demands of an activity exceeds the capacity or limitations of the musculoskeletal components of a human body. MSDs can occur suddenly due to a single incident or they develop gradually over long periods.

Signs and Symptoms of MSDs

MSD affecting a specific body area with a specific set of symptoms that has developed because of exposure to specific risk factor(s) is frequently referred to by different terms/names, symptoms of MSDs include numbness, tingling, aches and pain, localized inflammation, weakness, and/or difficulty in moving joints, which can significantly reduce the ability to do work or carry out daily activities (Rachel ,2012)

The occurrence of MSD injuries in the work environment may result in a cost that companies cannot afford. MSD injuries not only affect the organization's credibility, but also leave a significantly negative effect on its finances. Ergonomics may provide assistance to an organization through assessment tools that positively transform the work environment, which ultimately reduce medical costs and absenteeism, and maximizes productivity and efficiency (Miles, 2001).

Musculoskeletal Disorders (MSD) have become a major problem in various industrialized countries. MSD refers to conditions that involve the nerves, tendons, muscles and supporting structures of the body and also known as ergonomic injuries and illnesses. These disorders have caused a considerable human suffering and are also economically very costly because of reduced working capacity and lessen production (Muhammad, 2010).

Organizations face the challenge in identifying the symptoms of MSD. Musculoskeletal l injuries were investigated by experts in several systematic assessments performed in a controlled environment on selected subjects. The assessment over time was greatly successful in providing information to organizations to understand, recognize, and educate their employees regarding the signs and symptoms of MSDs. This facilitates recognition and reporting of MSDS without delay and aides the company in taking practical measurements to prevent them. Common symptoms linked with MSD are the inability to produce a tight grip with one's hands because of a lack of power, the reduction in the range of motion of one's arms and the inhibited ability to flex one's fingers because of loss of muscle function (Chengular, et al., 2004).

2.3. Ergonomic Risk Factors

Nature and nurture influences the wellbeing and functionality of an individual, the human body's tissues and organs develop, mature, and decline at different rates throughout the lifecycle of the body i.e. childhood, adolescence, young adulthood, adulthood and old age, nature (genetics) will pre-dispose individuals, and their component parts (cells, tissues, and organs) to achieve a potential maximum capacity (Rachel, 2012).

In addition to that the poor posture and movement can lead to local mechanical stress on the muscles, tendons, ligaments and joints resulting in discomfort in the neck, back, shoulder, wrist and other parts of the musculoskeletal system. This is because when maintaining a posture, the joints must be kept in a neutral position with the limbs, as far as possible, close to the body, thus enabling the muscles to deliver the greatest force (Chowdury et al., 2015).

Various ergonomic risk assessment methods have been developed in order to evaluate exposure to risk factors for MSD, most of them evaluate the risk of the various regions of the body for example the back, neck, shoulder, arms and the wrists.

Employees in the field of manufacturing are exposed to various ergonomic risk factors that lead to MSDs. The first step toward taking proactive measures is to reduce exposure to ergonomic risk factors, which may cause MSD signs and symptoms. These risk factors result from stresses being applied to specific parts of the body during the execution of tasks (Christopher, 2014). The World Health Organization (WHO), recognizing the impact of 'work-related' musculoskeletal diseases, which is characterized WMSD as multifactorial, indicating that a number of risk factors contribute to and exacerbate these maladies. The presence of these risk factors produced increases in the occurrence of these injuries, thus making WMSD s an international health concern. These types of injuries of the soft tissues are referred to by many names, including WMSD s, repetitive strain injuries (RSI), repetitive motion injuries (RMI), and cumulative trauma disorders (CTDs) (McCauley, 2011,isabel l,2012).

Repetitive motion may cause stress on the muscles, tendons, and nerves, thereby increasing the chances of developing various bodily injuries such as strain or cumulative trauma disorders (Mcclymont, 2013). Not all repetitive movements result in MSD injuries, but depend on diverse contributors such as the rate of motion, the frequency of repetition, the number of muscles involved in the completion of the motion and the force that is required to perform it. Each of these contributors may be equal in significance. A CTD is an injury developed by repetitive stress and varies in its effects according to the specific movements involved in performing the task and the degree of intensity with which it is being performed (Caventa, 2007 Maintenance of static posture requires constant muscle contractions, thus causing the muscle tension to increase. This pressure compresses the blood vessels within the muscle, and during contraction, it may restrict the flow of blood through the muscles, which may cause lactic acid to accumulate within the muscles and therefore effect in pain and exhaustion. Prolonged muscle contraction without any significant movement also generates pressure on synovial joints (e.g., the wrist joint, knee joint). This pressure then causes the bones to press the synovial fluid that forces the lubricant to the sides, unlike in the case of dynamic pressure, which allows fluid to circulate (Geffen, 2009).

Generally employees are exposed to various ergonomic risk factors that lead to MSDs, these risk factors result from stresses being applied to specific parts of the body during the execution of task. Ergonomic risk factors that may be identified as the cause of musculoskeletal injury or illness within a work environment include repetition, forceful exertion, awkward posture, contact stress, vibration, and temperature extremes.

2.4. Ergonomic assessment method

To evaluate the physical risks involved, which may lead to MSDs, there are numerous posture-based ergonomics methods, which are currently available. The use of established ergonomic evaluation methods that are designed for specific body parts include the rapid upper limb assessment (RULA) . These evaluation methods are used to let the risk factors of the process to be quantified and finally prioritize the need for improvements (ergo plus.com).

2.4.1. Rapid upper limb assessment (RULA)

According to Atamney & Corlett, 1993 RULA was developed to evaluate the exposure of each worker to ergonomic risk factors associated with upper extremity MSD. The RULA ergonomic assessment tool considers biomechanical and postural load requirements of job tasks/demands on the neck, trunk and upper extremities. A single worksheet is used to assess required body posture, force, and repetition. Based on the evaluations, scores are entered for each body area in section A for the arm and wrist, and section B for the neck and trunk. After the data for each area is collected and scored, tables on the form are then used to compile the risk factor variables, generating a single score that represents the level of MSD risk The RULA was designed for easy use without need for an higher degree in ergonomics or expensive equipment. Using the RULA worksheet, the evaluator will assign a score for each of the following body regions: upper arm, lower arm, wrist, neck, trunk, and legs. After the data for each region is collected and scored, tables on the form are then used to compile the risk factor variables, generating a single score that represents the level of MSD risk as outlined below:

Table 2. 1 Level of MSD Risk (Atamney & Corlett, 1993)

Score	Level Of MSD Risk
1-2	Negligible risk, no action required
3-4	Low risk, change may be needed
5-6	Medium risk, further investigation, change soon
6+	Very high risk, implement change now.

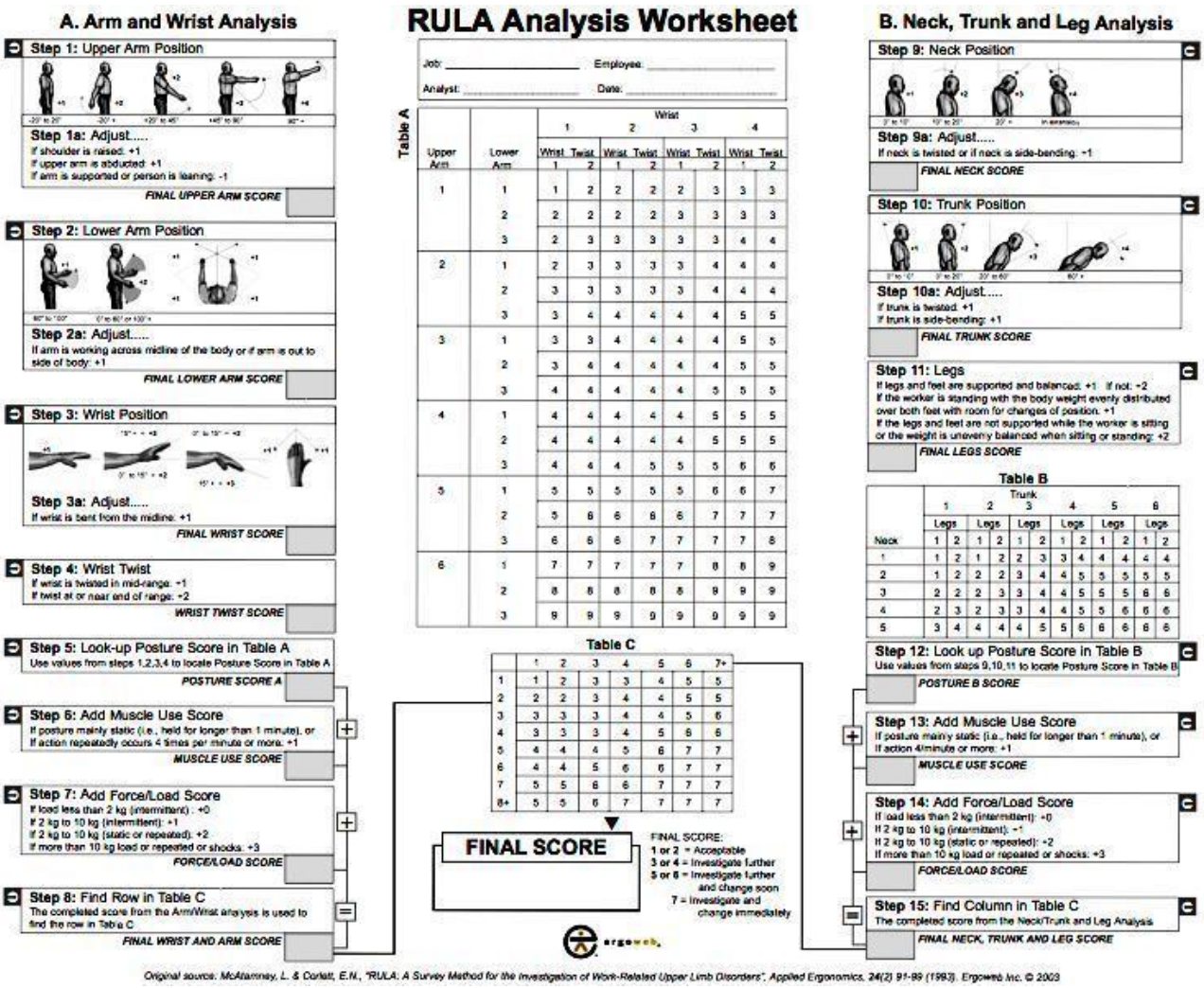


Figure 2. 1 RULA Employee Assessment Worksheet (Atamney & Corlett, 1993)

The evaluator should prepare for the evaluation by interviewing the worker being evaluated to gain an understanding of the job tasks and demands, and observing the worker's movements and postures during several work cycles. assortment of the postures to be evaluated should be based on: 1) the most difficult postures and work tasks (based on worker interview and initial observation), 2) the posture continued for the longest period of time, or 3) the posture where the maximum force loads occur. The RULA can apply quickly, so numerous positions and tasks within the work cycle can usually be evaluated without a significant time and effort. When using RULA, only the right or left side is evaluated at a time. After interviewing and observing the worker, the evaluator can determine if only one arm should be evaluated or if an assessment is needed for both sides (ergo plus).

2.5. Loss analysis

A company may suffer economic consequences due to injuries and/or illnesses. These losses may be a direct result of not dealing with the five risk factors in the workplace. Losses from injury and/or illness playa vital role in the economic structure, reputation and growth of the company. Losses drain and hinder a company's ability to generate profit (Tayler ,2008).

Loss analysis is the process of examining records of past losses and missed opportunities that the company has sustained (Wiening, 2002).

This analysis contributes to management information by revealing trends. A loss analysis will categorize the reported injuries into trends indicating the more frequent or severe injuries that have been occurring. If conditions continue to stay the same within work processes, then it is fair to say that there is a high probability of the identified injuries occurring again in the future. The analysis provides an evaluation of problems and procedures as a guide for risk management. The problems and procedures will help risk managers make decisions that relate to the organization's future operations(tayler ,2008)

Analyzing the organization’s past ergonomic- based injuries enables the researcher to identify any trends and major areas that require immediate attention. An analysis demonstrates the present value of losses because of injury and subsequent losses to earning capacity (Molak, 1997).

The Occupational Safety and Health Administration (OSHA) require employers to maintain records of their work-related injuries and illnesses (OSHA, 2004). The OSHA 300 Log of Work-Related Injuries and Illnesses is the document that employers will maintain for their work-related injuries and illness.

The log is used to classify work-related injuries and illnesses and the severity of each. If an injury or illness occurs, the company will record the specifics of what happened and how it happened. The log consists of records of work-related injuries and illnesses that result in death, loss of consciousness, days away from work, restricted work activity, job transfer or medical treatment beyond first aid. The log also records work-related injuries and illnesses. An incident rate can be calculated to determine the number of recordable injuries and illnesses a company is sustaining among a given number of employees over a period of time ((OSHA, 2004) cited in

Tyler k,2008). In general Looking at a company's past injury losses enables the researcher to identify the major areas that need attention and evaluation. An analysis demonstrates the present value of losses due to injury and subsequent losses to earning capacity.

2.6. Global and local condition of ergonomics and musculoskeletal disorder

Globally, the traditional way of producing goods and commodities has been revolutionized since the advent of the industrial revolution. This has made the workplace a concern of the public health sector. This concern seems to have emerged from the duty to protect workers from adverse health effects of workplace hazards (Tadesse, Kiros et.al,2016).

According to International Ergonomics Association (IEA),ergonomic is the scientific discipline concerned with the understanding of the interactions among humans and other elements of a system, and the profession that applies theoretical principles, data and methods to design in order to optimize human wellbeing and overall system (Pandve, 2012).

Practitioners of ergonomics, ergonomists, contribute to the planning, design and evaluation of tasks, jobs, products, organizations, environments and systems in order to make them compatible with the needs, abilities and limitations of people (Harshal ,2012)

Most ergonomics principles are originally formulated in Industrially Advanced Countries (IACs). Ergonomics has made great progress over the period of time especially in these countries. This progress in ergonomics application as well as research is pertaining to the needs of the IACs. The nature and principles of ergonomics are often not directly addressing the needs of the Industrially Developing Countries (IDCs) (Pandve, 2012).

With approximately 40% of the world’s occupational and work-related health costs attributed to musculoskeletal diseases, a reduction in the occurrence of musculoskeletal disorders (MSDs) is essential to the improvement of occupational health in both industrialized (developed) countries (DCs) and industrially developing countries (IDCs) (IOHAC,2005).

There are many factors that have a detrimental effect on the safety, comfort and performance of workers. The underlying causes are usually economic, socio cultural or climatic in their origins, often combined with inappropriate technology transfer (Mcneillk, 2002).

In Ethiopia, there is scarcity of comprehensive data and nationwide researches on rate of occupational injuries and its factors in industries. The recent studies in small and medium scale

industries showed that the occupational injury rate was 335/1000 workers exposed per year. Of these, the 17.1% of them being hospitalized with 40% of them for greater than 24 hours, 53.9% absent from work, 191 days were lost due to injuries. Another study in Afar showed that the overall prevalence rate was 783 per 1000 workers with the severity 11% is hospitalized and 6153 days lost due to injuries (yitagesu ,abera et.al,2012).

In another findings of a study conducted in 2007 among textile factory workers in Addis Ababa show that the most frequent causes of occupational injury were machinery 42 (29.4%), and being hit against objects 29 (20.3%)((Abera *et al.*,2007), cited in Tadesse ,2018)

Department of Environmental Health in Ministry of Health in Ethiopia reported that strike (25.5%), falling (12.8%), and flying objects from machines (8.5%) were the major causes of occupational injury. The Report shows abrasions, cuts, burns, puncture, and fracture were the common injury types among manufacturing industrial workers. The common affected body parts among eleven industrial workers in Addis Ababa were fingers (37.3%) and hands (11.6%) ((MOH,2007) cited in Tadesse T,2018).

In general occupational injury in Ethiopia is becoming a public health problem and a burden which needs a special attention and urgent solution.

2.7. Policy of Ethiopia

Legislation provides the basis for extending fundamental labor rights and giving workers actionable rights at the workplace in a given Member State. International Labor Standards (ILSs) are international legal instruments that set out basic principles and rights at work. These were adopted by the ILO's constituents, composed of Member States as well as representatives of workers and employers, at the International Labor Conference (ILC).

They represent the international consensus on how to tackle given labor issues based on knowledge and experience from countries around the world. ILSs are composed of Conventions and Recommendations that provide Member States with obligations and guiding principles for rights at work. Conventions are legally binding treaties that lay down principles to be applied by ratifying Member States, while Recommendations are subject to ratification, and serve as non-binding guidelines for all Member States on specific labor issues. They either supplement Conventions or are autonomous.

Ethiopia has had a regulation on Occupational Safety and Health (OSH) since the 1940's. The Ministry of Labor and Social Affairs (MOLSA) is the state organ that regulates workers' safety and health in work places, both private and state owned. MOLSA and its regional networks have an organizational structure lined to the periphery. Ethiopia is one among the many countries from around the world that have adopted ILO Convention No 155 of 1981 in 1991 which resulted in two major regulations: Labor Proclamation No. 377/ 2003(4) and Labor Proclamation No. 515/2007 on public civil servants (5). The national level policy on Occupational Safety and Health (OSH) has recently been developed and approved (July 2014) by the Central government (Tadesse, kiros et.al, 2016)

The International Labor Organization (ILO) is devoted to promoting social justice and internationally recognized human and labor rights. It has a tripartite structure and is the United Nations (UN) agency responsible for setting international labour standards that regulate conditions for work-related issues. The ILO has espoused the right to protection from employment injury since its early days. Standards on employment injury insurance are embodied in the Social Security (Minimum Standards) Convention, 1952 (No. 102) (Part VI), and the Employment Injury Benefits Convention, 1964 (No. 121), as well as its accompanying Employment Injury Benefits Recommendation, 1964 (No. 121).

Chapter Three

Research Methodology

3.1. Research design

A research design is the overall plan for obtaining answers to the questions being studied and for handling some of the difficulties encountered during the research process its developed to meet the unique requirement of the study (Polit & Beck, 2004).

This study engaged following methods, the first one is surveying the past injury data of the company the second one is observation of the subjects while performing the task, and the third one is questioner survey.

Descriptive type of research is used because the aim of this research is to identify what the ergonomic risk factors are which possess the potential lead to musculoskeletal disorders on the packaging line of the case company Birhan and Selam printing.

As polit and beck study descriptive research is a research method that describes the characteristics of the population or phenomenon that is being studied, this methodology focuses more on the what of the research subject rather than the why of the research subject.

3.2. Data collection and source

To perform the task, a list of the practices is involved through primary and secondary data collection methods using companies past injury data, interviews with the subjects, through questioner survey and with systematic observation of all the body movements, postures, joint angles, and the work environment of subjects during each task.

3.2.1. Data source

Primary and secondary data are the main data sources for this study, and its discussed as follows:

- The employees working at the industry.
- The industry's management.
- The employees working in the industry's clinic.
- Studies and literatures on musculoskeletal disorders both in international and national level.

3.2.2. Data collection methods

The following are basic data collection methods**;**

Secondary Data

Secondary data gives frame for the research that in which direction to go and are used in combination to give proper coverage to the topic. Secondary data has been collected from various secondary sources. It has been gathered from literatures regarding ergonomic injuries and MSD and also from the company's reports, journals, books, different articles, websites and other source were considered.

Primary Data

Primary data is a source of information which is original in nature and directly related to the issue or problem. The primary data sources are working surrounding of the industry (through field observation and measurement) and industry employees (interview and questionnaires).

3.3. Population and Sampling Technique

3.3.1. Population

The study population consisted of Birhan and Selam printing enterprise employees. To select representative area in the company, first it was considered the departments expected more potential to accidents based on the company's past injury data.

The sampling technique used in this study is purposive sampling. The purposive sampling technique, also called judgment sampling. It is non-probability sampling and it is the deliberate choice of an informant due to the qualities the informant possesses. It is a nonrandom technique that does not need underlying theories or a set number of informants (Dolores, 2007).

To determine the sample size, the case company's past injury data were collected from the safety office and the clinic. Table 3.1 shows the past two years injury data which is collected from the company's clinic. The table shows respiratory organ injury is the largest type of problem that the employees are facing but as justified in section 1.2 our target group is packaging line workers. Therefore, assessing the past injury data (Table 3.2) of the department work related musculoskeletal problem is the biggest problem. Hence in this study MSD is the area of concern and factors which expose workers to MSD is assessed.

Figure 3. 1 Injury data of a year 2017-2019

No	Types of injury	No of patients Year of 2018/2019	No of patients Year of 2017/2018
1	Respiratory organ injury	1064	1066
2	Musculoskeletal disorder	1029	945
3	Fever	159	171
4	Eye problem	258	174
5	Different Skin problems	230	161

Figure 3. 2 Packaging (finishing) line injury data of the year 2018-2019

No	Types of injury	No of patients Year of 2018/2019	No of patients Year of 2017/2018
1	Musculoskeletal injury	752	628
2	Respiratory organ injury	395	401
3	Eye problem	59	45
4	Different Skin problems	47	49
5	Fever	27	25

3.3.2. Questionnaires Sample Size Determination

Past injury data were assed to select the area of focus in the company and to select respondents for the study. The determination of the sample size was adopted from Yamane (1967) and Cochran (1997).

$$n = \frac{N}{1 + N(e2)}$$

Where n is the sample size, N is the total population and (e) is margin of error and it was Considered 0.1 (10%). This margin of error was considered 0.1.

$$n = \frac{N}{1 + N(e2)}$$

$$n = \frac{330}{1+330(0.1)(0.1)}$$

$$n = 76.755$$

The calculated total sample size is n=77 at the marginal error of 10%. During data collection 77 questioners were dispatched but only 69 of them are taken the rest are rejected because of missed data in the response. Hence, only 69 of them are taken which is 90% of the calculated sample size n=77.

The primary data collection tools were covered socio-demographic background variables such as age, sex, employment status, experience, educational level. The survey has used a structured questionnaire to produce the required data in the study. The data from workers was collected using structured pre tested questionnaire through interview of the safety manger of the company and some respondents. The draft questionnaire was pre-tested and finally the questionnaire was adjusted the feedback from pre-test.

The questionnaire used to collect data from injured workers was translated in to Amharic Language. The data collection begins with by explaining the purpose of the study and by obtaining their permission.

3.4. Ethical Consideration

To start the study, approval was obtained from Addis Ababa University, institute of technology, school of mechanical and industrial engineering. The data was collected after getting consent from company's representative. Each participant and the company were notified about the purpose of the study and Participant was informed that information obtained was used only for a research purpose. Necessary precaution was used to protect the confidentiality of the company's data.

3.5. Dissemination of Research Finding

The result of this study will be submitted and presented for Addis Ababa University School of graduate mechanical and industrial engineering. An attempt will made to present the result of this study to be published on international journal for research contribution. It can be provided to Birhan and Selam printing enterprise.

3.6. Data Analysis

The study assess the impact of work related musculoskeletal disorder and identify ergonomic risk factors which possess the potential which leads to musculoskeletal disorders on the packaging line workers by investigating specific flow cell and to control and reduce musculoskeletal disorders in the packaging line of the case company birhan and selam printing. The data analysis was carried out in three different steps, it starts by analyzing the past injury

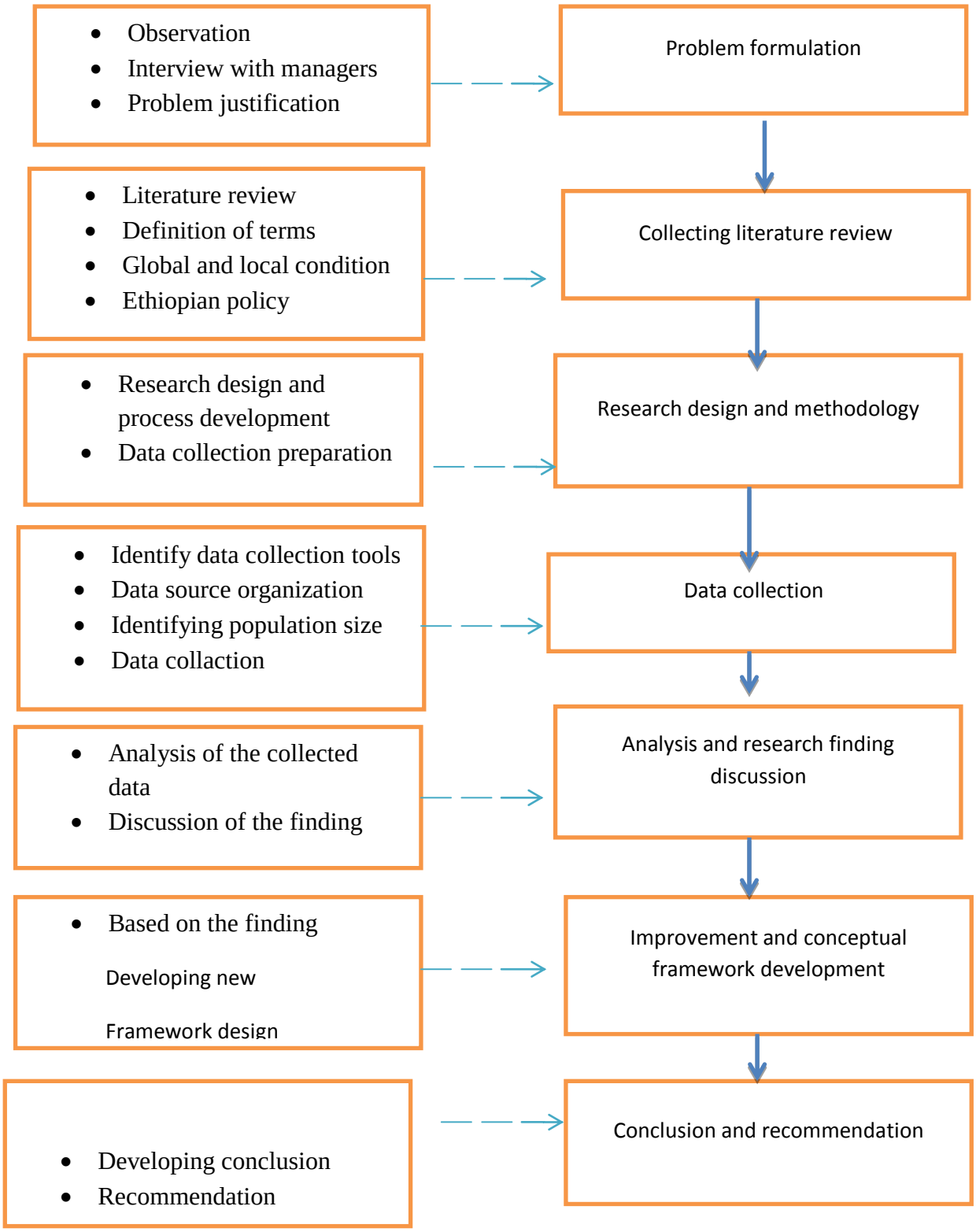
data, its collected from the companies clinic and safety office, by this it was able to recognize which department has the highest hazard and which body parts were exposed for injury .

The second step is to collect information from volunteers using ergonomics symptom survey.
The third stage is evaluating potential risk factors which were identified through observation and ergonomic assessment tools.
By combining the above three and the literature review its identified which task involves major potential risk factors.

3.7. Data Analysis Tools

Descriptive type of research was used to evaluate and its employed qualitative based tools which are found in the primary and secondary data and also qualitative data which are obtained from observation, interview and the past injury data of the company. Base on the data type, the data were analyzed. The RULA assessment method is used to analyze the data for the tasks involved in addition to that MS Word, Excel, AutoCAD, Catia**.**

Figure 3. 3 Research Flow Diagram



Chapter Four

Presentation, result analysis and Data Interpretation

4.1. Introduction

This chapter presents the existing work practice of the packaging line of the company and the data obtained from observation, past injury report, questioner and work place measurement are analyzed and identified. by using the data collected, the factor which exposes workers to major health problems are identified. The target of this section is to assess the method, actions, and tasks that employees perform within the packaging line of Brihan and Selam printing enterprise and analyze the types of ergonomic-based injuries that workers reported to their supervisors and after this to determine the types of pain and discomfort that workers are currently experiencing during their work activities and to identify ergonomic risk factors which exposes works to ergonomic injury.

4.2. Data analysis

4.2.1. Data Analysis Based on the Industry Records

BSPE has four main departments which have many sub departments, which are CEO, printing department, support and corporate business development, which has a total number of 857 employees. Printing department is higher in employees number they are 593 and 330 of them are packaging line workers.

In this study task demands and workstation characteristics that may contribute to MSDs is evaluated by using the data gathered from the companies past injury, observation result, interview with the employees and the questioners survey. The packaging line was under examination and involved task examining, process assessment, and evaluation of ergonomic risk levels with selected subjects. As discussed in the previous sections packaging line is a department which has higher number in work related musculoskeletal injury and because of this it has a higher record in absent work days. The data collected from the enterprises safety office shows this in the following Table 4.1.

Table 4. 1 injury records in different department

Job	**Injury Frequency**	**Percentage**
Laborer	13	10%
Messenger	9	7%
Printing workers	20	15.7%
Finishing workers(packaging line)	69	54%
Electrician	8	6.3%
Maintenance, civil work and human recourse	8	6.3%

A total of 127 injury data was collected from companies safety office employee injury record of the past twelve months of the last year /2018/, among them 54% out of the total or 69 of them out of 127 injured workers were packaging line workers, this data indicate that the highest injuries occurred in packaging line workers. Another data also shows the severity of the problem in the department by showing the absent days of the workers; this data is also collected from the company's safety office rescored of 2018 employees absent work days.

Table 4. 2 absent work day record

DEPARTMENTS	**INJURY**	**TOTAL ABSENT DAYS**
Customer service	14	14
printing	14	100
General service	16	36
Packaging line	36	224
Logistics	14	2
Human recourse	11	1
Printing technology	11	4
Record office	11	4

As Table 4.2 shows the highest absent work days is recorded in packaging line department its 224 absent work days 36 workers were injured this data is also another indication that the workers in the department are highly exposed to work place ergonomic injury hazards. In addition to this during interview with the company's management and the safety officer it was able to understand packaging line is a place in the company the employees reported their

discomfort frequently also complain repeatedly about the workplace design specially the chair. By taking those facts in to account packaging line is the area of focus in this study.

4.2.2. Questionnaires Data Analysis

4.2.2.1 The socio-demographic characteristics of respondents

The packaging line workers are the respondents of the questioner. all of them are female and their age group vary in between 21-29 is 17% and 29-40 years is only 42% in addition 9% of them are below 21years and 32% are above 40 years.

The study showed that the occurrence of MSD depending on the number of years they work in the company. It's indicated in the response that workers with higher work experience encounter more work related musculoskeletal disorder than workers with lower work experience.

Table 4. 3 Socio-demographic characteristics of respondents

Characteristics (demography)	Category	Frequency	Percent
Age	Less than 21	6	9%
	21-29	12	17%
	29-40	29	42%
	Greater than 40	22	32%
Educational level	Primary education	35	51%
	Secondary education	30	43%
	Tvte diploma	4	6%
sex	Female	69	100%
	Male		
Employment status	Temporary	20	13%
	Permanent	49	71%
Work experience	Less than five years	9	25%
	5-10 years	16	23%
	10-20 years.	24	35%
	More than 20 years.	20	29%
Job title	Packaging line workers	69	100%

23% of the respondents has 0-5years job experience, 35% of them have 10-20 years work experience, the rest have more than 20 years of work experience and 30% of them have educational level of secondary school, 35% of them have primary educational level, the rest 4% Tvte diploma.

Table 4. 4 frequency of MSD

Work experience	Frequency of musculoskeletal disorder	Percentage of the total.
0-5 years	2	22%
5-10 years	12	75%
10-20year	24	100%
Above 20	20	100%

The frequency of developing MSD increases with the job experience increases, for 0-5 work experience out of nine workers only two of them are experiencing MSD which is only 22% out of the total, and work experience from 5-10, 75% out of the total are experiencing the pain but the rest of the workers who has a work experience of more than 10 years has 100% percentage of feeling the pain. It indicates that the longer they work the job the more they are exposed to work related musculoskeletal disorder.

Table 4. 5 pain in different body parts

	Frequency of pain on different body parts								
Job experience	Neck	Shoulder	Elbow/ Forearm	Hand/ wrist	Upper back	Lower back	Thigh/ knee	Low leg	Ankle/ Foot
0-5		2		1		1			
5-10	2	3	5	5	10	8	3		1
10-20	10	10	6	8	13	15	5	2	3
Above 20	8	13	6	10	15	17	8	4	6

The higher frequency of MSD appear in work experience above 20 years, One respondent may feel more than one part of the body which mean, they might experience pain for example in

neck, lower back and shoulder. Workers who has 10-20 years of experience has also higher frequency of developing MSD and moderately injured workers experience fall in between in a range 5-10 years.

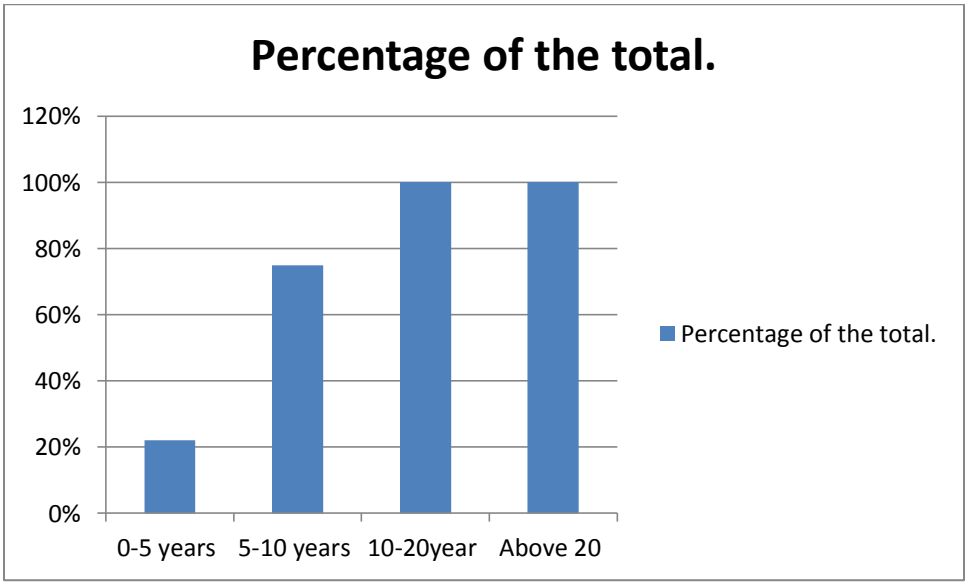


Figure 4. 1 occurrence of MSD according to work experience

4.2.2.2. Reasons for developing musculoskeletal disorder

The overall reason that causes discomfort on workers while performing the task is discussed from the response of a yes or no question that asks what the causes are that exposes workers to the occurrence of discomfort while working.

The basics of this questions on factors that causes discomfort on workers was to rate which factor contribute much in exposing workers to develop musculoskeletal disorder.

Table 4. 6 reasons for MSD

reason for MSD	Yes	No
inadequate work station design	66(96)	3(4)
repetitive motion	60(87)	9(13)
awkward posture	55(80)	14(20)

As it can be seen from Table 4.6 inadequate workstation design takes the highest rate 96% of the workers agree, the workstation design is the cause for their pain and 60% of the workers also

points that repetitive motion is the cause of their discomfort and 55% of them believe their own working poster exposes them to feel the pain.

4.2.2.3. Knowledge and training on MSD

This part of the questioner is to assess the knowledge level and awareness of the workers about protecting themselves from ergonomic injury and keeping their posture in neutral position. They have been asked to respond whether or not they have given training about work environment safety and protecting themselves from MSD.

The response rate of only 10% knows about neutral position and 90% of them don't know about neutral position. This indicate that the majority of the workers doesn't know about to keep their posture in neutral position.

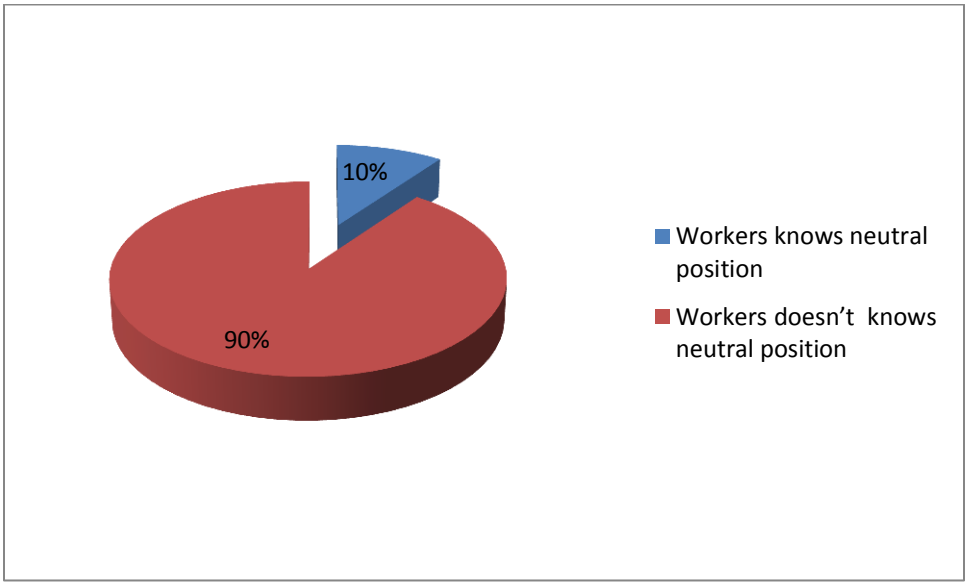


Figure 4. 2 Knowledge and Awareness Status of Respondents

The workers were also requested to give their answer on whether or not they have been trained on workplace safety. And they have responded 95% of them have not been trained and only 5% of them respond they take training. These 5% respondents who says they get training were also requested to give their answer on what kind of training they get weather they get formal training by professionals or in formal on job training given by their supervisors, and all of them respond that its informal training given by their supervisors.

4.2.2.4.Respiratory organ injury

The questioner on respiratory organ injury is to rate how many workers are suffering from it. Workers have been asked to respond whether or not they feel pain regarding to respiratory organ 78% of them respond yes, and 23% of the response is no and the remaining considered missing. This indicates majority of the workers are suffering by this reparatory organ injury.

Table 4. 7 respiratory organ injury

Questions	**Yes**	**No**
Do u have any problem regarding respiratory system	54(78%)	15(22%)
Is your work expose you to respiratory system injury	65(94%)	4(8%)
Is dust the cause of the respiratory system injury	69(100%)	-

The workers were also requested to give their answer on what kind of respiratory system diseases symptom they are facing. All of the respondents are facing more than one type of symptom, 70% of the workers say they have cough and sneezing, 40% of them respond they have breathing problems, 20% respond they have itchy through, 10% of them has chest pain and 8% says they have berating problems. All of them agree dust is the main cause of the problem.

4.2.2.5 Light and temperature

There is a high effect of light and temperature in the work place regarding to the workers safety and comfort. The existence of adequate light and temperature promotes the safety of the worker and increases productivity, by eliminating injury, discomfort and fatigue.

In this part of the questioner the workers were asked to respond if there is sufficient light and suitable room temperature in their work place in all types of weather condition.50 (79%) of the workers respond there is enough light in the room the rest 19(28%) of them responds there is no enough light and none of them says there exists too much light in the room.

Table 4. 8 light and temperature

Question	Frequency		Percentile
	Yes	No	
Is there enough light in the room?	50		79%
Is there enough light in the room?		19	28%
Is there too much light in the room?	-	-	-
Is the temperature varies with the weather?	60		87%
Is temperature always suitable?	7		10%
Is the temperature always hot?	2		3%
Is the temperature always cold?	-	-	-

And for the temperature 60(87%) of the workers responds the temperature varies with the weather, 7(10%) of the workers says the room temperature is always suitable, and the rest 2(3%) says the room temperature is always hot.

4.3.Interview data analysis

In this section management commitment and involvement to workplace safety is investigated through interview. The concept of management involvement in safety refers to the extent to which top- and middle-level managers become personally involved in critical safety activities within the organization. Work-related accidents and incidents are symptoms of low management involvement in safety issues because most accidents could be prevented.

Ensuring health and safety is usually done through complying with legal arrangements, developing a management system and establishing a healthy and safe working environment (vandyck,2015). However, the improvement of safety culture in an organization is not only achieved through a strong institutional pressure but also through a change of mind-set and a real commitment of all employees to the issues of OHS. Such commitment should begin from the top management to all members of the organization (Metin, 2018).

Data collected from interview questions for the purpose of data analysis. The interview was conducted on ten employees in management position. The interview questions response have given the highlight to safety practice in the industry.

Table 4. 9 response of interview

	Interview question	Yes	No
1	Do you involve in safety issue?	30%	70%
2	Is yes to question no 1, do you give high priority for safety issue?	10%	20%
3	Do you investigate the cause on minor and major safety problems?	20%	80%
4	Do you know the risk associated with work operation in the industry?	60%	40%
5	Do you stop unsafe operation or activity?	20%	80%
6	Do you think there is a good communication about safety in the company?	50%	50%
7	Do you think top management improves safety in the workplace?	90%	10%

4.4. Field Observation Data Analysis

Observations in the industry were made. The observation was mainly to observe the body movement while the workers performing the task. Direct observation was done on the workers upper limb angle of movement and it was recorded on the RULA worksheet (appendix 2) and as discussed in section two, the angle of movement of their upper limb were carefully recorded. To perform these task ten workers was under observation, the movement of their upper arm position, lower arm position, wrist position wrist twist, neck and trunk position was under observation. The result of this section is useful to determine whether the workers are at risk or not.

4.4.1. Rula analysis

RULA was developed to evaluate the exposure of individual workers to ergonomic risk factors associated with upper extremity MSD. The RULA ergonomic assessment tool considers biomechanical and postural load requirements of job tasks/demands on the neck, trunk and upper extremities. A single page worksheet is used to evaluate required body posture, force, and repetition. Based on the evaluations, scores are entered for each body region in section A for the arm and wrist, and section B for the neck and trunk. After the data for each region is collected and scored, tables on the form are then used to compile the risk factor variables, generating a single score that represents the level of MSD risk (ergo plus.com).

To make the Rula assessment on our case company the first step was to observe the activities done on the packaging line, during the activity it was observed the angle movement of the upper limb and the movement of the joints and the upper body parts were recorded.

4.4.2.work break down

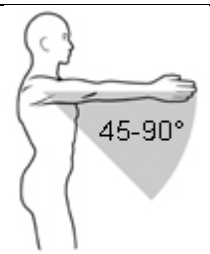
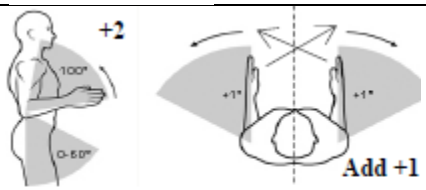
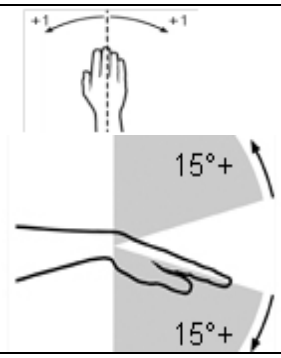
The activity breaks down for packaging line workers

The tasks done on this line is to organize the papers in sequence, to sew small page books, to cover the stapled edge with paper and to pack the finished ones.

To organize papers in sequence first they pick the first page, continue picking the second and so on until the end of the page then put it at the edge of the table.

To cover the stapled edge, they first grab the brush then put it in a glue then by taking the glue with the brush they put it on a piece of paper, after this they stick the glued paper on the edge of the work piece.

Table 4. 10 RULA analysis scoring method

		Activity(locate the position)	angle	Scores /according to RULA work sheet/
		Arm position		
Step 1	Upper hand	While performing the task they put their hand on the table, the upper hand movement will be from 45-90 degree.		+3 score is used for upper arm position (45+ degrees)
Step 2	Lower hand	The movement of lower arm is also limited by the table and also moves on the surface of the table from left to right freely therefore it is within the 100 degree.		+2 score is given for the lower arm position (<60 degrees)
		Wrist position		
Step 3	Wrist position			wrist score was +3 for wrist flexion (>15 degrees), and +1 was added for lunar deviation which +4.
Step 4		The task needs handling materials so the workers wrist moves up and down , it moves out of the mid line.		wrist score is +2 because the wrist is twisted near the end range
Step 5	Posture score	The posture score is using the values from step 1-4 and located in Rula worksheet.	Using the values step one to four locate in the score table A(appendix2)	5
Step 6	muscle use score	Add muscle use score	The posture is static	0

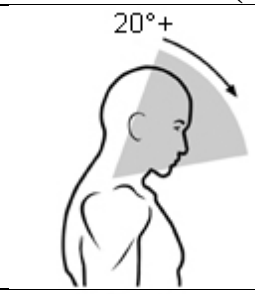
Step 7	Force	Add force load score	If load between 4.4 to 22Ibs(intermittent)	1
Step 8			Find row in table C(appendix2)	6
Step 9	Neck position	The neck position is between 20 degree.		+3
Step 10	Trunk position	The trunk position is between 0 and 20 degree.		+2
Step 11	Legs	If legs and feet supported		+1
Step 12			Place posture of neck, leg and trunk score in table B(appendix 2)	3
Step 13	Add muscle score		If muscle mainly static 0	0+3=3
Step 14		Add force/ load score	If load between 4.4 to 22Ibs(intermittent)	1
Step 15			Add values from step 12-14	7
			Find row in table c by taking step 14	7

Table 4. 11 RULA analysis

Analysis	**Scoring**
Arm position	
Upper arm	2
Lower arm	2
Wrist position	
Wrist twist	2
Wrist twist	4
Posture score	
Muscle use	0
Force load	1
Arm and wrist score	**7**

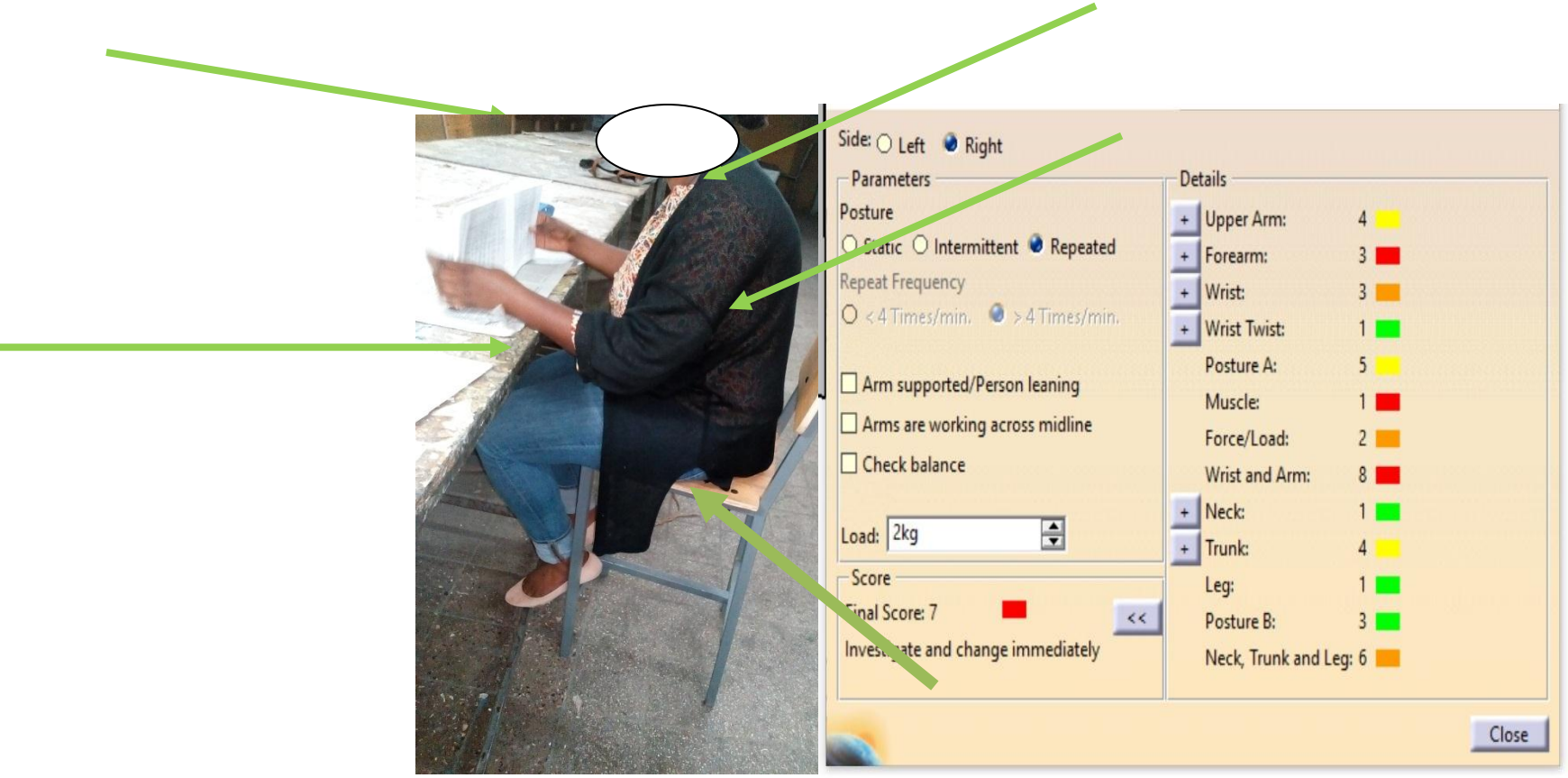
Neck and truck position	
Neck position	3
Trunk position	2
legs	1
Posture score	3
Muscle use score	3
Force load score	1
Neck, trunk, leg score	7
Final RULA result	7

By filling the RULA employee assessment work sheet on appendix 2, the result in table 4.5 determined, the final RULA score is 7, according to the risk scoring table 4.4, it indicates high risk and calls for engineering and/or work method changes to reduce or eliminate MSD risk. The upper limbs, arms and wrist of posture assessed using RULA score sheet; the range of movement for each body site is divided into sections. These sections are scored so that the score 1 is given to the range of movement or working posture where the risk factors present are minimum. Higher scores are allocated to sites of the movement range with more extreme postures indicating an increasing presence of risk factors causing load on the structures of the body segment. The exposure scores according to RULA were divided into four 0, 1, 2, and 3 exposure categories: negligible, low, medium and high respectively. Medium and high risk actions should be urgently addressed to reduce the level of exposure of risk factors.

The above result showed the RULA analysis which was done manually by filling RULA employee assessment work sheet on appendix 2, but in the following section the rula analysis is done with a computerized way by using CATIA software, to do the analysis in such a way the first step is the measurement of the existing work station and determining each dimension. by doing so the existing work station is evaluated according to the posture it gives for the user, the combination of the sit and the work surface dimension plays a great role in the workers posture, therefore the soft ware analyzes upper limbs, arms and wrist like its done manually.

Figure 4. 3 existing work station

Figure 4. 4 RULA analysis for existing work station



The outcome of the posture investigation using RULA analysis of CATIA software gives the same result with the one which is done manually both have the final score 7 and the results reveal that all categories of the risk levels exist in jobs postures. Figure 4.2 showed that the workers are at high risk level and needs investigation and change immediately it also showed that posture of the workers who performing the activities is at high risk levels. A further investigation with an immediate change was recommended to these workers, it also shows that none of the worker is at negligible risk level. The study was done on workers working in the packaging line and their activities were divided in different categories , the result showed that, if the workers continued to work in the same posture they suffer from the MSDs related to neck, trunk and wrist in the near future., the workers were working at high risk levels and their neck, trunk and wrist were under high physical strain and needed a necessary action soon. They were bending their trunk to unacceptable limit and most of them had upper arm under high strain.

4.5. Workplace Site Measurement

In this section site measurement results are presented and discussed with international recognizes standards. The site measurement is focused on heat stress, light and workstation of the work places.

4.5.1. Workplace heat stress measurement

The measurement is carried on for three days two times a day, morning and afternoon in our case company Birhan and Selam printing enterprise.

Table 4.12 temperature measurement

	Morning	Afternoon
Day 1	18^0C	26^0C
Day2	21^0C	27^0C
Day3	19^0C	27^0C

The occupational health and safety administration (OSHA) recommends maintaining workplace temperature in the range of 20degreecentigrade to 24 degree centigrade. But as it's seen on table 4.12 the temperature is cold at the morning and hotter in the afternoon.

4.5.2. Lighting measurement

Research has shown that in many workplaces productivity can raise, and the error rate fall, by improving the quality of lighting. Poor lighting can increase the rate of visual fatigue, general tension and can create poor posture in a bending to improve vision. To measure the illumination in the room, it's required to determine the total area of the room and the light imitation flow of the bulb.

The total area of the room (wall, ceiling, and floor) is:

Length=15 meter

Width = 5 meter

Height= 5 meter

There are 20 classic florescent tubes which are 32watt, each one emits 70 lumens per watt in average. Therefore each florescent emits 2240 lumens.

1 lux=lumens/m2

=119.5 lux

Packing is moderately precise work , 200–300 lux is recommended for the work (Hussein, 2019) this shows there is insufficient light in the room, which makes the workers bend to perform the task and this leads to musculoskeletal disorder.

4.5.3. Workstation measurement

In the existing work station, as its shown in figure 4.2 the table and the chair are made of plywood, the chair has no arm rest on it and has no comfort, there is no separate foot rest, the chair is also a high sit chair which is not adjustable, the following table 4.6 shows the dimension of the existing workstation.

Table 4. 13 Existing work station measurement

Table	In centimeter
Table height	100cm
Table width	122cm
Table length	245cm
Foot rest	25cm
Chair	
Seating height	73cm

Back rest height	80cm
Seat length	50cm
Seat width	40cm
Foot rest	30cm
Arm rest	-

4.5.3.1. Anthropometry measurement

Anthropometry measurement is important for the design of the work station, the following Table 4.12 Shows Anthropometry Measure of different Body parts Which essential for the design of table and Chair

Description of Measurements

The description of measurement is based on a study by (Parcells C and Hubbard R. P, 1999).

Sitting Height

The workers sit erect with the head in the up-front with arms hanging at the sides and hands resting on the thighs. Vertical distance from the seat surface to vertex of the head.

Sitting Elbow height

The vertical distance from the bottom of the tip of elbow to the sitting surface, measured with the elbow in 900 of flexion. The subject fully erect with thighs fully supported and the lower legs hanging freely. The upper arms hang freely downwards and forearms are horizontal. The Sitting Elbow height is required to determine the arm rest height.

Sitting Shoulder height

The subject sits erect with her upper arms at the sides and hands on the thighs. The vertical distance from the top of the shoulder to the sitting surface measured. This dimension is essential in the determination of Back rest Height (Upper).

Thigh Clearance

The subject sits erect with the legs extended and relaxed. The vertical distance from the sitting surface to the top of the thigh at its intersection. The thigh clearance, popliteal height and shoe clearance are necessary for the determination of the table height.

Sitting Knee Height

This is the vertical distance from the floor to the uppermost point on the knee. The subject sits erect on a chair and the knee was at the right angle.

Popliteal height

The vertical distance measured with 900 knee flexion from the foot resting surface to the posterior surface of the knee (popliteal space). The subject sits fully erect with thighs fully supported and sitting surface extending as far as possible into the hollow of the knee, the lower legs hanging freely. The distance is measured from the measuring block to the forward edge of the sitting surface. The measurement is necessary in the determination of seat height.

Buttock-Popliteal length

The horizontal distance is measured with 900 knee flexion from the posterior surface of the buttock to the posterior surface of the knee or popliteal space. The subject sits fully erect with thighs fully supported and sitting surface extending as far as possible into the hollow of the knee, the lower legs hanging freely. The distance is measured from the measuring block to the forward edge of the sitting surface. The buttock-popliteal length is needed to determine the seat depth.

Sitting Hip Breadth

This is the maximum horizontal distance across the hips in the sitting position. The sitting hip breadth is essential to specify the seat width.

Buttock-knee length

The subject sits erect with the feet on the floor at 900 knee flexion, arms at the sides and hands resting on thighs. The horizontal distance from the most posterior point on the buttocks to the most anterior point on the knee.

Forearm-Hand length

The subject sits erect with the upper and lower arms at right angles to one another and the hand stretched out. The distance from the posterior end of the elbow to the longest finger of the hand while the upper arm was at an angle of 900 with the lower arm. The forearm-hand length is the relevant measurement that is necessary to specify the table depth.

Seat depth

The chair seat depth is the horizontal distance of the sitting surface from the back of the seat, at a point where it is assumed that the buttock begins at the front of the seat. This should be deep enough to ensure that the region behind the knees (popliteal) would not hit the front of the seat.

Table height: - The table height is the vertical distance from the floor to the top of the front edge of the desk or table.

Table clearance: - The table clearance is the vertical distance from the floor to the bottom of the front edge of the desk or table.

Table 4. 14 Anthropometry measurement analysis

No	Anthropometry data	Average	Sd	5th Percentile	95th Percentile
1	Popliteal height	17.13	2.34	13.26	20.98
2	knee height	20.71	2.43	16.7	24.72
3	buttock knee length	21.85	2.61	17.54	26.16
4	buttock poplietal length	21.46	2.49	17.35	25.57
5	hip breadth	15.55	2.95	10.68	20.42
6	sitting elbow height	8.95	1.95	5.73	12.17
7	thigh clearance height	6.02	1	4.37	7.67
8	forearm length	16.57	2.79	11.97	21.18
9	sitting height	31.22	3.18	25.97	36.47
10	sitting height shoulder	20.3	2.72	15.81	24.79

Anthropometric Dimension

The anthropometric data of the workers are presented in Table4.1 2 as means, standard deviations (SD), and 5^{th} and 95^{th} percentiles. In anthropometry, percentiles of various body dimensions are used to determine design values for an application. For seat height, the 5th percentile (lower percentile) of the popliteal height of the population is usually recommended so that a larger number of the population is accommodated and thus allow a short person to use the chair. Similarly, 5th percentile of: buttock-popliteal length is considered for seat depth; sitting shoulder height for upper back rest height; arm rest height for lower back rest height. However, the 95th percentile (larger percentile) of the hip breadth is usually recommended in the design of the seat and table/desk widths to accommodate as many people of the population as possible and thus allows a fat person to use the chair.

The seat surface height, seat depth, seat width, backrest height, and backrest width are the important dimensions for the design of chairs while table height, table width and table length are the dimensions that are essential for the design of tables.

4.6. Identification of ergonomics risk Factors

In the previous chapters, literature review, data collection and analysis part were used to find and identify the ergonomic risk factors in the industry. Based on the discussion and data analysis findings, ergonomic risk factors which affect workers of the industry were identified.

As acquired from the overall discussions, the ergonomic risk factors were poor work place design, awkward posture, repetitive task, static posture, dust, temperature and lighting.

The selected was based on the result from questioner, interview, workplace measurement and the RULA analysis.

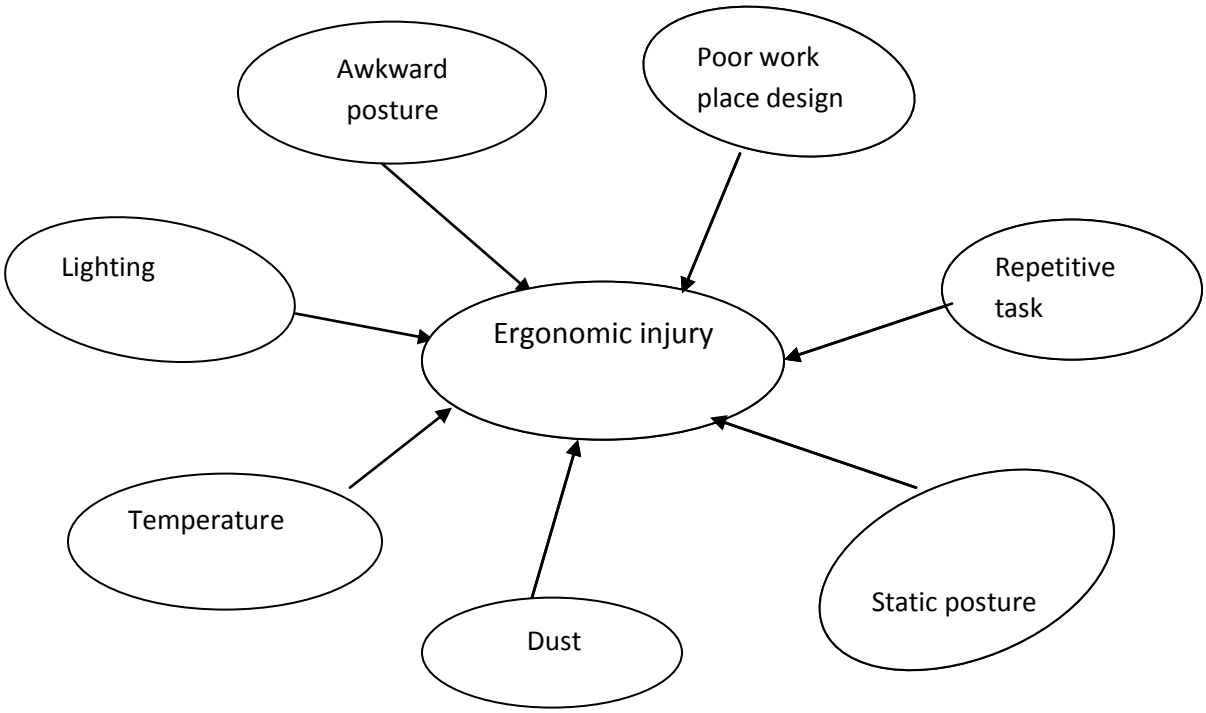


Figure 4. 5 Ergonomics risk factors

Chapter Five

New Model and Mitigation Development

5.1. Introduction

This purpose of this chapter is to develop a safe working place and to propose work place improvement to reduce the occurrence of MSD and workplace injury. After analyzing in detail the ergonomic risk factors and hazards which leads to MSD, a model have been developed which is considered improving the current working condition.

In this study three factors were considered to improve workplace that protects, promotes and supports the complete physical, mental and social well-being of workers, these factors are:

Enterprise community involvement, the psychosocial work environment and the physical work environment. Based on the previous analysis physical work environment is at the top of the main concern, so stress has been given to the physical work environment in this chapter. The improvement development in this study was conducted based on the identification of existing problems through the detail analysis.

5.2. Result and discussion

5.2.1. Ergonomic assessment and impact of MSD

Level of MSD risk according to the RULA analysis scoring method is 1-2negligible risk, no action required, 3-4 low risk, change may be needed, 5-6 medium risk, further investigation, change soon,6 plus very high risk, implementation change now .Among the study conducted on the company, the scoring of the RULA analysis final result is seven which falls on the range of very high risk which needs implementation change now.

From the RULA analysis score, the interview and the questioner survey it was able to determine the impact of MSD directly from the workers, one of the basic reasons for the workers to develop MSD is the inappropriate work place design, which exposes workers to awkward posture that leads to ergonomic injury and fatigue. There is mis-match between the workers anthropometry to the table and chair dimension in addition to that the chair is made of wood without hand support and back support, which exposes workers to develop lower back, upper back pain and spine bending, the mis match between the table and the chair height will make the workers to develop upper arm and neck ache, the seat is made of plywood with no comfort on it, seating for

long period of time will make them develop a pain on the buttock. ingeneral, the workplace design plays a great role for the workers to develop musculoskeletal disorder.

The root causes of MSD are presented in Fig 5.1 those main causes are due to inadequate work place design, management problem, method, the worker themselves. Each main cause has sub factors contributing to the causes.

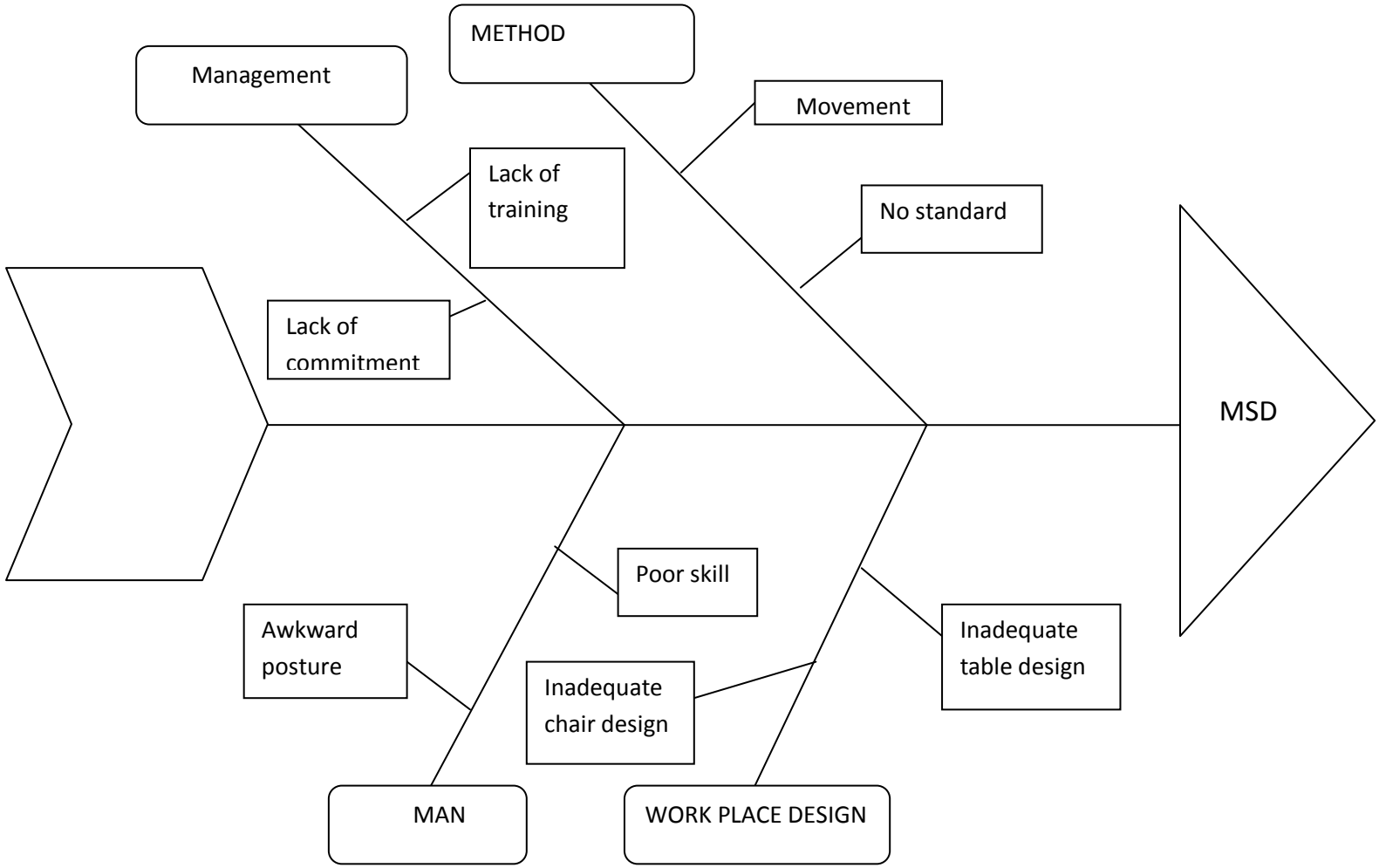


Figure 5. 1 Cause and effect Diagram

5.3. Conceptual frame work development

To develop a safe workplace and reduce ergonomic injuries and MSD, improvement models help the company by increasing productivity and by reducing cost. In order to do these there have been four factors that were considered in this study as improvement method; they are enterprise community involvement, the psychosocial work environment and the physical work environment, personal health recourses. These approaches were aroused from the need of health and safety concerns in the physical work environment health, safety and well-being concerns in the psychosocial work environment including organization of work and workplace culture personal health resources in the workplace and ways of participating in the community to improve the health of workers and derived based on data analysis of the workers response in the questioner , the result of the site observation and from the interview of the top management. This improvement approach is proposed by borrowing from WHO healthy workplace framework and model (loan, 2010). These are four ways that an employer working in collaboration with employees can influence the health status of not only the workers but also the enterprise/organization as a whole, in terms of its efficiency, productivity and competitiveness.

5.3.1. Enterprise community involvement

According to WHO healthy workplace framework and model (loan, 2010) enterprise community involvement comprises the activities, expertise, and other resources an enterprise engages in or provides to the social and physical community or communities in which it operates; and which affect the physical and mental health, safety and well-being of workers and their families. Enterprises may become involved in the community in the following ways:

- Provide free or affordable primary health care to workers, and including access for family members
- Institute gender-equality policies within the workplace to protect and support women.
- Provide free or affordable supplemental literacy education to workers and their families.
- Provide leadership and expertise related to workplace health and safety to without such resources in the community.

5.3.2. Personal Health Resources in the workplace

Personal Health Resources in the workplace means the supportive environment, health services, information, resources opportunities and flexibility an enterprise provides to workers to support

or motivate their efforts to improve or maintain healthy personal lifestyle practices, as well as to monitor and support their ongoing physical and mental health.

5.3.3. The Psychosocial Work Environment

The Psychosocial Work environment includes the organization of work and the organizational culture; the attitudes, values, beliefs and practices that are demonstrated on a daily basis in the enterprise /organization, and which affect the mental and physical well-being of employees. These are sometimes generally referred to as workplace stressors, which may cause emotional or mental stress to workers.

- reallocate work to reduce workload,
- remove or retrain managers /supervisors in communication and leadership skills;
- enforce zero tolerance for harassment, bullying or discrimination in the workplace;
- apply all legal standards and laws regarding workplace conditions or put policies in place to supplement the laws(e.g., maternity leave supplemental compensation; accommodation of nursing mothers; smoke-free workplace).
- Lessen the impact on the worker*:* Allow flexibility to deal with work-life conflict situations; provide supervisory and coworker support (resources and emotional support); allow workers to choose their shift schedules as much as possible; allow flexibility in the location and timing of work; provide timely, open and honest communications about coming organizational changes.
- Protect the worker*:* Train workers on stress management techniques, including cognitive approaches. Raise awareness and provide training for workers, for example, in the prevention of conflict or harassment situations. (This could fall under Personal Health Resources, below).

The psychological environment can also be thought of as those features of the work environment which are relevant to worker behavior. The psychological environment is therefore the set of those characteristics of work environment that affect how the worker feels, thinks and behaves.

First, aspects of work such as temperature and lighting have been shown to affect a number of psychological processes in both direct and indirect ways.

Temperature

To eliminate a stress from heat in the work area of the packaging line, its appropriate to keep natural ventilation by opening windows and doors, to increase air circulation dirt must be avoid from the floor because those things are heat retains, painting the roof light color to make it reflect back the light from the sun, for the time when the room temperature is beyond to be controlled by all of this, ventilation and fanning device should be installed.

In addition to that hot surfaces should be insulated by the use of material such as foam or polyester over the metallic surface. And also in the near future the company should install air conditioning to provide an indoor climate conductive to health and comfort of people.

Lighting

Most of the light should fall on the material or objects that are working with. The light source should as a rule be positioned behind and to the side of the left shoulder if the person is right-handed. This only applies to the actual lighting of the individual work station.

Lighting is important at the workplace of the company, eyes can adjust to a wide range of brightness, but inadequate lighting makes it difficult to work and contributes to accidents and also MSD by making the worker bend to see closely. Poor lighting can also result in eye problems. While performing the jobs its needed to see the materials, products and other equipment clearly.

Therefore General lighting is needed which is lighting from ceiling or wall lamps, it illuminates the entire premises. In the work place of the company, the output of light decreases with the age of the light source to improve this by wear of the light sources (lamps), cleaning dirty fittings and/or dirty light sources , painting bright color to remove dirt on the surfaces of the room.

5.3.4.The Physical Work Environment

The Physical Work Environment is the part of the workplace facility that can be detected by human or electronic senses, including the structure, air, machines, furniture, products, chemicals, materials and processes that are present or that occur in the workplace, and which can affect the physical or mental safety, health and well-being of workers.

To prevent exposure to hazards and the resulting illnesses and injuries, hazards in the workplace must be recognized, assessed and controlled through a hierarchy of controls that includes engineering controls, administrative controls.

5.3.3. 1Administrative Controls

Administrative controls are designed to reduce exposure of workers to MSD hazards by developing specific policies and procedures, changing work schedules, adjusting staffing levels, etc. They may also include efforts to develop and train workers to use work methods that reduce the risk of MSD.

Administrative controls change the way work is done. They do not change the physical work environment. Administrative controls do not eliminate hazards, but they can greatly reduce the risk of MSDs.

Training

They should arrange continual training for both new and existing workers, ergonomics and MSD, to keep them in neutral position. The training is not only for the packaging line workers but also for managers and supervisors too. The training should include:

Practical training (on the job): this includes the correct use of work equipment, safe working posture, safe manual work technique.

Training of ergonomics basic principles: this will help them to recognize and understand work related risks and how to prevent them, but also to increase awareness of MSD so that safe work methods and healthy lifestyle adopted. Overall body posture and individual joint posture are important determinants of injury risk. A number of work postures have been identified with an increased incidence of injury. Posture is an interface between the job we are required to do and the tools we have to complete the task. Good posture requires education as to how to complete these tasks using the tools appropriately.

What is good posture?

Good posture should involve: minimum joint strain or biomechanical loading economy of energy – minimal muscular loading avoidance of prolonged, repetitive or awkward movements .The soft tissues around a joint – articular cartilage, muscles, tendons, ligaments and joint capsule – are usually in their greatest balance in the middle third of their range of motion. As this range is extended, there is increasing soft tissue stress(Wiening,2002)

Personal protective equipment

Respiratory organ injury in the packaging line is another burden next to musculoskeletal injury as it is seen in the company's past record and the response of the workers in the questioner. During investigation it was determined the cause of the injury is dust particle. The first priority in tackling back the reparatory injury is to eliminate the hazard from source but in the cause company it is very difficult to do so because of the characteristic of the work therefore the second option of fighting back respiratory organ injury is to use personal protective equipment called respiratory protective equipment.

Respiratory Protective Equipment (RPE) is a particular type of Personal Protective Equipment (PPE), used to protect the individual wearer against inhalation of dust in the workplace air. RPE should only be used where adequate control of exposure cannot be achieved by other means, in other words, as a last resort on the hierarchy of control measures. PPE is considered a last resort because it only protects individual workers should use it properly otherwise prone to failure or misuse. The following lines states the responsibilities of both the employer and the employee for the proper usage of RPE.

The company must provide information, training and instruction for all PPE provided for. Personal Protective Equipment is required to be maintained and replaced appropriately. The company is also obliged to ensure that there is adequate supervision provided. The RPE must be provided without charge.

Employees should use RPE properly whenever it is required to be used, report any defects in or damage to the RPE immediately, participate in any training or instruction provided on RPE, inform their employer of any medical conditions they have that might be affected by the use of the RPE provided to them

5.3.3.2. Engineering Controls

Engineering controls reduce or eliminate the worker's exposure to MSD hazards by modifying the workplace, it include:

Modifying Workstations

Changing the design and/or layout of a workstation by using the anthropometric data in table 4.14.

The design of the chair and table was based on the following criteria:

The following description of design is based on a study by (s.o.ismaila,a.i. musa etal, 2013) and (baba md, darlian m,et al, 2009).

General requirement for chair design

The armrest: of chairs was designed to be adjustable, which is parallel to the floor, or held with the hand higher than the elbow.

This is to ensure the wrist can be place flat on the table and in the same plane as the forearm.

With reference to the data in Table4.14, the adjustable seat height of the chair can be adjusted from 33.7cm – 53.3cm. This data was taken from 5th percentile of popliteal height and 95th popliteal height. It allows the operators to place their feet firmly on a footrest this protects hanging which puts extra loads on lower back muscles and allows to lower the height of the chair when they want to stand, this eliminate the hazard of falling and ergonomic injury Besides, this combination with the work surface heights, adjustable chairs height allows the operators to achieve the task suitably . The armrest of chairs was also designed to be adjustable from 14.22cm to 301cm, which is parallel to the floor, or held with the hand higher than the elbow. These ranges were taken from the 5th elbow rest height and 95th percentile elbow rest height.

This is to ensure the wrist can be place flat on the table and in the same plane as the forearm. A flat wrist is very important in order to avoid pressure building on the median nerve.
The backrest was designed with a curve shape so that the depth of the seat is capable to allow Maximum contact between the operators' lumbar region and the seat back. It can also be adjusted backward from 90 degrees to 150 degrees perpendicular to the ground. The operators should be able to adjust the height and tilt of backrest without using any tools.
Lumbar support helps to restore the forward curve of the spine found in a standing position. This spinal position requires the least muscles work to be maintained and the least pressure on the spinal discs is desirable for long periods of sedentary work. Middle and upper back support

allows an operator to shift to a reclining position to relieve the strain muscles required for sitting up straight.

Seat height

With reference to the data in Table 4.11, the adjustable seat height of the chair can be adjusted from 33.7cm – 53.3cm. This data was taken from 5th percentile of popliteal height and 95th popliteal height.

Seat Depth

The anthropometric dimension to be considered in the design of the seat depth is the buttock-popliteal length. The seat depth should not exceed the buttock-popliteal length of the shortest user and as such the 5th percentile of the buttock-popliteal length should be used to determine the seat depth, which 44.07cm.

Seat Width

The dimension of the seat width should be determined using the hip breadth of those with wide hips its 51.9cm. The seat width should be wide enough not only to accommodate the user's hips and clothing but also allow the use of arms comfortably.

Arm Rest Height

The sitting elbow height is a determinant in the design of armrest height. As long as/Providing that the lowest value is accommodated, the others could also be accommodated, the 5th percentile of the elbow rest height was considered in the design its 14.55.

Seat Back Rest Height (Upper)

The backrest: was designed with a curve shape so that the depth of the seat is capable to allow maximum contact between the workers' lumbar region and the seat back. This is to avoid pressure points on the back side of the leg above and below the knee.

For the design of the upper part of the backrest, the 5^{th} percentile shoulder height (sitting) is considered 40.15.

General requirement for table design

The table is important furniture in the Packaging line. The main function of the table is to place the items packed and its dimensions provides adequate clearance for the operator's legs and feet.

The table is also important furniture in the workstation. The dimensions of the tables should provide adequate clearance for the operators' legs and feet. The width and depth should also be able to accommodate the largest operators.

Table surface Height

$E + [(P + 2)\cos 30°] \leq D \leq [(P+2)\cos 5°] + (E0.8517) + (S0.1483)$

Which: E = Sitting elbow height

P = Popliteal Height

S = Sitting Shoulder Height

309.1+[(532.8+2)0.866] [(532.8+2)0.996+(309.1*0.8517)]

D is between 772.24 and 889.2, and we take the higher because the table is not adjustable .

Table surface length and width

The distance between the elbow and the hand should be a deciding dimension when determining the desk size, but in this case we leave the existing size as it is because the workers perform their task in group and they need to sit together.

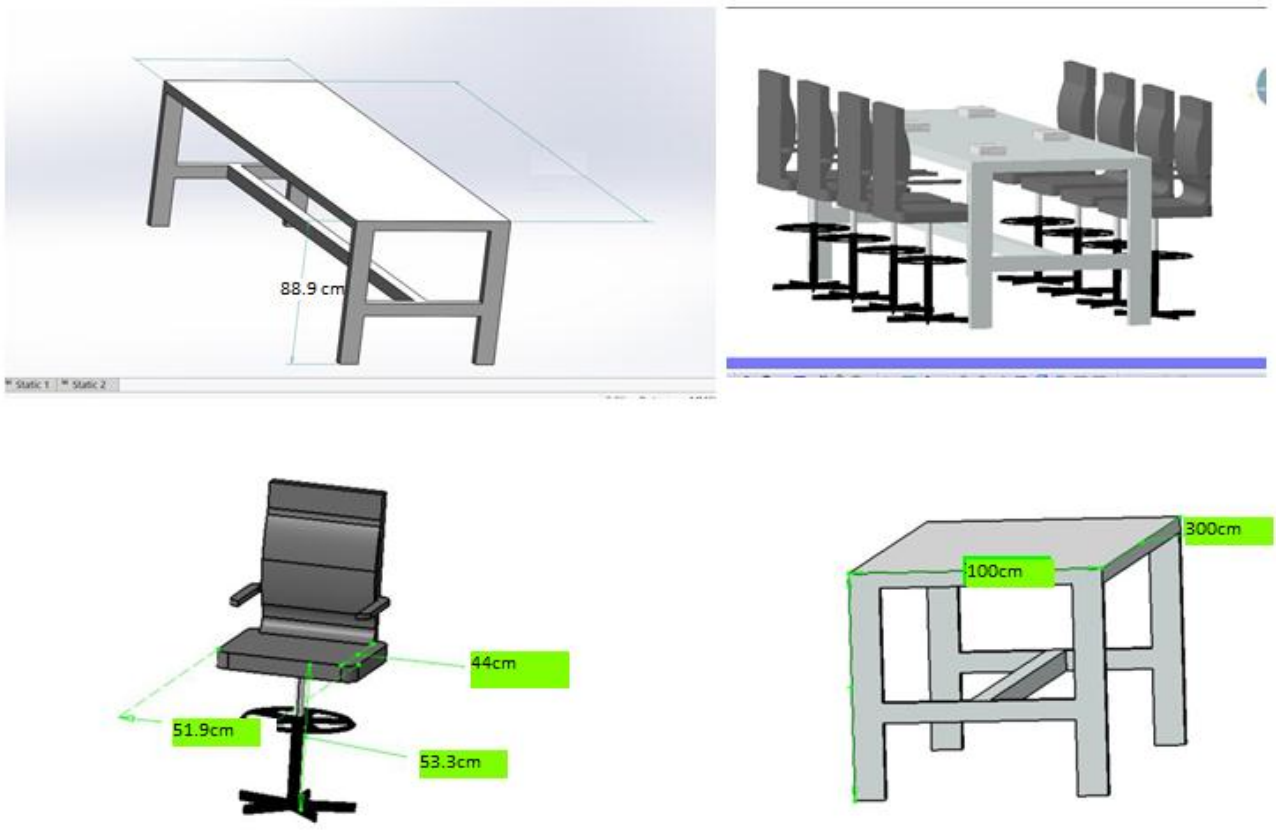
Table 5. 1 the general requirement for table and chair design

Feature	**Anthropometric Measures**	**Design Dimension In cm**	**Criteria/Determinant**
Seat surface height	Popliteral height	33.909-53.3	5^{th} Percentile of popliteal height + 0.45cm shoe heal allowance
Seat depth	Buttock –popliteral length (BPL)	44.069	5^{th} Percentile of buttock – popliteal length
Seat width	Hip breadth, sitting	51.94	95^{th} Percentile of hip breath, sitting + 15 percent allowance for cloth
Back rest width	Hip breadth, sitting		As with seat width
Back rest height (upper) above seat	Sitting shoulder height	40.16	5^{th} Percentile of sitting shoulder height
Back rest height (lower) above seat	Sitting elbow height	14.56	5^{th} Percentile of sitting elbow height
Back rest angle to horizontal		110^{0}	
Arm rest height	Sitting elbow height	14.56	5^{th} Percentile of sitting elbow height
Table height	Seat height 95% + functional elbow height + shoo heel allowance	46.61	
Table depth	Forearm – hand length	30.4	5^{th} Percentile of forearm hand length
Table width	Hip breadth		95^{th} Percentile of hip breadth + 15% allowance for clothing + 15%allowance as clearance

Table 5. 2 existing and proposal work station dimension

	Existing work station Dimension	**Proposal work station Dimension**
Table	In cm	In cm
Table height	105	88.9
Table width	100	100
Table length	300	300
Foot rest	-	30.5
Chair	**Existing work station Dimension**	**Proposal work station Dimension**
	In cm	In cm
Seating height	80	33.6.8-53.3
Back rest height	1.50	40.1
Seat length	40	44
Seat width	3.90	51.9
Arm rest	-	14.56
Foot rest	-	w- 30.4, L30.4

Figure 5. 2 Proposed Design



Compare and Contrast the existing and the proposed design

Figure 5. 3 Compare and Contrast

5.4. Worker safety conceptual frame work

The ultimate goal of eliminating MSD and ergonomic hazards is to keep the workers safety, in the previous chapters its been discussed and in this chapter conceptual frame work developed for improvement approach.

One of the best ways to eliminate ergonomic hazards and MSD in the company is to keep workers safety, based on the data analysis and the literature review a conceptual framework has been developed.

To keep the workers safety according to the frame work it needs the collaboration of the company's staff from top management to the lower level, it starts from top management commitment by creating policy and work rule and also to take corrective measure on inadequate workplace design. in addition to that they should facilitate training, the training should include about neutral position, about material handling and ergonomic hazards and the workers have to apply what they have trained by doing so its possible to keep the workers safety.

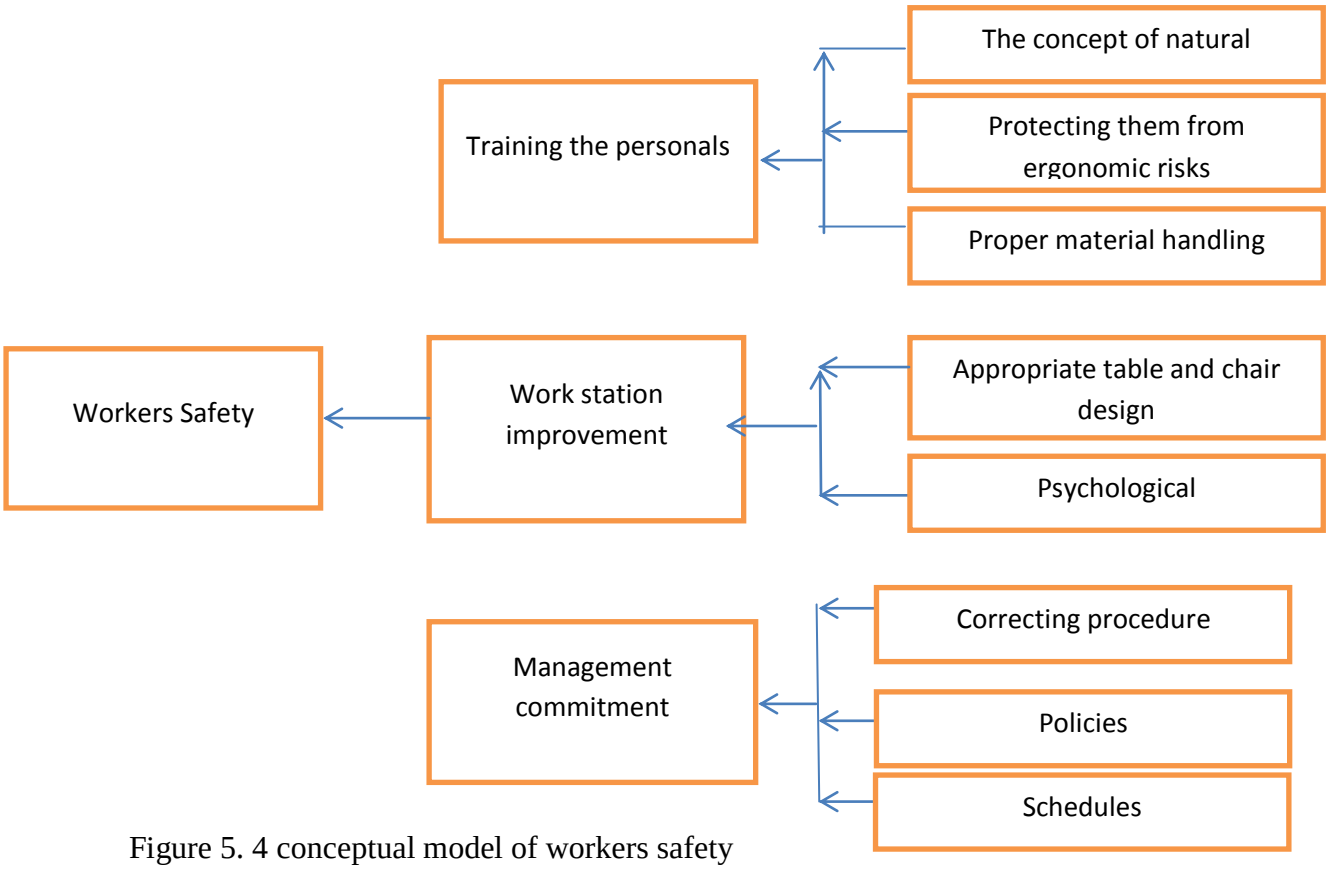


Figure 5. 4 conceptual model of workers safety

Summary

This chapter has proposed work station improvement model based on the information obtained from the previous analysis conducted in this research. The chapter has attempted to investigate proposed framework in terms of its contribution to the overall improvement.

The first part of the model discusses the Enterprise community involvement; it's all about top management commitment to fight back the hazards of ergonomic injury and musculoskeletal disorder. The second one is about the physiological work environment, it discusses about the environment which are relevant to worker behavior. The psychological environment is therefore the set of those characteristics of work environment that affect how the worker feels, thinks and behaves, the last one is engineering control of physical work environment this model controls, reduce or eliminate the worker's exposure to MSD hazards by modifying the workplace. Based on this a new work place design and corrective measures are proposed in this chapter in order to reduce or eliminate ergonomic injuries and musculoskeletal disorder from our case company.

Chapter six

Conclusion and recommendation

6.1. Conclusion

1. Annually occurred ergonomic injury and musculoskeletal disorder are substantial.
2. The direct and indirect costs absorb significant amount of annual operating budget
3. Most injuries and MSD cases are the result of workplace design and lack of knowledge.

The study also concluded that:

The workers are working in uncomfortable and painful postures as found by analysis. This is due to lack of ergonomics knowledge and awareness and inadequate work place design. Thus the workers are under high risk of musculoskeletal disorders as determined from RULA risk level. Data collected from the assessment tools used in this study the RULA and the symptom survey/questioner/ shows that the packaging line processes falls at high risk of MSD and ergonomic injuries. Ergonomic assessment results and loss history conclude that the packaging processes require alterations and further investigation. Reviewing the total case of incidence at birhan and selam enterprise for the past three calendar years (i.e., 2016, 2017 and 2018) shows the company experienced a higher recordable incidence.

Based on the evaluation of ergonomic symptom survey forms/questioner/, the ergonomic risks associated with the packaging processes include unnatural posture, awkward position and repetitive motion has likely resulted in symptoms.

6.2. Recommendations

Based on the conclusions of ergonomic assessment results , the following control measures are recommended to reduce the exposure of ergonomic risk factors and the occurrence of musculoskeletal while performing the packaging process. The first two items on the hierarchy of controls are correcting the work place design and training the employees.

Engineering control

Engineering controls reduce or eliminate the worker's exposure to MSD hazards by modifying the workplace it include:

seat width, Table, Chair, Chair back rest, Seat depth, Modifying Workstations

Training

Creating Awareness on ergonomics to employees to prevent ergonomic injuries and work related musculoskeletal disorder in order to make them aware of the consequences of every awkward position.

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የአዲስ አበባ ዩኒቨርስቲ የቴክኖጂ ተቋም

የመካኒካልና ኢንዱስትሪያል የትምህርት ክፍል

ይህ መጠይቅ በብርሃንና ሠላም ማተሚያ ድርጅት በሚሠሩ ሠራተኞች ላይ ከሚሰሩት ስራ ጋር በተያያዘ የደረሰባቸውን ጉዳት ለማጥናት የተዘጋጀ መጠይቅ ነው፡፡

የዚህ ጥናት ውጤት ለሚመለከታቸው አካላት ሁሉ የሚሠራጭ በመሆኑ በቀጣይ በስራ ላይ የሚደርስ አደጋን ለመከላከል ከፍተኛ ሚና የሚጫወት ነው፡፡

ጥያቄውን ሚመልሠው ሠራተኛ ማንነት እና ስም በጥናቱ ውስጥም ይሆን ለሌላ ወገን በፍፁም አይጠቀስም ::

ከዚህ ባሻገር ማይፈልገውን ጥያቄ እንዲመልስ አይገደድም እንዲሁም ካልፈለገ መጠይቁን በማንኛውም ግዜ ማቋረጥ ይችላል፡፡

ቀን _____ ፊርማ_____

ክፍል አንድ

የስራ መጠሪያ_____ ዕድሜ_____ የቅጥር ሁኔታ_____

የስራ ልምድ _____ጾታ_____ የትምህርት ደረጃ_____

ሺፍት_____

ክፍል ሁለት

1. ስራውን በሚከውኑበት ሰአት በክፍሉ ውስጥ በቂ ብርሃን አለ

   አለ ☐ የለም ☐

2. ከሚሠሩት ስራ የተነሣ የተፈጠረቦት የጤና እክል አለ?

   አለ ☐ የለም ☐

3. መልሱ አዎ ከሆነ ህመም የሚሰማህ/ሽ የትኛው የአካል ክፍል ላይ ነው?

አንገት ☐ ትከሻ ☐ መገጣጠሚያ የታችኛው የእጅ ክፍል ☐

የእጅ መዳፍ ☐ የታችኛው ጀርባ ☐ ላይኛው ጀርባ ☐

ጉልበት/ጭን ☐ እግር ☐ የእግር መዳፍ ☐

4. ለዚህ ህመም መንስኤ የሚሆነው ምንድነው?

የመስሪያው ቦታ ዲዛይን ☐ የስራው ባህሪ ☐
መቀመጫ/ጠረጴዛ…ወዘተ

የአቀማመጥ ችግር ☐ ሌላ ካለ ይግለፁ _____

ክፍል 3 የሚሰማህ/ሽ የህመም አይነት ምንድን ነው?

ቁርጥማት ☐ ማቃጠል ☐ የጡንቻ መቆጣት ☐

እብጠት ☐ መጨምደድ ☐ ውጋት ☐ የድካም ስሜት ☐

ሌላ ካለ ይገለጽ_____

ክፍል 4

ይህን በሽታ ያስተዋልከው/ሽው መቼ ነው?

1-6 ወር ☐ 6-12ወር ☐ 12-16 ወር ☐ ከ16 ወር በላይ ☐

- ባለፉት 7 ቀናት ውስጥ ይህ ህመም ተሰምቶት ነበር አዎ ☐ አይ ☐
- የህክምና አገልግሎት ተጠቅመህ/ሽ ታውቃለህ/ሽ አዎ ☐ አይ ☐
- መልሱ አዎ ከሆነ ምን አይነት ህክምና ተጠቀሙ?

  የመጀመሪያ እርዳታ ☐ ተመላልሼ ታከሜያለሁ ☐
- ህክምናው ለውጥ አመጣ አዎ ☐ አይ ☐

ክፍል አምስት

- ህምሙ ለምን ያህል ቆየ ለአጭር ጊዜ ☐ እየተሻለኝ ይመለሳል ☐

  ያለመቋረጥ ለረጅም ጊዜ ☐
- ባለፈው አመት ውስጥ ለምን ያክል ግዜ ታመህል/ሻል____
- በዚህ ህመም ምክንያት ባለፈው አመት ለምን ያህል ቀናት ከሥራ ገበታህ/ሽ ቀርተዋል/ሻል_____
- በዚህ ህመም ምክንያት ባለፈው አመት ለምን ያህል ቀናት ቀላል ያለ ስራ እንድትሰራ/ሪ ታግደህ/ሽ ነበር_____

  _____

ክፍል 6

- ከዚህ በፊት እራስህን ከጡንቻና መገጣጠሚያ በሽታ ስለመጠበቅ ስልጠና ወስደህ ታውቃለህ/ሽ
- አውቃለሁ ☐ አላውምቅ ☐
- መልሱ አዎ ከሆነ ምን አይነት ስልጠና?

  በቅርብ አለቃ በቃል የተነገረ የአሰራር ዘይቤ ☐

  በአሰልጣኝ የስልጠና አካሄድ ተከትሎ ☐

✓ ከዚህ በላይ ባለው መጠይቅ ላይ ህመም ወይም በሽታ ተብለው የተጠቀሱት በስራ ላይ የሚደርስ አደጋንና የጡንቻ እና የመገጣጠሚያ ህመምን የሚወክሉ ናቸው::

ክፍል 7 የመተንፈሻ አካል

1. ከመተንፈሻ ካል ጋር የተገናኘ ህመም ይሰማዎታል?

   አዎ ☐ አይሰማኝም ☐
2. በስራ ገበታዎ ላይ በመተንፈሻ አካል ላይ ጉዳት ሊያደርሱ የሚችሉ ነገሮች አሉ?

   አለ ☐ የለም ☐

   መልሱ አዎ አዎ ከሆነ ምን እንደሆነ ይግለፁ_____
3. የትኛው የመተንፈሻ አካል ህመም ይታይቦታል::

   የጉሮሮ መዘጋት ☐ የተለያዩ አካል ክፍል ቁርጥማት ☐

   ሣል ☐ የመተንፈስ ችግር ☐

   ትኩሣት ☐

   የደረት ህመም ☐

በስራ ገበታዎ ላይ ስራውን ለማከናወን የሚያስችል በቂ ብርሃን አለ?

አለ ☐ የለም ☐

ለአይን የሚከብድ ከፍተኛ ብርሃን አለ?

አዎ ☐ የለም ☐

በክፍሉ ውስጥ ያለው የሙቀት መጠን ከአየር ንበረቱ ጋር ይለዋወጣል?

አዎ ☐ የለም ☐

ሁልጊዜ ተመጣጣኝ ሙቀት ነው ያለው?

አዎ ☐ የለም ☐

ከፍተኛ ሙቀት አለ?

አዎ ☐ የለም ☐

ከፍተኛ ቅዝቃዜ አለ?

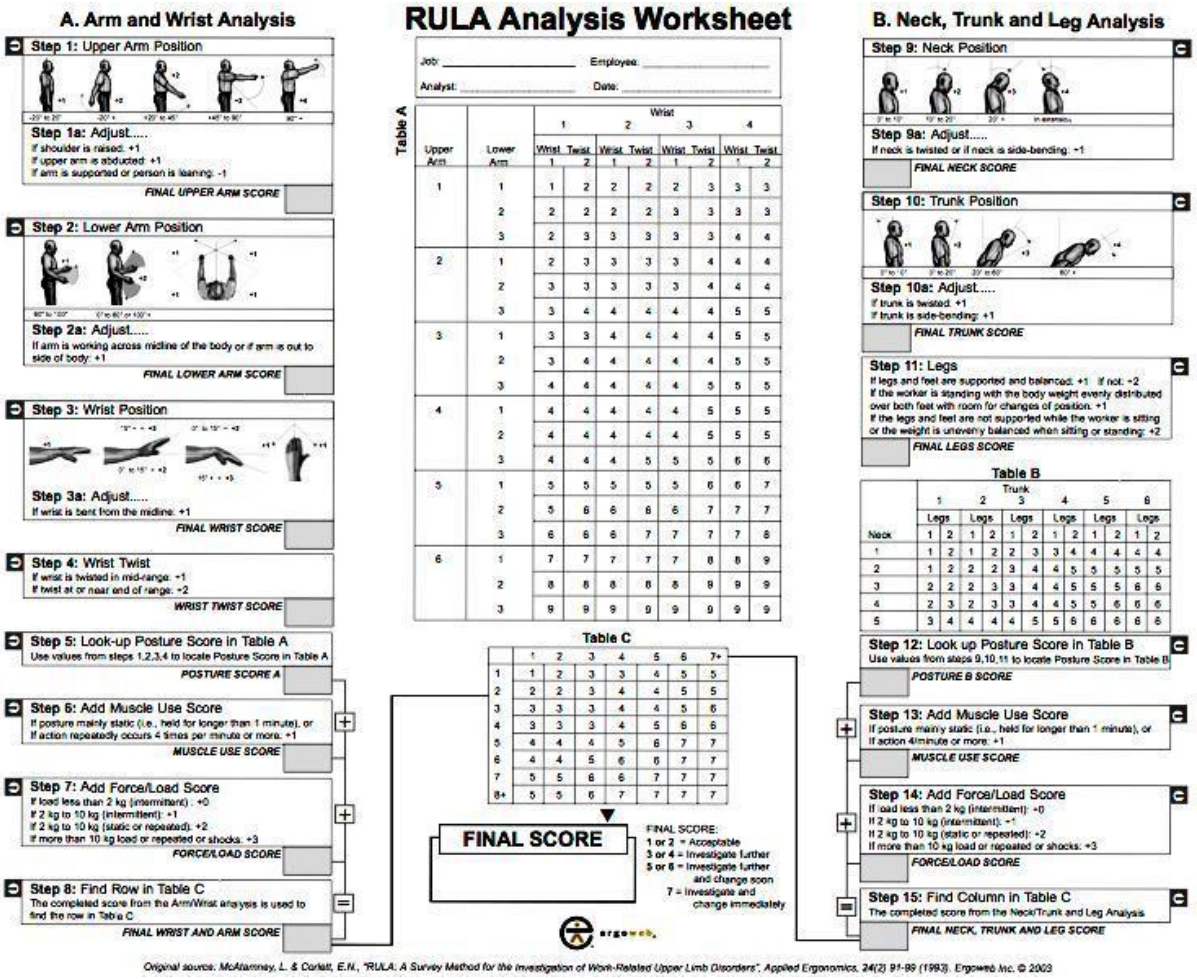
አዎ ☐ የለም ☐

Appendix III Questioner Analysis

Question 2.1								E1	E2	E3	E4	E5	E6	E7	E8	E9	E10	E11	E12	E13	E14	E15	E16	E17	E18	E19	E20
1	Yes			2	No			1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Question 2.2																											
Neck	shoulder	Elbow/f.a	Hand/w					1,4	2	1	1	4	1,3		1	2	4	1	2	3	1	4	2,4	1	1	1	2
1	2	3	4					5		5	5		5	5	5		5	5		5	5	5	5	5		5	5
Upperb	Loweb	Thigh/k	Lowl						6	6			6	6		6	6		6	6		6		6	6		6
5	6	7	8						7		7	7		7				7			7				7		
Question 2.3								8				8			8	8			8	8			8			8	
Inadequate workstation Height 1		Repetitive motion 2		inadequate chair design 3																							
awkward posture								1			1		1	1					1			1					
4									2						2	2							2				2
										3		3					3	4		3	4			3	3	4	

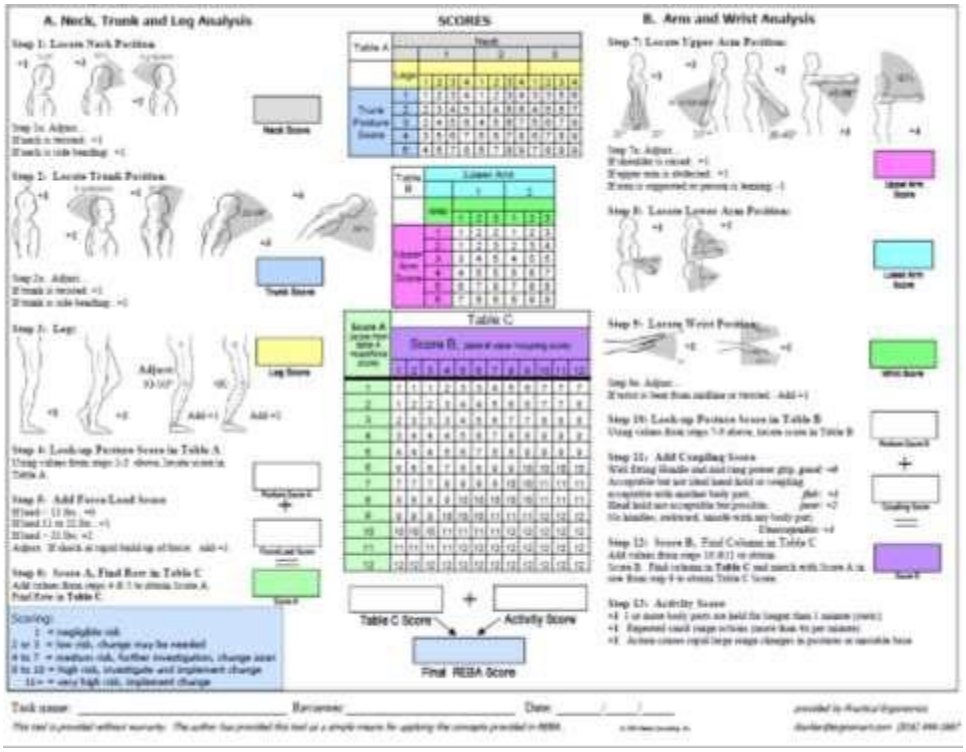
Question 3.1		E1	E2	E3	E4	E5	E6	E7	E8	E9	E10	E11	E12	E13	E14	E15	E16	E17	E18	E19	E20
1.Aching	5.Swelling	1			1			1	1		2			1		2					
2.Burning	6.Stiffness	3	3	5		3	3	3		5	3	3	5	3	3		3		3		3
3.Cramping	7.Tingling			6	6				6			6						6		6	
4.LossofColor	8.Weakness	8	7			8				7			7		8	7		7	8	7	7
Question 4.1																					
1-6 Mon	6-12 Mon	12-16 Mon	Above 16																		
1	2	3	4	1	2	3	1	4	1	2	3	1	1	2	2	1	2	1	3	2	1	3	2
Question 5.1																					
1.for short time		2			1		1		2		1		2		2			2		1	2
2.frequently			1			2				2		2		3		1			2		
3.for long time continuously				3				3									2				

Appendix II

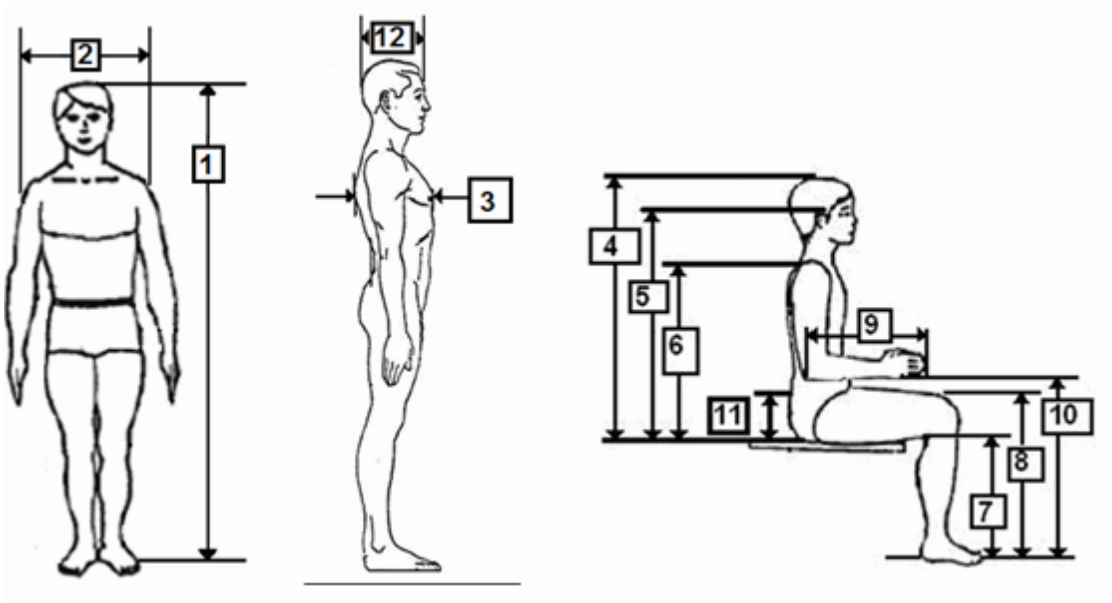


Original source: McAtamney, L. & Corlett, E.N., "RULA: A Survey Method for the Investigation of Work-Related Upper Limb Disorders", Applied Ergonomics, 24(2) 91-99 (1993).

Appendix III



Appendix IV



ANTHROPOMETRY DATA	UNIT/mm	ANTHROPOMETRY DATA	UNIT/mm
1. Stature		7. Popliteal height	
2. Shoulder breadth		8. Sitting knee height	
3. Chest depth		9. Forearm hand length	
4. Sitting height		10. Sitting elbow height	
5. Sitting eye height		11. Thigh clearance	
6. Sitting shoulder height		12. Head length	