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Singh, Gundeep. ***An Ergonomic Analysis of the Current Packaging Process at Company XYZ***

Abstract

The purpose of this study was to evaluate the packaging process in the shipping department and determine the potential ergonomic risk factors to an employee working in the packaging line at Company XYZ. Goals were established to define the purpose of this study. Multiple quantitative (the REBA, the RULA, the Moore-Garg Strain Index) and qualitative (Ergonomic Symptom Survey) assessments were conducted on the tasks involved in packaging to determine the severity of the problem. The assessed tasks were evaluated and the appropriate controls measures were recommended for implementation. Along with ergonomic assessments, the evaluation process consisted of data collection, subject observations, workstation assessment, symptom survey review and loss history analysis to identify ergonomic risk factors associated with the tasks at Company XYZ. The study concludes that the assessed processes in the packaging line are at a high ergonomic risk level. The four major upper extremities contributing to MSD injuries were determined to be awkward posture and repetitive motion of spine, neck, shoulders and wrists. Based on the study results and the hierarchy of controls, the appropriate control measures are recommended to minimize the exposure of ergonomic risk factors resulting in musculoskeletal injuries while performing the packaging process.

Acknowledgments

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Chapter I: Introduction

When employees are forced to accommodate to the workplace, there may be significant potential risks involved that can result to a health issue. Musculoskeletal disorders in the work environment usually results from excessive force exertion, awkward posture or repeated motion that involves repetitive use of same muscles, tendons, and ligaments. Over the years, experts have been able to identify numerous common symptoms of these disorders which result from this employee/workplace mismatch (Putz-Anderson, 1988). Ergonomic practices within the workplace can alleviate these symptoms and thus 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 (Henry, 2004).

This study was completed at Company XYZ, a leading custom-designed manufacturer of thermal solutions. In this competitive business market and non-flourishing economy, Company XYZ is successful for its precision product quality, customer satisfaction and lean manufacturing. A key element to a lean business is taking action to reduce waste which may include time, material, equipment, employee skills and processes. Applying a lean strategy on the production floor not only helps the company to strive for continuous improvement, but also diminishes latter risk exposures to employees. Company XYZ has been operating with the same process for last six years in the shipping department but has been continuously receiving complaints from the employees regarding upper and lower limb such as musculoskeletal disorders (MSDs) and carpal tunnel disorders (CTD’s) In the past, Company XYZ has made attempts to rearrange the work area once through a KAIZEN event. The event included rearranging equipment and materials to a one piece flow, but the main focus of the event was to change the way products are being packaged and did not prepare an efficient process that will increase safety, quality and employee comfort.

Company XYZ is one of the largest custom designers and manufacturers of industrial heaters, sensors, controllers, and software in the Midwest. The company manufactures products for a wide variety of commercial markets in a low volume and a high product mix manufacturing environment. The company has over 2,500 employees who work in thirteen manufacturing facilities in the United States, Mexico, Europe, and Asia, and also holds over two hundred patents. Headquartered in St. Louis, Missouri, Company XYZ has brought its thermal expertise to numerous applications and markets since its inception in 1922. Some of the company's in-demand applications include semiconductor, photovoltaic, analytical, medical, clinical, plastics processing, foodservice equipment, packaging, and aerospace-based technology. Company XYZ manufactures engineered thermal products that are utilized worldwide in the above industries.

Observations that were recorded by the researcher indicate that there are noticeable risk factors in the current packaging process that may cause musculoskeletal injuries in the upper extremities. It was also determined that certain risk factors are likely to be the cause of Company XYZ's past high OSHA recordable injuries, musculoskeletal disorders, days away, restricted or transfer, excessive workers compensation costs and high employee turnover. More specifically, the identified ergonomic risk factors consist of forward flexing the cervical spine greater than twenty degrees, lumbar hyperflexion, shoulder abduction, excessive pressure on legs from standing, variation of wrist movement, and a high level of task repetition. Continued occurrence of these risk factors has the potential to lead to musculoskeletal disorders (MSDs) or cumulative trauma disorders (CTDs). Thus, employees within the Shipping Department at Company XYZ are likely to be exposed to various ergonomic risk factors which may result in the continued occurrence of musculoskeletal disorders.

Purpose of the Study

The purpose of this study is to determine the ergonomic-based risk factors which Company XYZ Shipping Department employees may be exposed to.

Goals of the Study

The goals of this study are to:

1. Assess the process, procedures and tasks that employees must perform within the shipping department of Company XYZ.
2. Analyze the types of ergonomic-based injuries that employees have reported to their supervisors for the past three calendar years.
3. Determine the types of musculoskeletal symptoms that employees are currently experiencing during their work activities at Company XYZ.

Significance of the Study

A study conducted on shipping department's packaging line at Company XYZ 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 to 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 may assist the company to determine controls that will prevent injuries or reduce the risk exposure that may lead to financial loss, legal loss, or quality loss due to the processes involved in the packaging line.

The type of financial loss that Company XYZ may incur as a result of deficient workplace design includes the impact of the workers compensation dollars, lost work hours, the cost of rehiring replacement workers as well as employee retraining and rehabilitation costs. Legal loss occurs when an employee claims his or her injury was work-related and occurred due to inadequate equipment, work environment, or resources provided by the employer. Quality loss includes customer dissatisfaction and credibility loss which may in turn, create a drop in Company XYZ market share that could ultimately place the company out of business.

Assumptions of the Study

1. Employees will be honest when they complete the surveys/questionnaires that are presented to them.
2. Employees will perform their job functions in the same manner as they would during a non-observed day.

Limitations of the Study

This study has a number of limitations, which include:

1. This study is limited to the dates between 4/01/2013 and 5/01/2013.
2. Assessment tools, the REBA, RULA, and Moore-Garg strain index are considered initial screening tools.
3. Conclusions and recommendations for this study pertain only to activities required to perform packaging of the product in the shipping department.

Definition

Ergonomics. Ergonomics is a specialized field within Human Factor Engineering, focusing on the human body interacting with its work environment. Ergonomics

a. Considers human capabilities

b. Considers human tendencies (Kapellusch, 2008).

Kaizen. Kaizen refers to activities that involve complete chain of command i.e. from upper management to janitorial for continuous improvement in all functions (Robert, 2004).

Human Factors. Human factors focus on human beings and their interaction with products, equipment, facilities, procedures and environment used in work and everyday living Kapellusch, 2008).

Rapid Upper Limb Assessment (RULA). RULA is a systematic assessment tool that primarily asses the distal upper limbs risks of cumulative trauma disorder through posture, force, and muscle-use analysis. (McAtamney and Corlett, 1993).

Rapid Entire Body Assessment (REBA). REBA is a quick and systematic assessment tool that assesses the entire body postural risks for work related musculoskeletal disorders (Hignett and McAtamney, 2000).

Musculoskeletal Disorders (MSD). Disorders of the muscles, tendons, ligaments, joints, cartilage, nerves, blood vessels, or spinal discs. Some examples are muscle strains, ligament sprains, joint and tendon inflammation, pinched nerves, and spinal disc degeneration (Chengular, et al., 2004).

Engineering Controls. Engineering controls are physical changes to various aspects of work environment such as workstation, process, equipment, materials, or facility that reduces or prevents exposure to risk factors (Kapellusch, Jay, 2008).

Work Environment. An environment at which employees perform their standard work. It includes:

a. Logistical conditions the employees are working in such as number of hours worked, break periods, workspace layout and the environmental conditions.

b. Resources available to the employees that include tools, equipment and people (Kapellusch, Jay, 2008).

Chapter II: Literature Review

The purpose of this study is to evaluate task functions, production demands, and workstation characteristics of the shipping department packaging line at Company XYZ that may contribute to the occurrence of upper extremity MSDs. This study includes the assessment of specific work environments to identify the magnitude of the potential ergonomic risk factors present. In this study, the researcher attempted to combine safety within the company's lean culture to reduce the occurrence of future work-related MSD injuries. This study is an attempt to assist Company XYZ's financial outlook through the reduction of worker compensation costs, employee claim costs, and other direct and indirect costs associated with work-related injury. In this chapter, the researcher reviews literature centered on lean manufacturing culture and describes the role that safety plays within it. This chapter includes a description of ergonomics, the benefits of ergonomics, a description of musculoskeletal and cumulative trauma disorders and the process implemented to identify ergonomic risk factors which include the analysis and assessment of the workstation, job task and the human body. It also includes an evaluation of the tools used to identify the risks and the controls that minimize worker exposure.

Ergonomics

Ergonomics is the science of modifying the workplace environment to suit the employee (i.e., design the work environment such that it adapts to the body rather than the body adjusting to the workspace). This organized structure ultimately maximizes safety, efficiency, and comfort of the employee. Organizing the work environment in this manner is just as important in preventing injury as the appropriate use of tools and equipment (Reyes, 2003). Employees incur MSD and CTD injuries at work when the workplace demands exceed the employees' physical capabilities. Ergonomics minimizes these discrepancies and reduces injuries that may result when a work environment demands forceful exertion, awkward posture, repetition, vibration, contact stress, and duration of exertion from the employee. Ergonomics may reduce organizational stress and other personal and work-related outcomes such as task-induced tension, fatigue, and dissatisfaction through an analysis of how comfortably the worker exists in the workplace environment (Miles, 2001). Making changes to a workstation, process, or tools to perform a task by using ergonomic controls may fulfill the purpose of reducing MSDs or CTDs in an organization. Ergonomics aid organizations in developing work practices that reduce exposure to risk factors and increase productivity. A safe working environment increases employee output and prevents undesirable behavior (Laquindanum, 1997). Work practices may include modifying equipment, providing alternative tools, and improving the operation process by redesigning workstations as ergonomic-friendly, therefore, affording the employees leverage to rotate through different types of tasks throughout the day, and in turn, minimizing any strain on a particular muscle. Lastly, the act of providing ergonomic personal protective equipment (PPE) may also be used to provide additional protection from potential ergonomic risk factors (Henry, 2004)

Musculoskeletal Disorders (MSDs)

Injuries to the musculoskeletal system are a leading cause of suffering among employees. These lead to a loss of productivity, time, and substantial expenses because of worker compensation (Putz Anderson, 1988). Musculoskeletal disorders are injuries of the soft tissue and nervous system, which affect the body’s muscles, tendons, and nerves, thus leading to MSDs such as carpal tunnel syndrome, lumbar pain, eye strain, tendinitis, trigger finger, torn ligaments, weak joints, cervical spine strain, muscle tearing and injury to the spinal disks. Nearly 63% of MSD injuries occur from repetitive motion, 20% from repetitive placing, grasping or moving objects, 9% from key entry typing, and 8% from repetitive use of tools (Spaulding, 2005). 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).

Cumulative Trauma Disorders (CTDs)

It appears that CTDs have become a common occurrence among workers in industry. According to a US Bureau of Labor Statistics report, of the 368,300 occupational disease cases in 1991, 233,600 cases were associated with repeated trauma. Hand and wrist repetitive trauma illnesses account for a large proportion of injuries. The National Occupational Exposure Survey conducted by NIOSH in 1981 to 1983 projected that 4,034,474 workers in the U.S. potentially were exposed to hand and wrist chronic trauma (National Institute for Occupational Safety and Health, 1996).

CTDs are a combination of musculoskeletal and nervous system disorders, which may be caused by repetitive tasks, improper posture, vibrations, forceful exertions, and compression on a sharp or hard surface. Common workplace CTDs such as carpal tunnel syndrome (CTS), tenosynovitis, and tendinitis develop gradually over a period of weeks, months, or years (N.J. Department of Health and Senior Services, 2003). CTS refer to the compression of the median nerve by a sharp surface or an awkward shaped object, which passes the carpal tunnel in the wrist. CTS also occur because of swollen tendons within the carpal tunnel area. Work that combines high force exertion, high repetition, awkward posture such as typing, assembly work, packaging, sewing and cutting, are leave a person at high risk of CTS. If CTS remains untreated, the condition may deteriorate and may cause a loss of grip strength, increased pain during the night, and the permanent loss of hand function. Tenosynovitis is a generally a term for irritation of the synovial sheath of the tendon caused by CTD risk factors. The sheath is stimulated to generate excessive amounts of synovial fluid, which accumulates and causes the sheath to inflate, resulting in pain. Ineffective workstation design, tool design, and work culture may contribute to the development of this disease. Tendonitis occurs when a tendon is repetitively tensed or used, causing inflammation. During normal use, the fibers of the tendons are subjected to small tears, which are easily repaired by the body, but excessive use and the lack of recovery time do not allow the tears to heal completely. The affected areas are usually wrists, elbows, and shoulders. Occupational risk factors for tendonitis include repetition, frequency, force, awkward posture, over-extension of muscles, and vibration. Lack of proper rest and recovery time required for tissues to heal may cause permanent damage to the tendons (Putz-Anderson, 1988). CTDs may occur outside the work environment from activities involving repetitive motion or sustained awkward posture. It may be difficult to determine the main cause of a CTD in a person who is suffering from various symptoms which may occur (N.J. Department of Health and Senior Services, 2003).

Tasks requiring high rates of repetitive motion require greater muscle work than less repetitive tasks. The CTD risk is also increased by the worker adopting awkward postures because of technical designs developed to accomplish work economy and simplification. CTDs associated with stressful postures include tenosynovitis of the flexor and extensor muscles of the forearm and arising from extreme flexion and extension of the wrist. Non-occupational factors associated with CTDs include physical size, strength, earlier injuries, and joint alignment. Highly repetitive work combined with awkward postures increases the risk of developing CTDs. The recommended solution for reducing the risk involves redesigning the tools and tasks to reduce biomechanical and repetitive stresses on the musculoskeletal technique (Putz-Anderson, 1988).

Signs and Symptoms of MSDs

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). Organizations face the challenge of proactively identifying the symptoms of MSD injuries. In recent years, the role of psychosocial elements in musculoskeletal injuries was investigated by experts in several systematic assessments performed in a controlled environment on selected subjects. E. S Geller (1998) performed behavior analysis using various ergonomic assessment tools, periodic medical examination, and past medical reports to understand the psychological effect of the work environment on each subject. This assisted them in defining signs and symptoms of MSDs. 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 identification and reporting of MSDS without delay and aides the company in taking proactive measurements to prevent them. Common symptoms associated with MSD are the inability to produce a tight grip with one's hands because of a lack of strength, 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). The list does not end there. Other signs and symptoms may include numbness in fingers, arms, and legs, shooting pain and prolonged stiffness in the spine, lumbar region or shoulders, and swelling and soreness in the wrists, elbows, and knee joints.

Ergonomic Risk Factors

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 (Henry, 2005). The six prime categories of 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.

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 (Sheau-yueh, Ching, & Chiang, 2001). Not all repetitive movements result in MSD injuries, but depend on various 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). Low frequency of repetition with high speed and excessive force may contribute an equal amount as high repetition and a small, exerted force to the development of cumulative trauma disorders (Tayyari & Smith, 1997). The common types of repetitive motion injuries are tendonitis and carpal tunnel syndrome, which are difficult to distinguish and may often coexist (NIOSH Workplace Safety and Health, n.d.)

Force is the amount of physical strength generated by the muscles required to perform a task. Force may be classified as isometric or static and isokinetic or dynamic. In static muscle exertion, the body segment involved and the object held remain stationary, while in the event of dynamic muscle exertion, both the body segment and the object travel (Mittal et al., 1986). 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 contractions, it may restrict the flow of blood through the muscles, which may cause lactic acid to accumulate within the muscles and therefore result in pain and fatigue. 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 squeeze the synovial fluid that forces the lubricant to the sides, unlike in the case of dynamic pressure, which allows fluid to circulate (Geffen van, 2009). Although there is no movement between limb and object, static force is as critical to consider as dynamic force is while designing industrial tasks and workstations (Karwowski, 2001). Dynamic force will aid in determining individual physical capabilities (Mittal et al., 1986). Static force aids in determining required movements and body posture (Karwowski, 2001). According to Health and Safety Executive (1990), one of the main risks for the development of MSD is the forceful exertion of specific parts of the body in the accomplishment of work-related tasks. Inflammation of the tendons, nerves, and joints is frequently the result of these forceful exertions. Common contributors of forceful exertion are duration, body posture, object weight, or the type of grip required (Krajewski, Steiner, & Limerick, 2009).

Awkward postures cause stress on muscles and tendons. Such stress occurs due to lack of movement or when bodily joints are significantly deviated from the neutral position. The contributors for this work-related common risk factor include overexertion, overreaching, twisting, hyperflexing, and static posture for lengthy periods. When combined with unhealthy posture, these actions lead to lumbar pain, tendinitis, and damage to joints (Chengular, et al., 2004). The comfortable postures for joints are ones that generate minimum strain on muscles and also provide maximum body control and strength to perform a particular task.

Contact stress is a commonly identified ergonomic risk factor in the work environment. It is the stress generated from sustained contact between body and an external object such as contact of sharp surfaces and dense objects with sensitive body tissues (e.g., example, grasping a hard object, such as a tool handle while pressing against the soft tissue of the palms, placing a forearm against the edge of the computer desk, or grasping sharp parts while pressing against the soft tissue of the fingers). In each situation, the continuous contact will place pressure on the nerves, tendons, and blood vessels, and therefore, inhibit the function of this body parts (Roberts & Mottershead, 1990). The common compounding factors to contact stress include the task duration, frequency of the activity, and required grip strength (Roberts & Mottershead, 1990).

Being subject to vibration for extended periods of time because of constant shaking and pulsating of the body may be a major risk factor for MSDs. According to a qualitative study performed by Wasserman, Badger, Doyle, and Margolies in 1974 using open-ended surveys, in the United States alone, 8 to 10 million people each day are exposed to vibration in the work environment. Vibration from hand-operated power tools may tear or inflame the tendons, muscles, ligaments, and joints, as well as affect the nervous system. Collectively, these effects are referred to as “hand-arm vibration syndrome” or HAVS (Wasserman, 1987). The main contributor of occupational HAVS involves vibrations, which may occur from power tools that are inadequately maintained. These tools often lack vibration damping devices and feature inadequate grip designs that result in restriction of the blood supply (Roberts & Mottershead, 1990). Examples of power tools which may produce significant levels of vibration include jackhammers, sanders, saws, chippers, routers, and drills.

Extreme temperatures may cause various issues for workers. According to the Occupational Safety and Health Administration (2002), hot temperatures may lead to dehydration and muscle fatigue, especially when such is combined with high humidity. Cold temperatures cause muscles to become less flexible, leading to muscle strain and sprains. Issues may include shortness of breath, fatigue, reduced dexterity, sensory sensitivity, and reduced grip strength. Hot or cold work environments may be encountered in areas aside from the outdoors. Any location that is outside of the typical comfort zone of 55 to 85 degrees Fahrenheit is cause for consideration (Occupational Safety and Health Administration, 2002),

A worker’s internal body temperature may rises in high heat surroundings, thus leading to attempted body temperature regulation through increased blood circulation and increased sweat. A body will expend energy while attempting to cool down, thereby increasing overall fatigue (Henry, 2004). Heat stroke and heat exhaustion are serious health issues caused by working in hot environments. Heat stroke may be deadly and victims usually do not recognize the symptoms. While the symptoms of heat stroke may vary from one individual to another, they include dry hot skin, an elevated body temperature, and ultimately, a partial or complete loss of consciousness. Heat exhaustion is caused by a loss of body liquid through excessive sweating. Symptoms of heat exhaustion include heavy sweating, weakness, dizziness, intense thirst, nausea, headache, vomiting, muscle strain, and cramps (Occupational Safety and Health Administration, 2002).

According to the Occupational Safety and Health Administration (1999), exposure to low temperatures reduces sensory feedback, dexterity, blood flow, muscle strength, and balance. This may affect performance of complex mental and physical tasks and may even lead to potentially deadly side effects. Frigid surroundings decrease body heat, which may lead to a reduction of inner body temperature to dangerously low levels. Hypothermia is a common injury associated with low body heat from exposure to frigid conditions. This happens when the body loses energy faster than it is produced, thus dropping body temperature. Warning symptoms of hypothermia include numbness, stiffness, drowsiness, and loss of coordination (Occupational Safety and Health Administration, 1999). Frostbite is another common frigid injury, which typically affects the nose, ears, cheeks, fingers, and toes. The low temperature constricts blood vessels, which weaken blood flow and may cause permanent tissue damage. If damage is only to the skin and underlying tissue, complete recovery may be expected. However, if blood vessels are affected, this may be permanent and could lead to amputation of the affected part (Occupational Safety and Health Administration, 1999).

Ventilation and humidity also play a significant role in affecting the work environment. According to Galer (1987), workplaces with improper ventilation and temperature controls may result in loss of productivity, efficiency, and discomfort. They may also facilitate the occurrence of illnesses and increase the potential for human error. Overheated work environments may cause fatigue and lack of concentration, while excessive cooling may induce restlessness. Both conditions may lead to increased human errors and reduced performance. Hence, the maintenance of a comfortable thermal environment is essential (Morris & Dyer, 1998).

Ergonomic Assessment Methods

To assess the physical risks involved, which may lead to MSDs, there are several posture-based ergonomics methods, which are currently available. The use of established ergonomic assessment methods that are designed for specific body parts include the rapid upper limb assessment (RULA), the rapid entire body assessment (REBA), and the Moore-Garg strain index. These assessment methods are used to allow the risk factors of the process to be quantified and eventually prioritize the need for improvements.

Rapid Upper Limb Assessment (RULA). The RULA is a survey method, which was developed to be used in ergonomic assessment of workplaces where work-related upper limb disorders are identified or suspected (see Figure 1). It is a screening tool used to assess postural force exertion on the upper extremities with particular attention to the cervical portion of the spine, neck and muscle activities that contribute to MSD injuries. The RULA is a quick ergonomic assessment method, requiring zero instruments and minimal training. The general purpose of such an assessment method is to generate a scoring system based on observations, which include repetition, posture, joint angles, and exerted muscle force. This scoring system is then used to identify the exposure level and the appropriate required counter measures. The RULA is only a screening tool and is intended to be used as part of a broader ergonomic study (McAtamney & (McAtamney & Corlett, 1993). The analysis may be conducted before and after the implementation of control measures to demonstrate that the instituted control measures have worked to lower the risk of injury.

The RULA assessments are performed based on observations of the upper limbs and body postures of an employee performing a specific task. The assessment is focused on task duration, extreme joint angles, the exerted force on a specific limb, and how frequently the task is being performed. To select the postures to be assessed in the RULA worksheet, the body is divided into two groups. Group A includes arms, forearms, and wrists and group B includes the legs, the trunk, and the cervical portion of the spine. By means of the tables associated with the method, a score is assigned to each bodily zone as identified above (i.e., legs, wrists, arms, forearms, cervical portion of the spine and trunk). Once the values from group A and B have been calculated by adding muscle use and exerted force, they are used to determine a final score using Table C. The RULA assessment score from Table C will then refer to a list of correlating recommendations (McAtamney & Corlett, 1993). The score recommendations are designed to indicate possible ergonomic control measures to lower the overall score. The RULA includes instructions of use within the document. An example displayed below is the RULA assessment worksheet provided by Practical Ergonomics based on the methods of McAtamney & Corlett, Applied Ergonomics 1993, 24(2), 91-99.

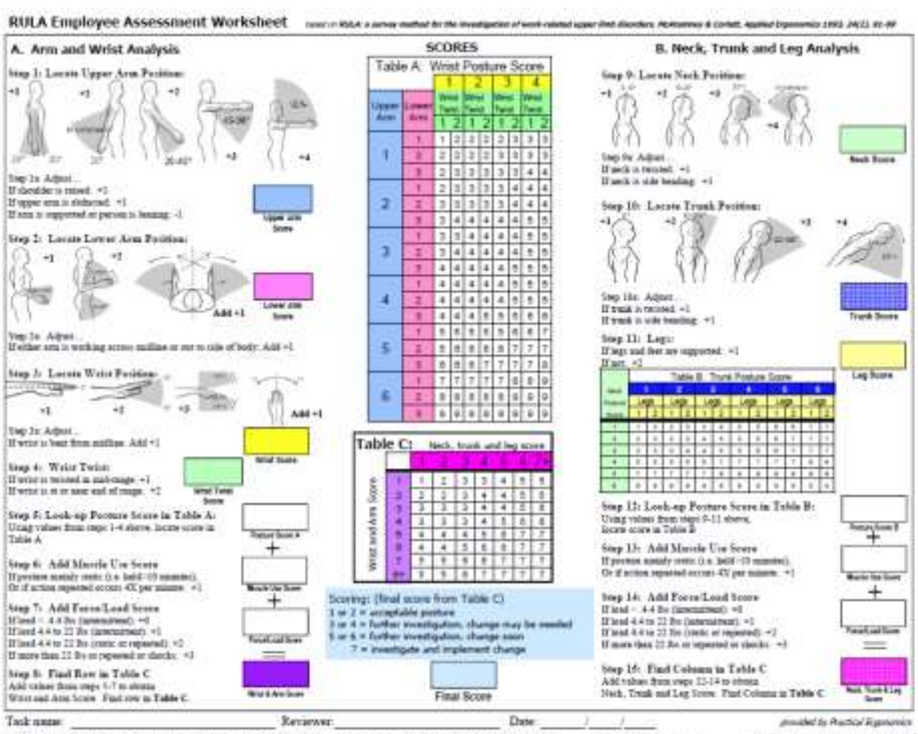

Figure 1: RULA Employee Assessment Worksheet

Rapid Entire Body Assessment (REBA). The REBA is a survey method developed to be used in ergonomic assessment of workplaces where work-related entire body disorders are identified or suspected (see Figure 2). The REBA is a screening tool, which requires no instrument and minimal training to perform an assessment. It is an ergonomic assessment tool targeted at an employee and his or her work environment. The general purpose of the REBA assessment method is similar to the RULA, in that a score is generated based on observations regarding the presence of repetition, posture, and muscle force issues for the entire body. Calculated final scores are then compared to standards or other tasks (Hignett and McAtamney (1995).

To perform the REBA assessment, observations are completed of the body posture, the parts that are frequently used, and any instances of extreme joint angles, task duration, and exerted forces. To select the postures to be assessed in the REBA, the body is divided into two groups. Group A includes legs, trunk, and cervical portion of the spine and Group B includes the lower arms, upper arms, and wrists. By means of the tables, a score is assigned to each bodily zone as indicated above (legs, wrists, arms, cervical portion of the spine and trunk). Once the values from group A and B have been calculated by adding muscle use and exerted force, they are then used to locate a final score from Table C (Hignett and McAtamney (1995). This final score from Table C corresponds to a list of related recommendations. An example displayed below is the RULA assessment worksheet provided by Practical Ergonomics based on the methods of Hignett, McAtamney, Applied Ergonomics 31 (2000) 201-205.

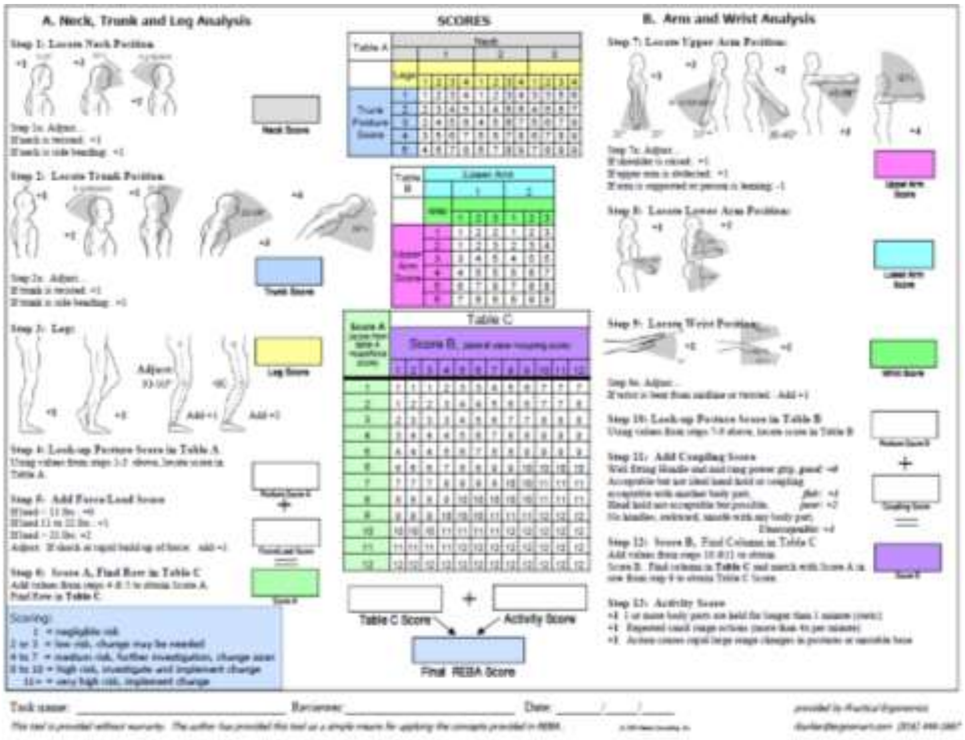

Figure 2: REBA Employee Assessment Worksheet

Moore-Garg Strain Index. According to the American Industrial Hygiene Association Journal, the Moore-Garg Strain Index is a proposed method to examine tasks for risk of distal upper extremity disorders (see Figure 3). It is a semi-quantitative analysis method in which most aspects are quantitative, but there are several measures which are qualitative. The calculation of the score is based on multiplicative interactions among task variables that are consistent with currently accepted physiological, biomechanical, and epidemiological principles. Although not specifically intended, it may also be used to predict the occurrence of distal upper extremity symptoms. The tool should be used to evaluate the specific tasks on a task and not individual performance. The prediction of hazardous tasks is based largely on the belief that localized muscle fatigue is a contributing factor to distal upper extremity injury (Moore & Garg, 1995).

To perform the strain index assessment, a duty is divided into distinct tasks. Each task will then be assessed for six individual strain index risk factors which include hand/wrist posture, frequency of task, its duration per day, repetitions per minute, and the intensity and duration of the exertion. For each risk factor, the rating is noted. The strain index is the product of the six ratings. Assessment is conducted for both right and left hand. (Moore & Garg, 1995). The final calculated rating will then be located on the index worksheet and defines the severity level. An example is the strain index assessment worksheet provided by Thomas E. Bernard based on J. Steven Moore and Arun Garg, The strain index is a proposed method to analyze duties for risk of distal upper extremity disorders (1995) and is presented below in Figure 3.

Moore-Garg Strain Index

Job / Task:

Date:

Analyst:

SI Score	Interpretation
< 3	Safe
3-5	Uncertain
5-7	Some Risk
> 7	Hazardous

Product of all multipliers

SI = **0.0**

Variable	Rating Criterion	Observation	Variable Multiplier	Enter Multiplier
Intensity of Exertion	Light	Light: Barely noticeable or relaxed effort (BS: 0-2)	1	
	Somewhat Hard	Somewhat Hard: Noticeable or definite effort (BS: 3)	3	
	Hard	Hard: Obvious effort; Unchanged facial expression (BS: 4-5)	6	
(BS is Borg Scale)	Very Hard	Very Hard: Substantial effort; Changes expression (BS: 6-7)	9	
	Near Maximal	Near Maximal: Uses shoulder or trunk for force (BS: 8-10)	13	
Duration of Exertion (% of Cycle)	< 10%		0.5	
	10-29%		1.0	
	30-49%		1.5	
	50-79%		2.0	
	> 80%		3.0	
Efforts Per Minute	< 4		0.5	
	4 - 8		1.0	
	9 - 14		1.5	
	15 - 19		2.0	
	> 20		3.0	
Hand/Wrist Posture	Very Good	Perfectly Neutral	1.0	
	Good	Near Neutral	1.0	
	Fair	Non-Neutral	1.5	
	Bad	Marked Deviation	2.0	
	Very Bad	Near Extreme	3.0	
Speed of Work	Very Slow	Extremely relaxed pace	1.0	
	Slow	Taking one's own time	1.0	
	Fair	Normal speed of motion	1.0	
	Fast	Rushed, but able to keep up	1.5	
	Very Fast	Rushed and barely/unable to keep up	2.0	
Duration of Task Per Day (hours)	<1		0.25	
	1 - 2		0.50	
	2 - 4		0.75	
	4 - 8		1.00	
	> 8		1.50	

Figure 3: The Moore-Garg Strain Index

Source: J. Steven Moore and Arun Garg, The Strain Index: A proposed method to analyze jobs for risk of distal upper extremity; disorders *Am. Ind. Hyg. Assoc. J.* 56:443-458, 1995.

Anthropometric Measurement

Anthropometry is the science of measuring human dimensions comparatively. It is a tool used to measure physical attributes such as body size, weight, and proportions in a population, which is then used in designing work places. The purpose of anthropometry is to obtain values for movements and body consumption of an individual (Lohman, Roche & Martorell, 1988; Gibson 1990). The commonly used measurements are stature (i.e., height, length) and body weight. These measurement values are also known as anthropometric data (Simko, Gilbride, & Cowell, 1984).

Anthropometric measurement indicates variations in physical dimensions and the gross composition of the human body (Gibson, 1990). The appropriate amounts of body composition are based on body size, usually weight and height. Measurement of these dimensions among a population form a statistical data set. A statistical spread of this data can also be expressed as a percentile (Lohman, Roche, & Martorell, 1988).

It is common practice to design for the range from the 5th percentile female to the 95th percentile male. The 5th percentile female value for a particular dimension (e.g., sitting height) usually represents the smallest measurement for design in a population. Conversely, a 95^{th} percentile male value may represent the largest dimension for which one is designing. The 5th percentile to 95th percentile range accommodates approximately 90% of the population (Lohman, Roche, & Martorell, 1988). For a listing of form weight, height, and selected body dimensions of adults 1960-1962, refer to Table 1 highlighting data from the National Health Survey (1965).

Table 1: Selected Anthropometric Features of Adults

Selected Anthropometric Features of Adults						
	Male Percentile			**Female Percentile**		
Body Feature	**5th**	**50th**	**95th**	**5th**	**50th**	**95th**
Height	63.6	68.3	72.8	59	62.9	67.1
Sitting Height, Erect	33.2	35.7	38	30.9	33.4	35.7
Sitting Height, Normal	31.6	34.1	36.6	29.6	32.3	34.7
Knee Height	19.3	21.4	23.4	17.9	19.6	21.5
Popliteal Height	15.5	17.3	19.3	14	15.7	17.5
Elbow-Rest Height	7.4	9.5	11.6	7.1	9.2	11
Thigh Clearance Height	4.3	5.7	6.9	4.1	5.4	6.9
Buttock-Knee Length	21.3	23.3	25.2	20.4	22.4	24.6
Buttock-Popliteal Length	17.3	19.5	21.6	17	18.9	21
Elbow to Elbow Breadth	13.7	16.5	19.9	12.3	15.1	19.3
Seat Breadth	12.2	14	15.9	12.3	14.3	17.1
Weight in lbs.	126	166	217	104	137	199

Anthropometric measurement is used widely in industries to design adequate workplaces for maximum efficiency. Ineffective design of the workplace contributes to numerous musculoskeletal injuries each year. Inadequate ergonomically designed or mismatched chairs and workbenches may cause fatigue and discomfort, circulation problems, and pressure on nerves. The dimension of a workplace is determined by its worker. The problem is that people vary significantly due to body size, gender, ethnic origins, and with age (Gibson, 1990).

Ergonomic Instrumentation

Various ergonomic assessment tools have been developed to assess exposure to awkward posture. Observation methods are usually not difficult to implement, are not in conflict with the work processes, and do not require expensive equipment (Karwowski, Genaidy, & Asfour, 1990). McAtamney and Corlett (1993) designed the RULA to investigate work-related upper limb disorders. This method uses diagrams of body postures and scores from three tables for assistance in the assessment of risk factors, such as repetition, static muscular work, force, position, and time, without solution of continuity. Only pencil and paper are needed to complete this analysis, which is mainly applicable to sitting-oriented tasks (McAtamney & Corlett, 1993). The REBA was created by Hignett and McAtamney (1995). While based on the RULA, this tool is used to assess dynamic or static postures. This tool is used to divide the body into segments and codes individually using a scoring system. These results are then combined with the REBA activity score, which involves action at the level of urgency. This combination will then provide a final score of the assessment (Hignett & McAtamney, 1995). The strain index was proposed by Steven Moore and Arun Garg, (1995). This is a semi-quantitative tool that allows the measurement of hazards for each hand by dividing a job into distinct tasks. Tasks are then assessed for six job risk factors and based on the evaluation, a strain index score is generated which then assists to identify areas that require immediate attention.

Video task analysis (VTA) is a relatively new tool which is used to assess the posture of a worker through observation. VTA is based on an exposure assessment program, which may be used to perform time and motion studies and ergonomic analysis from videos. In relation to the carriage, VTA allows the assessment of any predetermined position in a continuous period. Advantages of the systems of video include the ability to observe the posture in real time, forward to backward movement, and in slow motion, if necessary. The possible effects of the presence of observers is avoided because the movement of the body may be camera recorded (Li & Buckle, 1999). Slowing down or stopping the video allows specific observations to occur. High portability, the reasonable cost of equipment, and the generation of permanent recording of the activity are further advantages. Disadvantages may include extended analysis times if the task parameters are in detail (Li & Buckle, 1999). In addition, the camera setup may be limited in its ability to record dynamic body positions at certain angles, which may not be suitable for the estimation of the posture. The classification criteria of posture are not always well-defined (Li & Buckle, 1999) which essentially means that the assessors may need to interpret the worker's posture.

Ergonomic Control Measures

Ergonomic control measures include any process, procedure, system, or device that are intended to eliminate or prevent potential risks that result in MSDs or to mitigate the consequences of any injuries that may occur (Konz, 1983). The major forms of ergonomic controls consist of engineering and administrative approaches as well as personal protective equipment.

Engineering controls. According to NIOSH Workplace Safety and Health, (n.d.) engineering controls refer to a physical modification of a task, workstations, tools, equipment, or processes. They are considered a reliable means of control within the work environment as long as they are used and maintained properly. Engineering controls provide assistance to reduce the exposure of risk at the source by eliminating variables such as employee incompetency, inexperience, inefficient training, or human error. Implementing engineering controls may increase the company's initial capital cost compared to administrative or PPE approaches, but will assist in reducing future direct or indirect costs. Several of the common engineering controls at the workplace include:

1. Redesigning workstation layout,
2. Introducing lifting mechanisms on workstation desks to provide height adjustability,
3. Providing ergonomic hand tools with improved grip, reducing the force exertion on an employees' hands,
4. Using a hydraulic lifting device to raise products above the employee's shoulder level,
5. Reducing vibration effects by replacing a hand grip with a robotic arm,
6. Reducing source noise by designing an enclosed box with sound damping material,
7. Changing the operation process or redesigning the workstation assembly sequence, thereby reducing the repetitive use of the muscle or joint, and
8. Modifying machines and introducing automation to reduce repetition, awkward posture, and duration of exertion. For example, it may be an option to create a fixture to hold several parts to crimp and using Java code programming to maintain the quality of the part (Karwowski, & Marras, 2003)

Administrative controls. Administrative controls are workplace policies, procedures, and practices, which control or prevent exposure to potentially harmful effects by implementing administrative changes such as task rotation, task enlargement, recovery breaks, task speed adjustment, the redesign of task methods, and employee education. Administrative controls are considered less effective than engineering controls because they do not reduce the hazard directly at the source, but instead reduce the frequency and duration of risk exposure. Administrative controls are applied when engineering controls are either not effective or cost efficient (Konz, 1983). Various common administrative controls at the workplace include:

1. Training employees concerning improved operation process and reducing human error,
2. Adding a number of employees to perform a heavy lifting task,
3. Introducing updated policies and procedures concerning workstation housekeeping to reduce the potential risk of slips, trips, and falls,
4. Reducing noise exposure by introducing a hearing conservation program,
5. Reducing the duration of exertion by introducing rest breaks and task rotation, and
6. Reducing excessive frequency, duration, and force on the body by prohibiting overtime (Karwowski, & Marras, 2003).

PPE. The use of PPE control does not eliminate the ergonomic-based hazard, but rather, it is used to reduce or minimize the exposure to a specific work related risk. This approach should be the last means of control when a hazard cannot be controlled directly at its source. PPE includes items such as gloves and kneepads, which provide support and reduce hazard exposure until other controls are implemented or to supplement existing controls. It is critical to ensure that introduced PPE controls fit the individual employee, are appropriate for the task, and do not contribute to extreme postures or force (Konz, 1983). Examples of common PPE controls that may be present at a workplace environment include:

1. Gloves, which protect the hands from injury or cold, but may also impede blood circulation, reduce dexterity, and increase force exertion if not fitted properly;
2. Ergonomic anti-fatigue mats, which provide relief from musculoskeletal fatigue that develops from prolonged standing on hard floor surfaces. If not maintained properly or used in an appropriate area, mats could increase potential risk of tripping and falling or the building of a static charge, and

3. Knee protection pads that may be used to avoid prolonged contact with hard or sharp surfaces. Knee protection pads should be well-padded, well-fitted to the individual without impeding blood circulation, and should cover the entire knee (U.S. Dept. of Labor, Occupational Safety and Health Administration, 2003).

Administration of Symptom Surveys

A symptom survey is an important tool structured to collect both quantitative and qualitative data that may be missed in general medical exams and reports. The quantitative data are in the form of closed questions that require simple marking of the most appropriate answer (Gile, n.d.). For example, the identification of specific parts of the body, which was experienced pain. The qualitative data are in the form of open-ended questions used to collect additional information about the experienced symptoms as brief comments. For example, describing the date, location and the activity was carried out, when the first symptom experienced. This technique is used in this study to identify the location, period of discomfort, and degree of pain that employees may be experiencing at work. The symptom survey is confidential and the data are used to determine the root cause of these symptoms and risk factors posed to employees that may lead to an injury. If needed, it can also be used for early detection of MSDs to determine information relating to pain and discomfort of employees (Cohen & National Institute for Occupational Safety and Health, 1997). An example of the symptom survey sheet can be found in Appendix D.

Loss Analysis

Loss analysis is the process of examining records of past losses and missed opportunities that the company has sustained (Wiening, 2002). 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). A loss analysis will assist the researcher to categorize the past reported injuries, which will reveal a trend of more frequent or severe injuries that have been occurring. Loss analysis provides an evaluation of risks and procedures, which will act as a direction manual to manage those risks and will help the management to make decisions that relate to the organization's future operations (Molak, 1997).

The Occupational Safety and Health Administration (OSHA) require employers to maintain OSHA 300 and 300A logs of Work-Related Injuries and Illnesses (OSHA, 2004). The loss history is for the classification of occupational accidents and illnesses, and the severity of the particular uses. If the injury or illness occurs, the company records the specific details of what happened (Safety and health statistics, n.d.). Data recorded in OSHA log 300 are then used by the company as a lagging indicator to measure the OSHA Recordable Incident Rate (RIR), which allows the company to compare its RIR to industry statistics and identify problems within the workplace (Fessler, 2007). The incident rate can be determined by calculating the total amount of recordable injuries and illnesses that occurred within the company during that year by the number of hours worked by all employees (OSHA, 2004). This number is then multiplied by a given factor of two hundred thousand and the final provided numerical value will be the company's recordable incident rate. Even though recordable incident rate is considered to be a valuable indicator of the company's safety performance, it never adequately addresses the importance of variation within the calculated rate. This can cause the company to miss vital risks hidden within the data that can help improve safety performance (Fessler, 2007).

Like OSHA RIR, another valuable lagging indicator widely used in loss analysis is financial loss because of an accident, injury or illness. If dollars are involved in a discussion, there is much more involvement of management as it becomes a business strategy, rather than a safety concern (Fessler, 2007). The financial loss of accidents can be measured and controlled. Medical and Insurance are the two major categories, the cost can be broken into. However, to calculate actual cost of an accident, other indirect costs need to be included. These costs include but are not limited to property loss, tools and equipment damage, downtime, litigation expenses, credibility loss, labor replacement, increased overtime, training new employees, and workers' compensation cost (Fessler, 2007). The worker's compensation records include the description of the injuries and illnesses suffered and the areas affected, which provide assistance during loss analysis. This enables departments and tasks to be identified and categorized into the most reoccurring injuries and those with the highest financial loss (Putz-Anderson, 1988).

Summary

The literature review highlights that risk factors such as force exertion, posture, repetition, joint angles, and vibration may affect the human body differently but may also contribute to the development of musculoskeletal disorders. This disorder is of great concern for the manufacturing industry, as these risk factors may exist within the working process. Various ergonomic tools such as the RULA, the REBA and the Moore-Garg Strain Index can provide assistance to identify and analyze these risk factors in the workplace. Information collected from symptom surveys and loss analyses are also key identifiers of potential ergonomic risk factors. Ergonomic symptom survey can be used in this study as a proactive indicator whereas analysis of past losses as reactive. Both indicators can provide a great support to the ergonomic tools in order to determine the degree of risk, and assist in identifying the risk factor requiring immediate attention. It is important that the assessment is performed using ergonomic tools designed to assess the degree of risk to which the employees are exposed, which is critical for creating a baseline for comparison after the controls have been implemented. Utilization of these quantitative and qualitative assessment methods will enable the company to identify the risk, and to analyze, prioritize, and recommend changes to current working procedures to reduce the risk exposure to their employees. Once exposures and risks have been identified and assessed, the hierarchy of control is used to reduce or eliminate risk. The hierarchy of means to eliminate ergonomic-based hazards includes engineering, as well as administrative controls, and the use of personal protective equipment.

Chapter III: Methodology

The purpose of this study was to assist Company XYZ's management in the identification and correction of workplace conditions and ergonomic risk factors that might expose employees to an increased risk of developing MSDs. To fulfill this purpose, certain goals were set for this study, including;

1. Assess the process, procedures, and tasks that employees perform within the shipping department of Company XYZ
2. Analyze the types of ergonomic-based injuries that employees have reported to their supervisors for the past three calendar years
3. Determine the types of musculoskeletal symptoms that employees are experiencing during their work activities at Company XYZ

In this chapter, the researcher discusses several quantitative tools used to assess the ergonomic risks of various tasks, and determines the degree of magnitude involved. Other data collection and analysis methods used in this study include loss analysis and employee symptom surveys.

Subject Selection and Description

The selection of three subjects for this study was based on their expertise at work and willingness to participate in the study. At Company XYZ, it requires up to six workers to perform the manual process of loading bundles of corrugate onto a machine. Exposing employees to ergonomic risk factors, the excessive amounts of force and repetitions required in that process were a matter of concern. Prior to subject selections for assessment, the researcher developed a subject consent form (see Appendix E). The form clearly stated that all participation is voluntary and all acquired data including images or videos would not reveal the subject's identity. It also states that all records from this study are confidential, stored in a secured location, and will be deleted or destroyed once the study is concluded.

The researcher selected the subjects from each observed flow cell, based on experience and expertise required to perform the task. A flow cell is a single production line, or multiple production lines, organized in a U formation to have one-piece flow without generating any waste. Each flow cell utilizes a maximum of six workers to perform the complete operation. The three subjects selected, volunteered to participate the day the study was conducted. They did not object to electronic video recording, digital imaging or answering any queries if asked by the researcher for the study. Subjects were provided the option to withdraw from this study at any time and for any reason. Before conducting any assessments or observations, the researcher introduced the subject consent form (see Appendix E) to the volunteers, explained the rights and the purpose of this form, and subsequently asked them to approve it with their signature. After the subjects signed the consent form, the researcher explained the ergonomic symptom survey form to the volunteers, had them complete it, and submit it back. The researcher applied the above-mentioned observation criteria to ensure that the collected data provided an accurate representation of practices performed by the selected subjects. Volunteers were given assurance that all documented information from this study would be kept confidential and would be used exclusively for this study.

Instrumentation

The researcher conducted the literature review of this study to analyze the risk factors responsible for MSDs and CTDs. The researcher selected the most useful ergonomic assessment methods to identify and analyze the operational processes of company XYZ. Selected ergonomic assessment methods include the RULA, the REBA, the Moore-Garg Strain Index, and visual observation. The RULA is a quantitative screening assessment method which utilizes a scoring system based on observations to evaluate repetition, posture, joint angles, and muscle force of the upper extremities. This scoring system is later utilized to measure individual ergonomic tasks and to identify appropriate corrective actions respectively.

The REBA assessment method is similar to the RULA, where an observation concerning repetition, joints, posture, and muscle force on the entire body generates a numerical score. This calculated score is subsequently compared to the standard operating procedures of other tasks within the company. To conduct the REBA assessment, observations are completed on the limbs and body postures being used frequently, extreme joint angles, task duration, and forces that are being exerted. Each of the upper extremities is then rated and the control measures are recommended based on individual rating.

The Moore-Garg Strain Index is a semi-quantitative task analysis method, used to evaluate the specific task, and not the individual worker performing the task. The evaluation provides assistance in the prediction of hazards involved. The prediction is largely based on the assumption that muscle fatigue is a contributing factor to distal upper extremity injury. A final score is generated based on multiplicative interactions among the task variables, consistent with currently accepted physiological, biomechanical, and epidemiological principles.

An electronic scale, a digital camera, and a digital video recorder are crucial set of tools used to provide accurate representation of the collected data. A weighing scale and a digital Vernier caliper are useful assessment tools, as well, to identify the weights of products, as well as required thickness of the materials and tools. Digital camcorders and cameras are the assessment tools considered essential for the study and such devices capture employee operation methods, movements, joint angles, and postures. The researcher utilized these visual-oriented tools to review the essential components involved within the task. The components include behavior, frequency and duration with the intent of minimizing the possibility of inaccuracy and human error. Other tools include a 25-foot tape measure, a laptop computer, and a standard desktop computer.

Data Collection Procedures

The researcher from each assessed flow cell conducted a selection of subjects for this study. After the subjects provided their formal consent to participate in the study, they were directed to perform their routine standard work. As subjects were performing the task, the researcher compiled a list of the practices involved in a task, and photographed/video-recorded all the body movements, postures, joint angles, and the work environment of subjects during each task observation. The following paragraphs outline the steps performed by the researcher for data collection, by means of assessment tools.

An electronic scale was used to measure the weights as well as thickness of the various materials used by the subjects while performing regular tasks. It provides accurate data to determine which individual tasks entail maximum lifting, and the appropriate thickness of the tool required to perform the process. Such data will then aid the researcher in recommending proper lifting solutions as well as adequate tool design.

Video analysis is the process of using a digital video recorder to capture the subjects performing the task. The researcher used multiple angles while videotaping, to obtain accurate postures, joint angles, extension, and flexion. Video analyses aid the researcher in delineating each process into steps, and allow further analysis in real time or at a reduced speed to increase accuracy of the analyzed data.

Image analysis is the process where digital photos are captured using a digital camera. During the process observations, multiple still photos were captured to determine angles of extension, flexion, abduction, adduction, and reach. The image analysis assists the researcher to describe posture as well as joint angles, and allows the collection of data with a high degree of accuracy. All attempts were made to avoid capturing employees' faces while taking videos and photographs. All videos and photographic records were stored in a locked location, and were deleted or destroyed at the conclusion of the study.

Completing the REBA survey:

While completing the REBA assessment process, the researcher performed the following actions:

1. Observe the entire process cycle to become familiar with the work practices and procedures
2. Select and appropriately record postures, muscle activity, range of motion, exerted force on muscles, coupling, extensions and flexion involved in performing the task in each observed flow cell
3. Evaluate postures with exerted force and fitting coupling for sections A and B using appropriate tables
4. Calculate a coupling score, determined by the quality of the grip on the object being handled
5. Generate a single score by combining sections A and B
6. Calculate an activity score by combining the single scores of sections A and B with section C to provide a final REBA score

7. Identify the risk level of each observed process based on the final REBA score, ranging from low, to moderate, to high
8. Determine interventions, action levels, or required controls based on the identified risk levels
9. Post interventions, implemented controls, and completed another REBA worksheet to monitor the performance and risk levels.

Completing the RULA survey:

While completing the RULA assessment process, the researcher performed the following actions:

1. Observe the entire task to become familiar with the work practices and procedures
2. Evaluate and appropriately record postures, muscle activity, range of motion, extension, flexion, and exerted force involved in performing the task in each flow cell
3. Identify specific process that included assessment of the body postures
4. Determine the score of each posture for individual body parts for both sections A and B of the RULA worksheet
5. Enter scores in the appropriate table per the instructions on the assessment score sheet,
6. Add muscle use and exerted force to calculate individual score of sections A and B
7. Combine sections A and B scores to produce a final RULA score
8. Evaluate risk level of each process based on the final RULA score, ranging from low, to moderate, to high
9. Determine interventions, action levels, or required controls based on the identified risk levels

10. Post interventions, implemented controls and completed another RULA worksheet to monitor the performance

Completing the Moore-Garg Strain Index

While completing the Moore-Garg Strain Index assessment process, the researcher performed the following actions:

1. Observe the entire task process to become familiar with the work practices and procedures
2. Identify and appropriately record postures, range of motion, speed, frequency, and duration and intensity of exerted force involved in performing the task for each flow cell by the subjects
3. Base the calculation of the score on multiplicative interactions among the task variables, the multipliers of which are from lookup tables
4. Calculate the final score by utilizing the strain index formula. According to the formula, strain index is a product of intensity of exertion multiplier, duration of force exertion multiplier, exertions per minute multiplier, posture multiplier, speed of work multiplier, and task duration per day multiplier
5. Correlate the final strain index score to the risk levels of developing distal upper extremity disorders
6. Determine interventions, action levels, or required controls based on the identified risk levels
7. Post interventions, implement controls, and complete another strain index worksheet to monitor performance

The researcher used an ergonomic symptom survey (Appendix D) to identify any potential health injuries that may be associated with the operation involved in the packaging line. It is a tool structured to collect both quantitative and qualitative data that may be missed, as the subject might feel reluctant to reveal such information in-person. The researcher instructed the subjects to complete the form, and submit it back in-person the same day before the shift ends. Subjects were directed to omit their names from the form and were assured that the information would be kept confidential, anonymous, and protected from all outside access. The researcher also assured the volunteers that all the collected information would only be used to conduct this study, and would be destroyed once the study was complete. The symptom survey was collected for all volunteered subjects.

Company XYZ's loss history data for the past three years was collected and analyzed to allow the researcher to identify what percent of injury and illness losses Company XYZ was sustained. The researcher ensured that no employee names would be included in the loss records received from the company. This loss analysis process included a review of Company XYZ's OSHA 300 log, first aid logs and the worker compensation cost involved for each injury or illness. It also included documented reports of all previous ergonomic assessments conducted in the years 2009, 2010 and 2011.

Data Analysis

The primary purpose of this study was to investigate Company XYZ's specific flow cells and identify potential ergonomic risk factors that were present. The data collection process was conducted in three different stages. Stage one involved an analysis of Company XYZ's past injury and illness losses. Such analysis was then used to identify which department had the highest loss percentage and what the target body parts were. Loss-based data which was collected and analyzed served as a form of prep work before the observational assessment was conducted. Stage two involved the collection of information from each volunteered subject using ergonomic symptom surveys. The researcher believed that this was a vital piece of information that could potentially be missed during redesign of the workstation. Stage three involved evaluation of potential risk factors, which were identified using video as well as image analysis and ergonomic assessment tools. Using information which was gathered during the literature review, video analysis, symptom surveys, and collected data during loss and process analysis, the researcher identified which flow cell required immediate attention, and what major potential risk factors were involved in a particular task. The findings of this study are published in the results section of this investigation.

Limitations of the Study

There are a number of limitations identified in this study as follows:

1. Employees' willingness to participate may alter the results.
2. This study is limited to shipping area from 4/1/13 to 5/1/13.
3. The REBA, the RULA, and the Moore-Garg strain index assessments are initial screening tools.
4. The findings, conclusions, and recommendations for this study are only applicable to Company XYZ's specific flow cell processes.

Chapter IV: Results

The purpose of this study was to assist in the evaluation of task demands and workstation characteristics that may contribute to MSDs of the spine and upper extremities. For the purpose of this study, the researcher focused on a packaging line for the ergonomic evaluation. The packaging line was under observation for one week and involved task monitoring, process evaluation, and assessment of ergonomic risk levels with selected subjects.

The report includes comments, observations, and estimations of potential risk factors existing in the workplace. The goals of this study include:

1. Assess the process, procedures, and tasks that employees perform within the packaging line of Company XYZ
2. Analyze the types of ergonomic-based injuries that employees reported to their supervisors for the past three calendar years
3. Determine the types of musculoskeletal symptoms that employees are currently experiencing during their work activities at Company XYZ

The methodology used in this study to collect data for the RULA, the REBA and the Moore-Garg Strain Index assessment was performed by delineating the packaging line process into the inventory, packing, and labeling sections. The selected subjects were observed performing their routine tasks on different days. The subjects chosen for the workstation assessment were a female and two males and their heights were 5’4”, 5’7” and 6’respectively.

Work Activity Description

To begin packaging, the first subject starts by unloading an open blue plastic container filled with parts onto a cart from an inventory storage rack. The container was located on the second shelf of the three shelve storage rack, which is 42 inches off the ground. Container weights differ based on type and number of parts. The average weight of the blue container is 22 pounds. The gap between shelves is 18 to 26 inches and the highest shelf is 62 inches off the ground. While loading and unloading containers, it was observed that the employee must flex his/her spine, overextend the neck and lift above the shoulder, thus resulting in an awkward posture of the upper extremities. Next, the parts within the containers were scanned resulting in a forward flexion of the neck and spine by fifteen and ten degrees respectively. The scanned parts were then carried to a cart and it was observed that the subject must abduct the shoulders and exert the forearm flexor muscles of the lower arms while lifting. Lastly, the parts are packaged using the tape machine, causing ulnar deviation of wrists to approximately twelve degrees as well as significant exertion by bicep muscles on the upper arm. This process is repeated once every five to six minutes.

The second subject fan-folds the cardboard manually into a box. The box is then filled with parts based on customer specification from the blue containers causing shoulder abduction and flexion of the neck by approximately twelve to fifteen degrees. The filled box is then lifted and placed on an electronic weighing scale. The scale rests on a table that is 42 inches off the ground and the average weight of the box is 35 pounds. It was observed that the subject lifted the box to waist height (i.e. ergonomically recommended area for lifting object as defined by NIOSH) but extended his spine backward while carrying it to the foam table. The inside of the box is sprayed with liquid foam causing the shoulder to abduct while lifting the foam gun, and a wrist ulnar deviation of approximately fifteen degrees while spraying. During this process, the subject must wear proper gloves to protect his/her hands from the hot steam generated as a result of the chemical reaction and to place pressure on the foam to keep it from inflating outside the box. It was observed that the employee was required to abduct his shoulder and exert the bicep muscles of the upper arm to apply pressure on the foam. Next, the box is taped manually on one side using a hand-held tape machine. During this process, it was observed that the subject using the tape machine experiences ulnar deviation of approximately twelve degrees on the wrists and a forward flexion of fifteen degrees on the neck and spine. Next, the subject rotates the box on the table to tape the other side. During the box rotation process, it was observed that the subject performs radial deviation of approximately fifteen degrees on the wrists and flexes the spine forward approximately twenty degrees. At this time, there is a pronation of the forearm of the subject when placing the box onto the conveyor, which is approximately five feet away from the 42-inch tall foaming table. If the second subject begins to fall behind during the packing process and there is a low volume of boxes to be labeled by the third subject, the packing process is shared by the third subject to maintain the desired rate of production.

The third subject then removes the box from the conveyor belt and walks it to the labeling table where first it is weighed and then labeled. During this process, it was observed that the employee must overreach to grip the box on the conveyor and to attach a required paper document to the appropriate box, which resulted in an overextension of spine and neck. The labeling table is height adjustable and it is positioned ten feet away from the mail cart. The platform of the mail cart is two feet off the ground. It was observed that while filling the mail cart, the first row of boxes on the platform cause the subject's spine to flex twenty degrees and the neck fifteen degrees forward, whereas the second and third row cause the subject's spine to flex fifteen and ten degrees and the neck twelve and eight degrees forward respectively. The maximum height of the stacked boxes cannot exceed five feet off the ground according to company regulations.

Analysis of Collected Data

Goal number one. The first goal of this study was to assess the process, procedures and tasks that employees perform within the packaging line of Company XYZ. The researcher employed qualitative based tools such as the RULA, the REBA and the Moore-Garg Strain Index assessment method to collect data on the subjects performing the tasks involved in the packaging line.

Rapid entire body assessment (REBA). The extent of ergonomic risk involving the entire body was determined using the REBA assessment method. The REBA assessment method was used to evaluate each individual task and assess awkward postures, movements and repetitions that are involved while performing the activity. The researcher chose to employ the REBA as an assessment tool because it not only accounts for the body parts such as the neck, spine, arms, wrists and legs, but also includes coupling with tools and the worker's required range of motion. The ergonomic risk factors for the packaging process are categorized as very high, high, medium, and low risk levels. The completed REBA survey is displayed in Appendix A. The calculated weights of randomly selected boxes and blue containers used in this process during assessment are displayed in Table 2.

Table 2: Weights of containers in process 1

Serial number	Randomly selected box Weight (pounds)	Blue container (randomly selected) Weight (pounds)
1	23.06	24.13
2	50.12	20.3
3	31.23	23.52

Serial number	Randomly selected box Weight (pounds)	Blue container (randomly selected) Weight (pounds)
4	34.5	23.06
5	36.07	20.2
6	26.06	19.3
7	38.13	21.4
8	37.2	21.14
AVERAGE	34.546 ~ 35	21.63 ~ 22

The REBA assessment scores that were generated for all three subjects performing their tasks in the packaging line are displayed in Table 3. Figure 4 also projects a visual display of the scores generated for all three subjects using the REBA upper extremities worksheet.

Table 3: REBA worksheet scores

Subject	Neck/ Spine/Leg	Arm and Wrist	Coupling	Activity	Final
1	2	7	2	2	7
2	5	7	2	2	10
3	6	3	1	2	8

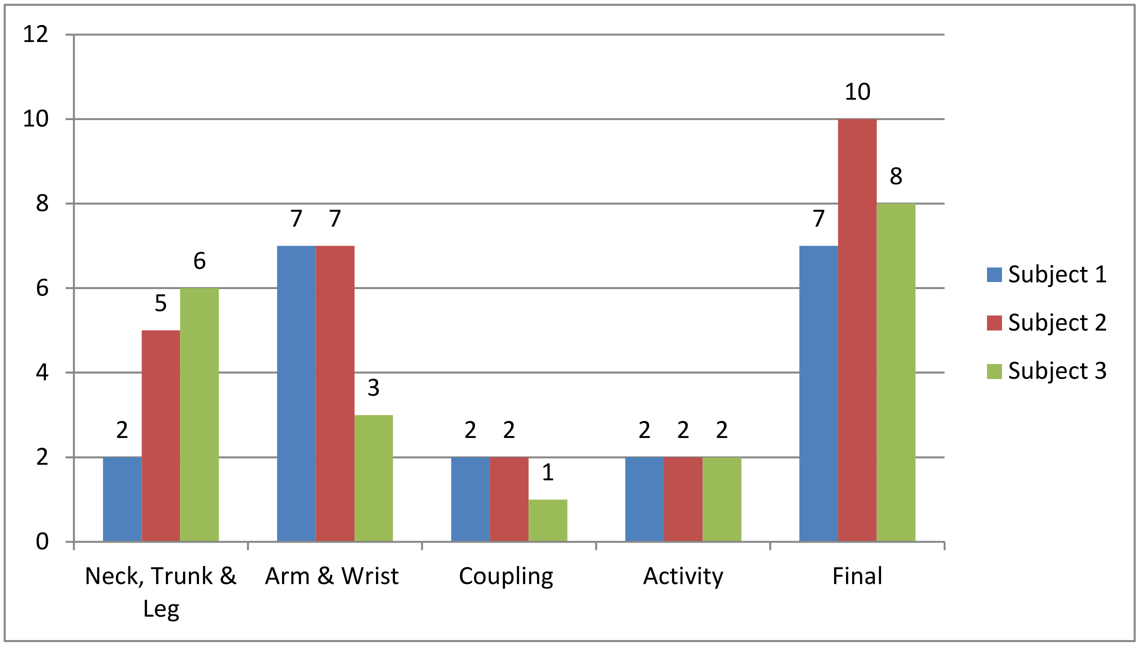

Figure 4: Rapid entire body assessment worksheet scores

Table 3 and Figure 4 above represent the individual section scores which were assessed from the REBA worksheet of each selected subject during the performance of routine tasks in the packaging line. Individual section scores for the wrists, arms, neck, spine, and legs along with proper handgrip and other activity scores were used to calculate the final score. The individual section scores displayed in Table 3 assist the researcher to categorize the process and the corresponding specific tasks that possess a high, medium, or low level of ergonomic risk. The standard REBA scoring system and their relevant ergonomic risk levels used during workstation assessment are displayed in Table 4.

Table 4: REBA scoring system

REBA Scoring System	Ergonomic Risk Level
1 = Negligible risk	Low
2 or 3 = change may be needed	Medium
4 to 7 = further investigation, change soon	High
8 to 10 = investigate and implement change	High
11 + = implement change	Very High

Data which is presented in Table 3 and Figure 4 indicate that the highest risk ergonomic factor in all three processes involve awkward postures related to flexing of neck and spine, pronation of wrists, abduction of shoulders and upper arm and a lack of support for the legs. The data in Table 3 also indicates that the final score for the process performed by subject two is ten on a scale of twelve. This indicates that the process performed by the subject poses a high risk of causing a MSD due to the presence of excessive range of motion, inappropriate tool grips, and static muscle exertion. With regard to Table 4, the REBA assessment score of subject two indicates that the process possesses a high ergonomic risk and there is a need to implement appropriate countermeasures. The REBA assessment score of subject three supports the scores of the first two subjects by confirming that the involved process contains a high level of risk due to constant lifting and inappropriate heights of the workstation, storage rack, and mail cart platform. The calculated scores, when compared to the REBA scoring system, indicate that appropriate countermeasures should be implemented to the process in the near future. The REBA score of subject one was used to determine that the process is a medium ergonomic risk level which indicates a need for improvement and may require changes over time.

Rapid upper limb assessment (RULA). Ergonomic risk involved in the upper extremities was determined using the RULA assessment method. The RULA assessment tool was employed to assess and evaluate each individual task and the postures, repetition, and exertion forces involved. The researcher chose to use the RULA as an assessment tool because it focused on the upper extremities of the body. Based on prior injury data and employee comments, the neck, shoulder, spine, and wrists have been major areas of risk in packaging tasks. The ergonomic risk factors for the packaging process are categorized as high, medium, and low ergonomic risk levels and the completed RULA survey is listed in Appendix B.

Table 5 and Figure 5 illustrate the RULA assessment scores that were generated for all three subjects performing their tasks.

Table 5: RULA worksheet scores

Subject	Arm and Wrist	Neck, Spine and Leg	Final
1	4	4	4
2	6	5	6
3	5	5	6

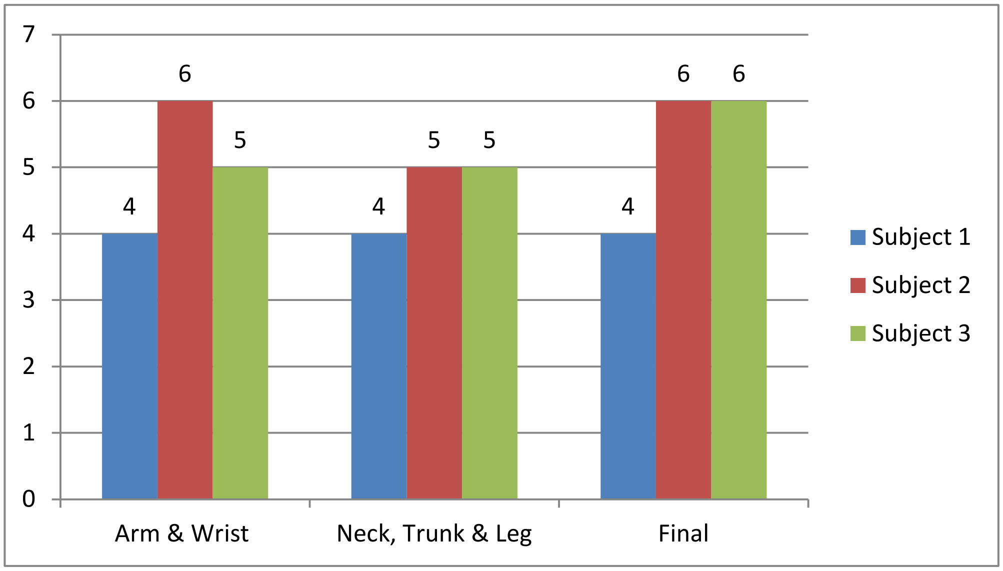

Figure 5: Rapid upper limb assessment worksheet scores

Table 5 and Figure 5 represent the individual section scores assessed from the RULA worksheet of each selected subject who was performing the packaging process. Individual section scores along with a final score for each subject aided the researcher in categorizing processes and specific tasks which possess a high, medium, or low ergonomic risk level.

Table 6: RULA scoring system

RULA Scoring System	Ergonomic Risk Level
1 or 2 = Acceptable posture	Low
3 or 4 = Further investigation, change may be needed	Medium
5 to 6 = Further investigation, change soon	High
7 = Investigate and implement change	Very High

Table 5 and Figure 5 indicate that one of the highest risk ergonomic factors in all three processes is the unnatural posture of the neck, spine, legs and wrists which were attained while performing the packing and labeling task. The data also indicates that the score for the packing process performed by subject two is five on a scale of eight for the neck, spine, and legs analysis section, and six on the arms and wrists analysis section of the RULA worksheet. This indicates that the process performed poses a high risk for employee's upper extremities and the posture of the spine, neck and wrists. According to Table 6, the RULA score for subject two and three indicated that the process has a high ergonomic risk level and that there is a need for changes to be implemented as soon as possible. The RULA score for subject one determined that the process is at medium ergonomic risk level which will require improvements to be implemented in the near future.

Mr. J. Steven Moore and Mr. Arun Garg proposed the Strain Index as a semi-quantitative task analysis methodology based on principles of biomechanics and epidemiology. Its purpose is to identify tasks that place workers at increased risk of developing upper extremity disorders, including the elbows, forearms, wrists, and hands. The researcher chose to employ the Moore-Garg Strain Index as an assessment tool because it focused on joint movements and postures of the arms and wrists. The RULA and the REBA briefly covered both these areas of the upper extremities. The Moore-Garg Strain Index requires the product of six task variables (i.e. intensity, speed and duration of the exertion per cycle, efforts per minute, hand/wrist posture, and speed of work and duration of the task per day). There four steps involved to obtain the Moore-Garg Strain Index score include data collection, assessment of rating values, determination of the multipliers, and calculation of the score.

Tables 7 and 8 summarize the ratings and the multipliers for each of the six variables as specified by the Moore-Garg Strain Index. The final Moore-Garg Strain Index score is a product of the intensity of the exertion multiplier (IEM), duration of the exertion multiplier (DEM), exertions per minute multiplier (EMM), hand/wrist posture multiplier (HPM), speed of work multiplier (SWM), and the duration per day multiplier (DDM). Processes that obtained Moore-Garg Strain Index scores of less than five were considered as being safe, whereas a score above this value was deemed to be ergonomically stressful.

Table 7: Moore-Garg strain index ratings

Rating Values	Intensity Exertion	Duration Exertion	Efforts per Minute	Hand/Wrist Posture	Speed of Work	Duration per Day (hrs.)
1	Light	<10	<4	Very good	Very slow	0–1
2	Somewhat difficult	10–29	4–8	Good	Slow	1–2
3	Difficult	30–49	9–14	Fair	Fair	2–4
4	Very difficult	50–79	15–19	Bad	Fast	4–8
5	Near maximal	≥80	≥20	Very bad	Very fast	>8

Table 8: Moore-Garg strain index multipliers

Rating values	Intensity Exertion Multiplier (IEM)	Duration Exertion Multiplier (DEM)	Efforts per Minute Multiplier (EMM)	Hand/Wrist Posture Multiplier (HPM)	Speed of Work Multiplier (SWM)	Duration Per Day Multiplier (DDM)
1	1	0.5	0.5	1	1	0.25
2	3	1	1	1	1	0.5
3	6	1.5	1.5	1.5	1	0.75
4	9	2	2	2	1.5	1
5	13	3	3	3	2	1.5

Table 9 below illustrates the strain index scores of the three assessed processes in the packaging line of the company XYZ.

Table 9: Calculated strain index scores of all three processes of packaging

	PROCESS 1		PROCESS 2		PROCESS 3	
Variable	Rating	Multiplier	Rating	Multiplier	Rating	Multiplier
Intensity	3	6	3	6	3	6
% Duration of Effort	2	1	3	1	3	1.5
Efforts per Minute	1	0.5	2	1	1	0.5
Hand/Wrist Posture	3	1.5	4	2	3	1.5
Speed of Work	2	1	3	1	3	1
Duration per Day	4	1	3	1	4	1
Strain index score	4.5		13.5		6.8	

The Moore-Garg Strain Index assessment method involved the breakdown of each process into steps which were then evaluated to determine the associated strain index variables of the individual subject. The researcher chose to use the most acutely affected arm of each of the subjects for this assessment as both arms are equally used in each process of the packaging line. The calculated strain index findings in Table 9 highlight that of the three processes performed within packaging line, process 2 and 1 were categorized as hazardous and safe, respectively. The calculated statistical results indicate that each process possess a similar intensity of force on each subject's hands, wrists, and forearms. The results also revealed that the pace at which each process was being performed was relatively normal. A significant difference between a safe process and a hazardous one was identified by two major variables (i.e. posture of the body and frequency of the task being performed). Assessment results confirmed that two of the major ergonomic risk factors within the packaging process were unnatural postures of spine, neck and shoulders, and high frequency repetitive motions of the wrists.

Goal number two. The second goal of the study was to conduct a loss analysis of the injuries that employees reported to their supervisors over the three calendar years of 2009, 2010, and 2011. Tables 10 and 11 indicate a slight increase in MSDs injuries in 2010. After further analysis, it was determined that due to a financial decline, the company chose to acquire certain economic measures to remain in business. These measures included an increase in the production rate to meet the customer demand without a corresponding increase in resources. This implies that Company XYZ was challenging their employees to produce a higher quantity of the product without any additional workers or overtime, which may have contributed in an increase in the OSHA recordable incident rate. Such challenges can cause fatigue and discomfort to employees due to awkward postures and increase in the frequency of repetitive motions, which may then result in the MSD rate to increase. In the year 2011, the company decided to improve their process by reducing the hands-on (manual) operations through the introduction of automated equipment as an engineering solution. Company XYZ also hired a consultant service to assist the management in the identification and correction of ergonomic risk factors that may place employees at increased risk for MSDs and to reduce injury rates. This resulted in a significant decline in MSDs during 2011.

Tables 10 and 11 contain data recorded from Company XYZ's OSHA logs. These tables indicate a trend in work injuries by using the injury frequency rate based on the level of exposure (the number of person-hours worked in the plant). The OSHA log data are summarized from the 2009, 2010, and 2011 calendar years over a 31-month period.

Table 10: OSHA recordable injury trend

OSHA LOG DATA			
Calendar Year	2009	2010	2011
OSHA Recordable	10	10	5
OSHA DART	6	8	4
OSHA MSDs	4	5	1
Hours Worked	501,654	374,542	280,907

Incidence Rate = (# entries in OSHA 300 log / 200,000/Hours worked) BLS: US Dept. of Labor, Bureau of Labor Statistics (BLS)—National Averages

MSDs Incidence Rate for all manufacturing from the BLS table.

Table 11: OSHA incidence rate trend

OSHA INCIDENCE RATES: Recordable Injuries and MSDs				
Calendar Year	2009	2010	2011	2009 BLS
RIR	4	5.3	3.6	2.3
DART Rate	2.4	4.3	2.8	1.3
MSDs Rate	1.6	2.7	0.7	2.4

According to Table 11, the number of days away, restricted, or transferred (DART) rate were not stable in 2010, but had been consistent in 2009 and 2011 when compared to the Bureau of Labor Statistics (BLS) National Averages of 2009. The DART rate jumped to over three times the national average in 2010. The DART rate declined in 2011 compared to 2010, but was still twice the national average. The musculoskeletal disorder rate as displayed in Table 11 has been inconsistent in the last three years of 2009, 2010 and 2011. The MSDs rate increased, but remained below national average in the year 2009 and 2011.

Goal number three. The third goal of this study was to determine the types of musculoskeletal symptoms that employees are currently experiencing during their work activities at Company XYZ. These symptoms were determined by examining the completed ergonomic symptom survey forms which were administered to volunteers by the researcher. The focus of this study was not only to analyze Company XYZ's loss data, but also to observe the task performance of employees in the packaging area and to identify the potential ergonomic risk factors that may result in MSDs injuries. This study includes an analysis of each response of the ergonomic symptom survey forms which were administered prior to the workstation assessment.

The results of the survey were later correlated with a loss analysis and a workstation assessment to determine the appropriate solutions.

Prior to conducting the workstation analysis, an ergonomic symptom survey form was administered to eight volunteers who consisted of current or past workers of the packaging line at Company XYZ. The survey form assisted the researcher identify the extent of pain, lost time, and previous medical treatment that the employees experienced. Each survey respondent was represented by a number to protect his or her identity. In addition, the answers to each question were presented in tabular format for comparison between employees. An example of the ergonomic symptom survey form is listed in Appendix D.

Results of the survey presented in Table 12 indicate that employees who volunteered for the symptom survey had experienced pain at some point while performing tasks at the packaging line. The most affected areas of the body included the wrists, lower back, shoulders, and neck. Based on results displayed in Table 13, the highest percentage (63%) of reported pain was in the hands and wrists. The second highest percentage (50%) of reported pain was in the lower back. The third highest percentage (38%) of reported pain was in the shoulder, followed by neck pain (25%), and pain in elbows and forearms reported by fourteen percent of the respondents. With respect to symptoms as referred in Table 14, the highest percentage (75%) of symptoms included “pain” among the most affected areas. The second highest percentage (50%) of the symptoms reported was “numbness”, followed by “stiffness”, “tingling” (38%) and “swelling” (25%). In addition, thirteen percent of the respondents reported symptoms such as aching and burning.

Sixty three percent of the respondents experienced symptoms within the first month of working on the packaging line (refer to Table 15). When asked to provide the length of time each episode of pain would last, thirty-eight percent of respondents reported the length to be in terms of multiple weeks. Twenty-five percent of respondents reported the length of experienced pain to be one to two days. Other reported lengths of experienced pain were, two to three hours and ongoing as displayed in Table 16. In addition, when questioned about the number of episodes experienced in the past year, thirty-eight percent reported that they had up to ten episodes. Twenty-five percent of the respondents indicated that they had experienced pain at numerous occasions, where another twenty five percent did not choose to answer this question (refer to Table 17). The five most common responses to the question, "source of the problem" as displayed in Table 18 were repetitive motion, standing on a hard floor, improper lifting, inadequate workstation and improper tools in descending order. As indicated in Table 19, fifty percent respondents experienced symptoms in seven days preceding the study, thirty seven percent did not experience pain, and thirteen percent chose not to answer. When asked to rate the severity of pain on a scale of 1-10, responses ranged from 0-6 at the time of the study and 6-9 when symptoms were the most severe (refer to Table 20, 21). When questioned about receiving any treatment, sixty-three percent of respondents (refer to Table 22) reported that they had received medical treatment in the past for symptoms experienced. Based on responses which are displayed in Table 23, a chiropractor was the number one response (50%) for the type of treatment, followed by a personal physician (33%), and surgery (17%). Several respondents failed to receive treatment for experienced symptoms because either the pain/discomfort did not reach to a certain severity level that required medical attention, or else the worker could not afford the associated medical expense (refer to Table 24). In the past year, the highest severity rate that was reported in terms of lost work was two weeks (refer to Table 25) and restricted duty was three weeks (refer to Table 26). The detailed information from the ergonomic symptom survey questionnaire is displayed below from Tables 12 to 26.

1. Have you ever had pain or discomfort while performing the task?

Employee responses to whether or not they experienced any pain while performing the assessed task are displayed below in Table 12.

Table 12: Employee response to questionnaire 1

Employee #	Response
Employee #1	Yes
Employee #2	Yes
Employee #3	Yes
Employee #4	Yes
Employee #5	Yes
Employee #6	Yes
Employee #7	Yes
Employee #8	Yes

2. Check area where you experienced pain or discomfort while performing the task:

Response to parts of the body that have been affected with pain and discomfort are highlighted below in Table 13 for each volunteer with "x".

Table 13: Employee response to questionnaire 2

Neck	Shoulder	Elbow/ Forearm	Hand/Wrist	Fingers
Upper Back	Low Back	Thigh/ Knee	Low Leg	Ankle/Foot

Employee #1									
Neck		Shoulder		Elbow/ Forearm	x	Hand/Wrist		Fingers	
Upper Back		Low Back		Thigh/ Knee		Low Leg		Ankle/Foot	

Employee #2									
Neck		Shoulder	x	Elbow/ Forearm		Hand/Wrist	x	Fingers	
Upper Back		Low Back	x	Thigh/ Knee		Low Leg		Ankle/Foot	

Employee #3									
Neck	x	Shoulder		Elbow/ Forearm		Hand/Wrist	x	Fingers	
Upper Back		Low Back		Thigh/ Knee		Low Leg		Ankle/Foot	

Employee #4									
Neck	x	Shoulder		Elbow/ Forearm		Hand/Wrist		Fingers	
Upper Back		Low Back		Thigh/ Knee		Low Leg		Ankle/Foot	

Employee #5									
Neck		Shoulder		Elbow/ Forearm		Hand/Wrist	x	Fingers	
Upper Back		Low Back	x	Thigh/ Knee		Low Leg		Ankle/Foot	

Employee #6									
Neck		Shoulder		Elbow/ Forearm		Hand/Wrist	x	Fingers	x
Upper Back		Low Back		Thigh/ Knee		Low Leg	x	Ankle/Foot	

Employee #7									
Neck		Shoulder	x	Elbow/ Forearm		Hand/Wrist		Fingers	
Upper Back		Low Back	x	Thigh/ Knee		Low Leg		Ankle/Foot	

Employee #8									
Neck		Shoulder		Elbow/ Forearm		Hand/Wrist	x	Fingers	
Upper Back		Low Back	x	Thigh/ Knee		Low Leg		Ankle/Foot	

Total number of responses for each body segment									
Neck	3	Shoulder	2	Elbow/ Forearm	1	Hand/Wrist	5	Fingers	1
Upper Back	0	Low Back	4	Thigh/ Knee	0	Low Leg	0	Ankle/Foot	0

Percentage of packaging employees affected in each body part									
Neck	38%	Shoulder	25%	Elbow/ Forearm	13%	Hand/Wrist	63%	Fingers	13%
Upper Back	0%	Low Back	50%	Thigh/ Knee	0%	Low Leg	0%	Ankle/Foot	0%

3. Please put a check by the words that best describes your problem

Best description of the problem experienced by each volunteer is displayed in Table 14.

Table 14: Employee response to questionnaire 3

Aching	Numbness	Tingling
Burning	Pain	Weakness
Cramping	Swelling	Other
Loss of Color	Stiffness	

Employee #1			
Aching	Numbness		Tingling
Burning	Pain		Weakness
Cramping	Swelling		Other
Loss of Color	Stiffness	x	

Employee #2					
Aching		Numbness	x	Tingling	X
Burning		Pain	x	Weakness	
Cramping		Swelling		Other	
Loss of Color		Stiffness			

Employee #3					
Aching	x	Numbness	x	Tingling	
Burning		Pain		Weakness	
Cramping		Swelling		Other	
Loss of Color		Stiffness	x		

Employee #4					
Aching		Numbness		Tingling	
Burning		Pain	x	Weakness	
Cramping		Swelling		Other	
Loss of Color		Stiffness			

Employee #5					
Aching		Numbness	x	Tingling	X
Burning		Pain	x	Weakness	
Cramping		Swelling		Other	
Loss of Color		Stiffness			

Employee #6					
Aching		Numbness		Tingling	
Burning		Pain	x	Weakness	
Cramping		Swelling	x	Other	
Loss of Color		Stiffness			

Employee #7					
Aching		Numbness		Tingling	
Burning	x	Pain	x	Weakness	
Cramping		Swelling		Other	
Loss of Color		Stiffness	x		

Employee #8					
Aching		Numbness	x	Tingling	X
Burning		Pain	x	Weakness	
Cramping		Swelling	x	Other	
Loss of Color		Stiffness			

Number of responses for each type of symptoms					
Aching	1	Numbness	4	Tingling	3
Burning	1	Pain	6	Weakness	0
Cramping	0	Swelling	2	Other	0
Loss of Color	0	Stiffness	3		

Percentage of employees affected by each type of symptom					
Aching	13%	Numbness	50%	Tingling	38%
Burning	13%	Pain	75%	Weakness	0%
Cramping	0%	Swelling	25%	Other	0%
Loss of Color	0%	Stiffness	38%		

4. When did you first notice the problem?

Employee response to the specific time when the pain was first experienced after starting work in the packaging line is illustrated in Table 15.

Table 15: Employee response to questionnaire 4

Employee #	Response (time after starting work in the packaging line)
Employee #1	1st month
Employee #2	After 1 year
Employee #3	Within 3 months
Employee #4	1st month
Employee #5	3rd-4th day
Employee #6	1st week
Employee #7	Within 6months
Employee #8	1-2 weeks

5. How long does each episode last?

Length of experienced symptom for each respondent is displayed in Table 16.

Table 16: Employee response to questionnaire 5

Employee #	Response (length of time)
Employee #1	2-3 hours
Employee #2	No answer
Employee #3	On going
Employee #4	1-2 days
Employee #5	Weeks
Employee #6	Weeks
Employee #7	1-2 days
Employee #8	Weeks

6. How many separate episodes have you had in the past year?

Number of episodes of experienced symptom for each respondent is displayed in Table 17.

Table 17: Employee response to questionnaire 6

Employee #	Response (# of episodes)
Employee #1	4-6
Employee #2	No answer
Employee #3	Few
Employee #4	No answer
Employee #5	Many
Employee #6	Many

Employee #	Response (# of episodes)
Employee #7	4-6
Employee #8	8-10

7. What do you think caused the problem?

The real cause of the problem presented by each respondent is mentioned in Table 18.

Table 18: Employee response to questionnaire 7

Employee #	Response
Employee #1	Inadequate workstation height
Employee #2	Standing all day on a hard floor
Employee #3	Inadequate tools / Improper lifting
Employee #4	Improper lifting
Employee #5	Repetitive motion
Employee #6	Repetitive motion
Employee #7	Standing all day on a hard floor
Employee #8	Repetitive motion

8. Have you had the problem in the last seven days?

Employee response to any sign of pain experienced in last seven days are displayed in Table 19.

Table 19: Employee response to questionnaire 8

Employee #	Response
Employee #1	Yes
Employee #2	No
Employee #3	No
Employee #4	No answer
Employee #5	No
Employee #6	Yes
Employee #7	Yes
Employee #8	Yes

9. How would you rate this problem right now?

(Rate this problem on a scale of 1-10; 1=no pain & 10=unbearable)

Respondent rating of the experienced pain at the time of study on a scale of one to ten is displayed in Table 20.

Table 20: Employee response to questionnaire 9

Employee #	Response (1-10)
Employee #1	4
Employee #2	1-2

Employee #	Response (1-10)
Employee #3	2
Employee #4	3
Employee #5	4
Employee #6	6
Employee #7	4
Employee #8	6

10. When it is the worst?

Respondent rating of the experienced pain at its worst, on a scale of one to ten is displayed in Table 21.

Table 21: Employee response to questionnaire 10

Employee #	Response (1-10)
Employee #1	7-8
Employee #2	6
Employee #3	6-7
Employee #4	6-7
Employee #5	8
Employee #6	8-9
Employee #7	7
Employee #8	8-9

11. Have you had medical treatment for this problem?

Responses to whether or not the volunteers seek any medical attention are displayed below in Table 22.

Table 22: Employee response to questionnaire 11

Employee #	Response
Employee #1	Yes
Employee #2	No
Employee #3	Yes
Employee #4	No
Employee #5	Yes
Employee #6	Yes
Employee #7	Yes
Employee #8	Yes

12. If NO, why not?

The reason for not seeking any medical attention by the respondents is displayed in Table 23.

Table 23: Employee response to questionnaire 12

Employee #	Response
Employee #2	Cannot afford
Employee #4	Not severe enough to seek medical treatment

13. If yes, what kind of treatment did you receive?

The types of treatment the employees seek for their experienced pain is illustrated in Table 24.

Table 24: Employee response to questionnaire 13

Employee #	Response
Employee #1	Personal Doctor
Employee #3	Chiropractor
Employee #5	Personal Doctor
Employee #6	Chiropractor
Employee #7	Chiropractor
Employee #8	Surgery

14. How much time have you lost in the last year because of this problem?

Employee responses to lost time due to experienced pain in past year are displayed in Table 25.

Table 25: Employee response to questionnaire 14

Employee #	Response
Employee #1	None
Employee #2	None
Employee #3	None
Employee #4	None
Employee #5	None
Employee #6	None

Employee #	Response
Employee #7	None
Employee #8	Two weeks

15. How many days in the last year were you on restricted or light duty because of this problem? Days away on restricted or light duty due to experienced pain by each respondent is presented in Table 26.

Table 26: Employee response to questionnaire 15

Employee #	Response
Employee #1	None
Employee #2	None
Employee #3	1 day
Employee #4	None
Employee #5	2-3 days
Employee #6	None
Employee #7	1-2 days
Employee #8	3 weeks

Discussion

The results of the REBA, the RULA and the Moore-Garg Strain Index assessment methods employed in this study indicate that there are various ergonomic risks involved within the assessed processes in the packaging line at Company XYZ. Although there is a hierarchy of controls in place within Company XYZ, including personal protective equipment, appropriate lighting tools, and height adjustable tables, the study highlighted that the subjects were still feeling distress and discomfort primarily in their upper extremities (i.e., the wrists, neck, and spine). The evaluation of the packaging processes, observation of subject performance, assessment of survey responses, results of used assessment tools, and review of prior injury loss data demonstrate close correlation to each other. Both qualitative assessment tools (the REBA, the RULA) were used to identify that the high-level ergonomic risk factors were the wrists, spine, and neck. These identified risk factors have a great potential to develop into CTDs and MSDs because of awkward postures while lifting which include flexion or extension of spine, neck and wrists at greater than twenty degrees for employees performing routine tasks on the packing line. The risk factors that were identified by both qualitative assessment methods the REBA and the RULA correlate with the information discussed in the literature review of this study. The results of both the qualitative assessment tools indicate that there are potential high-risk ergonomic risk factors that may exacerbate the occurrence of CTDs and MSDs. The scoring system of the REBA (Table 4) and the RULA (Table 6) indicates that the evaluated process requires further investigation to identify and facilitate appropriate countermeasures to protect the employees. The Moore-Garg strain index assessment also formally supports the results calculated by the REBA and the RULA. The tool identifies that the intensity of exertion on the hands and wrists is high because of repetitive motion and muscle exertion for a long duration.

Company XYZ's loss analysis and ergonomic symptom survey review aided the researcher in identifying the trend of MSDs injury and the affected body parts of employees performing tasks on the packaging line. This information leads to the conclusion that an increase in production rate with limited resources and no additional workforce in a limited time may increase the probability of an incident or an injury. Data obtained from the 2009, 2010, 2011 calendar year loss analysis coupled with the responses from the ergonomic symptoms survey forms led to the identification of high ergonomic risk factors. The REBA, the RULA and the Moore-Garg Strain Index assessment results indicate that the identified ergonomic risk factors such as unnatural postures of spine, neck and shoulders and repetitive motion of wrists and arms could be the major causes of increase in MSD injuries at Company XYZ. Unnatural posture of the spine while moving boxes to the mail cart, flexion and extension of the wrists, arms, and neck during the foaming and packing process, and high repetition of tasks using the arms and shoulders are the risk factors that may have contributed significantly to MSDs recordable incidents in the past three years (2009-2011).

A comparison of the data collected from workstation assessments, prior loss data records and ergonomic symptom surveys to the information presented in the literature review reveals a significant relationship between the injuries that the employees sustained in the packaging line processes and the work that they performed. As identified in the data collected from the assessment and the literature review, the packaging line processes were placed in the high-risk category for potential development of CTDs and MSDs. The reduction in existing and potential occurrence of CTDs and MSDs may be achieved by the implementation of the recommended countermeasures.

Chapter V: Conclusions and Recommendations

Company XYZ has experienced a higher incidence rate of injuries for employees than the national average rate compiled by the Bureau of Labor Statistics (BLS) due to continued occurrences of sprain and strain incidents in the last three years. Maximizing available resources after a reduction in the number of employees in an effort to maintain output levels was placing the organization at risk of incurring potential employee injury, illness or other production/ financial losses. Therefore, the purpose of this study was to determine the ergonomic risk factors to which employees of Company XYZ's packaging line are being exposed. From this study, ergonomic solutions were derived to aid in the elimination or reduction in severity of the determined ergonomic risk factors. To achieve this purpose, three objectives were developed:

1. To assess the process, procedures, and tasks that employees must perform within the shipping department of Company XYZ.
2. To analyze the types of ergonomic-based injuries that employees reported to their supervisors for the past three calendar years.
3. To determine the types of musculoskeletal symptoms that employees are currently experiencing during their work activities at Company XYZ.

To achieve the above objectives, the methodology used in this study was categorized into three levels. Level one involved collection of data through analysis of tasks and processes in the packaging line by using appropriate ergonomic assessment tools, which include the Moore-Garg strain index, the RULA and the REBA. This data collection methodology included observing the participants for behavior analysis, assessing the workstations, and recording the identified force, posture angles and other ergonomic parameters in their respective assessment worksheets. During each behavior assessment, subject observations, video recordings and digital photographs were collected and later analyzed to obtain ergonomic data from the packaging process. Level two involved the collection and analysis of injury loss data in Company XYZ for years 2009, 2010 and 2011, which includes OSHA recordable log, recordable incident rate, DART rate and MSDs rate. Level three involved the collection and review of all the submitted ergonomic symptom survey responses to identify the symptoms associated with the risk factors that are responsible for the MSD and CTD injuries and illnesses. This methodology aided the researcher to utilize the most effective/efficient ergonomic assessment tools in order to identify associated potential ergonomic risk factors.

Major Findings

The first objective of the study was to assess the process, procedures and tasks that employees must perform within the shipping department of Company XYZ. To achieve this objective, the packaging process was divided into three categories which include inventory, packing and labeling. Ergonomic assessment tools such as the REBA, the RULA and the Moore-Garg Strain Index were utilized to analyze each category. The methodology for analysis includes subject observation, task assessment and workstation evaluation. The collected data from the analysis of the RULA assessment indicated that the process performed by subject 2 is at a high ergonomic risk level (i.e., the RULA score is 10 from a maximum score of 12). The unnatural posture of spine attained while moving boxes, flexion and extension of the wrists, arms, and neck while performing the foaming and packing process and extensive repetition in the wrists, arms and shoulders are the identified high level ergonomic risk factors. Thus, the high RULA score indicates that the process 2 requires immediate alterations as well as further investigation. The data from the REBA analysis indicated that the packing and labeling process performed by subjects 2 and 3 respectively are at a high ergonomic risk level (i.e., the REBA score is 6 for both processes). Thus, the high REBA score indicates that the processes require immediate alterations as well as further investigation. Data gathered from the Moore-Garg Strain Index supported the REBA and the RULA assessments and highlighted that the packing process of the packaging line is at higher risk. This involves two major ergonomic risk factors, which include unnatural postures of spine, neck and shoulders, and high repetitive motions of the wrists.

The second objective of the study was to review the injury loss data recorded for the calendar years 2009, 2010 and 2011, in order to identify the injury trends, prioritize the most ergonomically stressful areas and identify appropriate assessment tools. After reviewing Company XYZ’s OSHA 300 log and other past loss records, it was determined that in 2009, 2010 and 2011, Company XYZ experienced an increase in the incidence rate of MSD and CTD injuries.

The third objective of the study was to analyze the responses reported by the employees in the completed ergonomic symptom survey forms to determine the musculoskeletal and cumulative trauma disorder symptoms that they experienced during work activities. When compared to the collected data from loss analysis, literature review, ergonomic symptom survey forms and the ergonomic assessment results, it was determined that the packaging line processes were at a high-risk category for potential CTDs and MSDs. The three processes which involve inventory, packing and labeling constitutes major part of the MSD injuries on the packaging line. The results of the assessment also corroborate the fact that the continual complaints of numbness and tingling in the wrists, arms (due to repetitive motion) and pain in employee’s spine and neck due to unnatural posture are because of non-ergonomic workstation design issues.

Conclusions

Based on the collected data from the study, the conclusions concerning the employees performing the tasks on the packaging line at Company XYZ are:

1. Data collected from the assessment tools used in this study such as the REBA, the RULA and the Moore-Garg strain index concluded that the packaging line processes falls at high risk of MSD and CTD injuries. Ergonomic assessment results and the Company XYZ's loss history conclude that the packaging processes requires alterations and further investigation to implement appropriate controls that will reduce the potential ergonomic risk factors. The above conclusions resulted from visual observations and behavior analysis of selected subjects performing the tasks involved.
2. Reviewing the total case incidence rate, DART rate, and MSDs rate of Company XYZ for the past three calendar years (i.e., 2009, 2010 and 2011) and comparing it to the Bureau of Labor statistics (BLS) national average, the analysis concluded that the company experienced a higher recordable incidence and DART rate than the BLS national average in all three years. The results also revealed that the Company XYZ made improvements to reduce the MSD incidence rate in 2009 and 2011 and managed to stay below the BLS national average. However, there is still a risk of potential MSDs for employees in the packaging line of Company XYZ.
3. Based on the evaluation of ergonomic symptom survey forms, the ergonomic risks associated with the packaging processes include unnatural posture of neck and spine while packing, abduction of shoulders while lifting and continuous deviation of wrists during repetitive motion. Lack of appropriate equipment, resources and tools for the employees to perform the associated tasks has likely resulted in symptoms which include

pain, numbness and tingling sensation in spine, neck shoulders and wrists among employees. These symptoms indicate an increase in the risk of MSDs and CTDs.

Recommendations

Based on the conclusions of ergonomic assessment results and the hierarchy of controls, the following control measures are recommended to reduce the exposure of ergonomic risk factors and the occurrence of musculoskeletal as well as cumulative trauma disorders while performing the packaging process. The first two items on the hierarchy of controls are elimination and substitution. It was impractical to eliminate the packaging process or substitute/transfer this process to an outside company, therefore, the researcher recommends beginning the hierarchy with the engineering controls.

Engineering Controls. Based on conclusions from the ergonomic assessment the following changes are recommended:

1. Workstation heights - packaging workstation tables should include height-adjustable mechanisms where the individual working height can be adjusted to approximately elbow height from the floor (Cohen, A. L., & National Institute for Occupational Safety and Health, 1997). This NIOSH ergonomic workstation design guideline will ensure that the shoulders, arms, spine, and wrists maintain a neutral posture and the neck-flexing angle is less than fifteen degrees to reduce the risk of MSDs.
2. Forceful hand exertions - cutting cardboard, taping, scanning, and labeling boxes with hand-held tools involve forceful exertions within the forearm muscles. If the repetitive work is combined with forceful exertions and awkward postures, such as wrist deviations, the probability of MSD illness/injuries increases. Minimizing forceful exertions and awkward postures by implementing automation within the packaging process is essential

to prevention of MSDs. Examples of these include the use of a power operated cutter for cardboard, installing an automated tape machine with a conveyor, and utilizing an automated labeling machine controlled by computer interface.

3. Shoulder abduction and arm flexion - constant lifting while unloading bins off the storage racks, weighing, foaming, and loading boxes on the mail cart involve abduction of the shoulders and flexion of arms approximately twenty degrees. Introducing an electrical conveyor and a height adjustable storage rack, such as the vertical carousel lift (see Figure 6) similar to the one being utilized in the base metal production area of Company XYZ will minimize lifting and reduce shoulder abduction. A vertical carousel lift is a heavy duty hydraulic powered device which rotates and stores product in a vertical plane) (Vertical Carousels, Horizontal Carousels and Shuttles or Vertical Lift Modules by Integrated Systems Design, n.d.). Additional cost-effective lifting solutions includes Presto-lift devices (see Figures 7 and 8) which are recommended to minimize awkward lifting, and transportation of heavy materials (Presto Lifts - Lift Tables, Stackers, Pallet Trucks, Manual Palletizers, Post Lifts and Morel, n.d.).

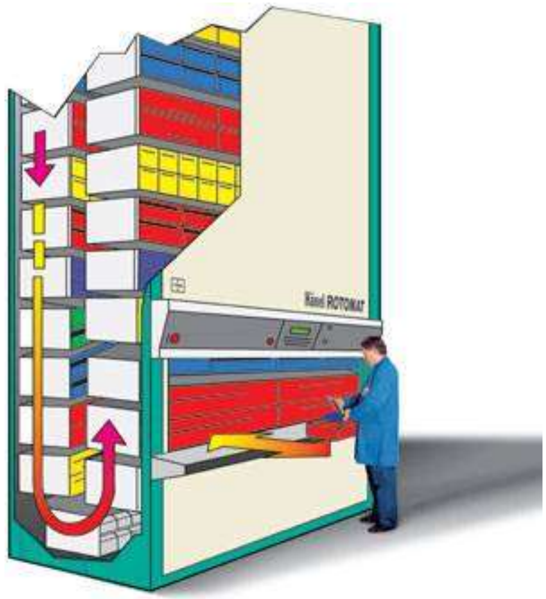

Figure 6: Vertical Carousel Powered Device

Source: *Kraftwerks: Space & Storage Solutions: Vertical Carousels & Vertical Lifts (ASRS)*. (n.d.). Retrieved from http://www.kraftwerks.net/home.php?cat=251

Figure 7: Presto Pallet Stacker

Source: *PowerStak. (n.d.). Retrieved from http://www.prestolifts.com/page201.html*

Figure 8: Container Tilters, Palletizers, Hand Pallet Trucks, Post Lift Tables

Source: *Presto Lifts - Lift Tables, Stackers, Pallet Trucks, Manual Palletizers, Post Lifts and More.* (n.d.). Retrieved from http://www.prestolifts.com/

Administrative Controls

1. Job rotation - developing a rotation schedule based on current and further investigation of the packaging process, individual ergonomic assessment results, workload, and identified ergonomic risk factors will likely reduce strain on the worker's muscles over an eight hour period.
2. Cross training - training employees from different departments on how to perform the packaging processes will provide the flexibility of rotating employees from one process to another, thus making job rotation effective and efficient.
3. Stretches - implementing an ergonomic stretching exercise program on the packaging line before and after the task function will be a proactive measure to reduce potential

symptoms of MSDs and CTDs. Performing pre- and post-stretching activities have proven to be highly effective in reducing muscle strains and sprains.

4. Rest breaks - schedule rest breaks for each employee based on job demand, work environment, available workforce, and the complexity involved within the task by providing a rest break between hours of highly repetitive tasks. This is an effective method of relaxing frequently used muscles and reducing the incidence of strains and sprains.
5. Lifting techniques - training employees in proper lifting techniques may aid in minimizing the strain and sprain on lower spine, wrists, and arms. According to the study, unnatural body posture due to lifting was one of the more significant risk factors in all three packaging processes that may contribute to potential MSD injuries. Implementing proper lifting measure is important if the company is unable to implement the recommended engineering solutions.
6. Consultant service - hiring an outside service with ergonomic expertise may aid the Company XYZ in developing an ergonomic-friendly culture and work environment. This solution may provide assistance in reducing MSDs both proactively and reactively. From a proactive stance, the consultant would need to perform assessments on each process, provide solutions, and recommend improvements. Reactively, a consultant will work with individual employees and provide in-house physical therapy as a containment measure.

Personal Protective Equipment. Utilized as a control measure to minimize the exposure level of ergonomic risk factors, personal protective equipment is a proactive solution that also enhances the effectiveness engineering and administrative controls.

1. Hand gloves - gloves are required by the employees when performing the foaming process as it can generate high temperature steam that may result in first or second degree burns. Gloves are recommended for employees lifting bins and boxes to facilitate improved gripping and reduce force exertion on hands and wrists. Gloves are also recommended to prevent skin contact with foaming chemical that may cause skin irritation or allergic reaction.
2. Safety glasses/Splash goggles - safety glasses are mandatory in all departments in Company XYZ, as employees are exposed to debris or flying objects. Splash goggles are required during the foaming process due to potential exposure of foaming chemicals that may result in an eye injury. Safety glasses may also aid in developing a safe work environment within the company.
3. Other ergonomic recommendations include:
    a. Utilize a mail cart with a height adjustable platform for the labeling process in order to minimize flexing of neck and spine while loading finished products. Also consider providing ergonomic anti-fatigue mats to employees in order to reduce fatigue/discomfort that develops from prolonged standing on hard floor surfaces.
    b. Perform testing to determine if energy efficient light bulbs at each workstation will improve area illumination, thereby reducing the potential for human error.
    c. Implement a near-hit safety observation program to identify, prioritize and correct potential ergonomic risks proactively. This methodology includes near-hit safety

feedback forms that are readily available throughout the plant. Employees would use these forms to report the initial symptoms of musculoskeletal disorders such as numbness, tingling, and pain. This could allow early identification of problems that could be addressed before a costly MSD injury develops. An example of such a feedback form is displayed below in Figure 9.

Date/Time:

Company Number:

Workers Name: | Supervisors Name:

Please check the box that best describes the situation.

☐ Asbestos/Benzene/Lead	☐ Overhead Lines
☐ Confined Space	☐ Pinch Points
☐ Damaged Equipment	☐ Poor Housekeeping
☐ Driving/Road Conditions	☐ Remote Conditions
☐ Environmental Spill/Containment	☐ Respiratory Hazard/Dust/Vapors
☐ Extreme Heat/Cold/Weather	☐ Rigging Equipment
☐ Fire/Ignition Sources	☐ Simultaneous Operations
☐ Hazardous Energy	☐ Uncontrolled Energy/Force
☐ Ladders/Ramps	☐ Underground Pipes
☐ Limited Access or Egress	☐ Unguarded Equipment
☐ Manual Lifting/Over Reach	☐ Working at Heights
☐ Noise	☐ Trenching/Excavation

Description of Unsafe Condition/Hazard or Near Miss

Immediate Actions Taken or Suggestions for Prevention of Similar Occurrence

Figure 9: Near-hit safety feedback form

Source: *Near Miss Report Card*. (n.d.). Retrieved from http://isite3.allegranet.com/saline/CustomerPages/WSUCatalog/tabid/1319/List/1/catpageindex/25/CreatedByUser/9/ProductID/404/Default.aspx?txtSearch=*&SortField=ProductName%2CProductName

Areas of Further Research

The scope of this study was particularly narrow as it only involved the packaging department of Company XYZ. Based on this study, other areas have been identified for further ergonomic research. The following areas should be considered for further investigation to identify the ergonomic risk factors that are present:

1. Perform a detailed loss analysis to determine the financial loss involved for an employee who must spend time away from work because of an MSD or CTD injury.
2. Expand the ergonomic analysis process to include other flow cells and their individual processes.
3. Perform an additional post workstation analysis after appropriate controls have been implemented to determine if ergonomic hazard risk levels have been reduced.
4. Perform research on packaging processes which are utilized in other manufacturing companies and implement identified improvements as needed.

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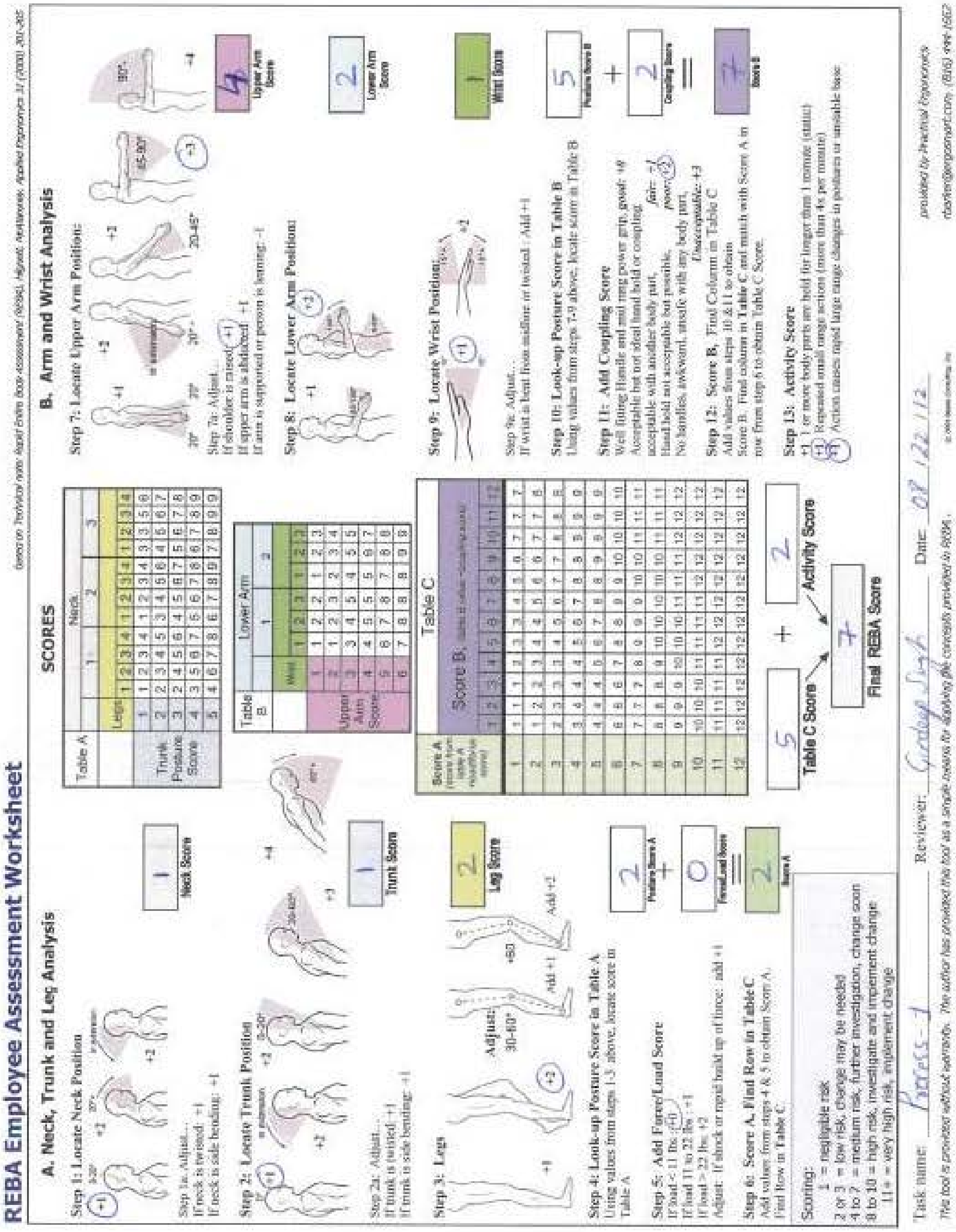
Appendix A: ***REBA Assessment of Packaging Process.***

Process 1



Process 2

REBA Employee Assessment Worksheet

based on Technical note: Rapid Entire Body Assessment (REBA), Hignett, McAtamney, Applied Ergonomics 31 (2000) 201-205

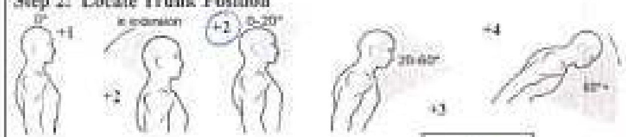
A. Neck, Trunk and Leg Analysis

Step 1: Locate Neck Position

Step 1a: Adjust...
If neck is twisted: +1
If neck is side bending: +1

Neck Score: 2

Step 2: Locate Trunk Position



Step 2a: Adjust...
If trunk is twisted: +1
If trunk is side bending: +1

Trunk Score: 2

Step 3: Legs

not supported

Leg Score: 2

Step 4: Look-up Posture Score in Table A
Using values from steps 1-3 above, locate score in Table A

Posture Score A: 4

Step 5: Add Force/Load Score
If load < 11 lbs : +0
If load 11 to 22 lbs : +1
If load > 22 lbs: +2
Adjust: If shock or rapid build up of force: add +1

Force/Load Score: 1

Step 6: Score A, Find Row in Table C
Add values from steps 4 & 5 to obtain Score A.
Find Row in **Table C**.

Score A: 5

Scoring:
1 = negligible risk
2 or 3 = low risk, change may be needed
4 to 7 = medium risk, further investigation, change soon
8 to 10 = high risk, investigate and implement change
11+ = very high risk, implement change

SCORES

Table A		Neck 1				Neck 2				Neck 3			
	Legs	1	2	3	4	1	2	3	4	1	2	3	4
Trunk Posture Score	1	1	2	3	4	1	2	3	4	3	3	5	6
	2	2	3	4	5	3	4	5	6	4	5	6	7
	3	2	4	5	6	4	5	6	7	5	6	7	8
	4	3	5	6	7	5	6	7	8	6	7	8	9
	5	4	6	7	8	6	7	8	9	7	8	9	9

Table B		Lower Arm 1			Lower Arm 2		
	Wrist	1	2	3	1	2	3
Upper Arm Score	1	1	2	2	1	2	3
	2	1	2	3	2	3	4
	3	3	4	5	4	5	5
	4	4	5	5	5	6	7
	5	6	7	8	7	8	8
	6	7	8	8	8	9	9

Table C

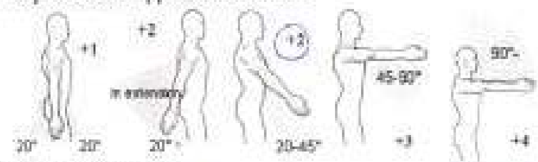
Score A (score from table A +load/force score)	Score B (table B value +coupling score) 1	2	3	4	5	6	7	8	9	10	11	12
1	1	1	1	2	3	3	4	5	6	7	7	7
2	1	2	2	3	4	4	5	6	6	7	7	8
3	2	3	3	3	4	5	6	7	7	8	8	8
4	3	4	4	4	5	6	7	8	8	9	9	9
5	4	4	4	5	6	7	8	8	9	9	9	9
6	6	6	6	7	8	8	9	9	10	10	10	10
7	7	7	7	8	9	9	9	10	10	11	11	11
8	8	8	8	9	10	10	10	10	10	11	11	11
9	9	9	9	10	10	10	11	11	11	12	12	12
10	10	10	10	11	11	11	11	12	12	12	12	12
11	11	11	11	11	12	12	12	12	12	12	12	12
12	12	12	12	12	12	12	12	12	12	12	12	12

Table C Score: 8 + Activity Score: 2

Final REBA Score: 10

B. Arm and Wrist Analysis

Step 7: Locate Upper Arm Position:



Step 7a: Adjust...
If shoulder is raised: +1
If upper arm is abducted: +1
If arm is supported or person is leaning: -1

Upper Arm Score: 4

Step 8: Locate Lower Arm Position:

Lower Arm Score: 2

Step 9: Locate Wrist Position:

Step 9a: Adjust...
If wrist is bent from midline or twisted : Add +1

Wrist Score: 1

Step 10: Look-up Posture Score in Table B
Using values from steps 7-9 above, locate score in Table B

Posture Score B: 5

Step 11: Add Coupling Score
Well fitting Handle and mid rang power grip, *good:* +0
Acceptable but not ideal hand hold or coupling acceptable with another body part, *fair:* +1
Hand hold not acceptable but possible, *poor:* +2
No handles, awkward, unsafe with any body part, *Unacceptable:* +3

Coupling Score: 2

Step 12: Score B, Find Column in Table C
Add values from steps 10 & 11 to obtain Score B. Find column in **Table C** and match with Score A in row from step 6 to obtain Table C Score.

Score B: 7

Step 13: Activity Score
+1 1 or more body parts are held for longer than 1 minute (static)
+1 Repeated small range actions (more than 4x per minute)
+1 Action causes rapid large range changes in postures or unstable base

Task name: Process-2 Reviewer: Gundeep Singh Date: 08 / 28 / 12

This tool is provided without warranty. The author has provided this tool as a simple means for applying the concepts provided in REBA.

provided by Practical Ergonomics
rbarker@ergosmart.com (816) 444-1667

Process 3

REBA Employee Assessment Worksheet

based on Technical note: Rapid Entire Body Assessment (REBA), Hignett, McAtamney, Applied Ergonomics 31 (2000) 201-205

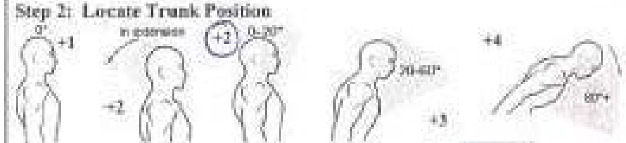
A. Neck, Trunk and Leg Analysis

Step 1: Locate Neck Position

Step 1a: Adjust…
If neck is twisted: (+1)
If neck is side bending: +1

3 — Neck Score

Step 2: Locate Trunk Position



Step 2a: Adjust…
If trunk is twisted: +1
If trunk is side bending: +1

2 — Trunk Score

Step 3: Legs

2 — Leg Score

Step 4: Look-up Posture Score in Table A
Using values from steps 1-3 above, locate score in Table A

5 — Posture Score A

Step 5: Add Force/Load Score
If load < 11 lbs : +0
If load 11 to 22 lbs : +1
If load > 22 lbs: +2
Adjust: If shock or rapid build up of force: add +1

\+ 1 — Force/Load Score

Step 6: Score A, Find Row in Table C
Add values from steps 4 & 5 to obtain Score A.
Find Row in Table C.

= 6 — Score A

Scoring:
1 = negligible risk
2 or 3 = low risk, change may be needed
4 to 7 = medium risk, further investigation, change soon
8 to 10 = high risk, investigate and implement change
11+ = very high risk, implement change

SCORES

Table A	Neck 1				Neck 2				Neck 3			
Trunk Posture Score / Legs	1	2	3	4	1	2	3	4	1	2	3	4
1	1	2	3	4	1	2	3	4	3	3	5	6
2	2	3	4	5	3	4	5	6	4	5	6	7
3	2	4	5	6	4	5	6	7	5	6	7	8
4	3	5	6	7	5	6	7	8	6	7	8	9
5	4	6	7	8	6	7	8	9	7	8	9	9

Table B	Lower Arm 1			Lower Arm 2		
Upper Arm Score / Wrist	1	2	3	1	2	3
1	1	2	2	1	2	3
2	1	2	3	2	3	4
3	3	4	5	4	5	5
4	4	5	5	5	6	7
5	6	7	8	7	8	8
6	7	8	8	8	9	9

Table C

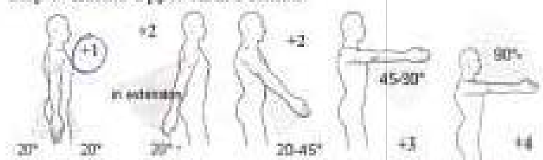
Score A (score from table A +load/force score)	Score B (table B value +coupling score) 1	2	3	4	5	6	7	8	9	10	11	12
1	1	1	1	2	3	3	4	5	6	7	7	7
2	1	2	2	3	4	4	5	6	6	7	7	8
3	2	3	3	3	4	5	6	7	7	8	8	8
4	3	4	4	4	5	6	7	8	8	9	9	9
5	4	4	4	5	6	7	8	8	9	9	9	9
6	6	6	6	7	8	8	9	9	10	10	10	10
7	7	7	7	8	9	9	9	10	10	11	11	11
8	8	8	8	9	10	10	10	10	10	11	11	11
9	9	9	9	10	10	10	11	11	11	12	12	12
10	10	10	10	11	11	11	11	12	12	12	12	12
11	11	11	11	11	12	12	12	12	12	12	12	12
12	12	12	12	12	12	12	12	12	12	12	12	12

6 — Table C Score + 2 — Activity Score

8 — Final REBA Score

B. Arm and Wrist Analysis

Step 7: Locate Upper Arm Position:



Step 7a: Adjust…
If shoulder is raised: (+1)
If upper arm is abducted: +1
If arm is supported or person is leaning: -1

2 — Upper Arm Score

Step 8: Locate Lower Arm Position:

2 — Lower Arm Score

Step 9: Locate Wrist Position:

Step 9a: Adjust…
If wrist is bent from midline or twisted : Add +1

1 — Wrist Score

Step 10: Look-up Posture Score in Table B
Using values from steps 7-9 above, locate score in Table B

2 — Posture Score B

Step 11: Add Coupling Score
Well fitting Handle and mid rang power grip, *good:* +0
Acceptable but not ideal hand hold or coupling acceptable with another body part, *fair:* (+1)
Hand hold not acceptable but possible, *poor:* +2
No handles, awkward, unsafe with any body part, *Unacceptable:* +3

\+ 1 — Coupling Score

Step 12: Score B, Find Column in Table C
Add values from steps 10 & 11 to obtain Score B. Find column in **Table C** and match with Score A in row from step 6 to obtain Table C Score.

= 3 — Score B

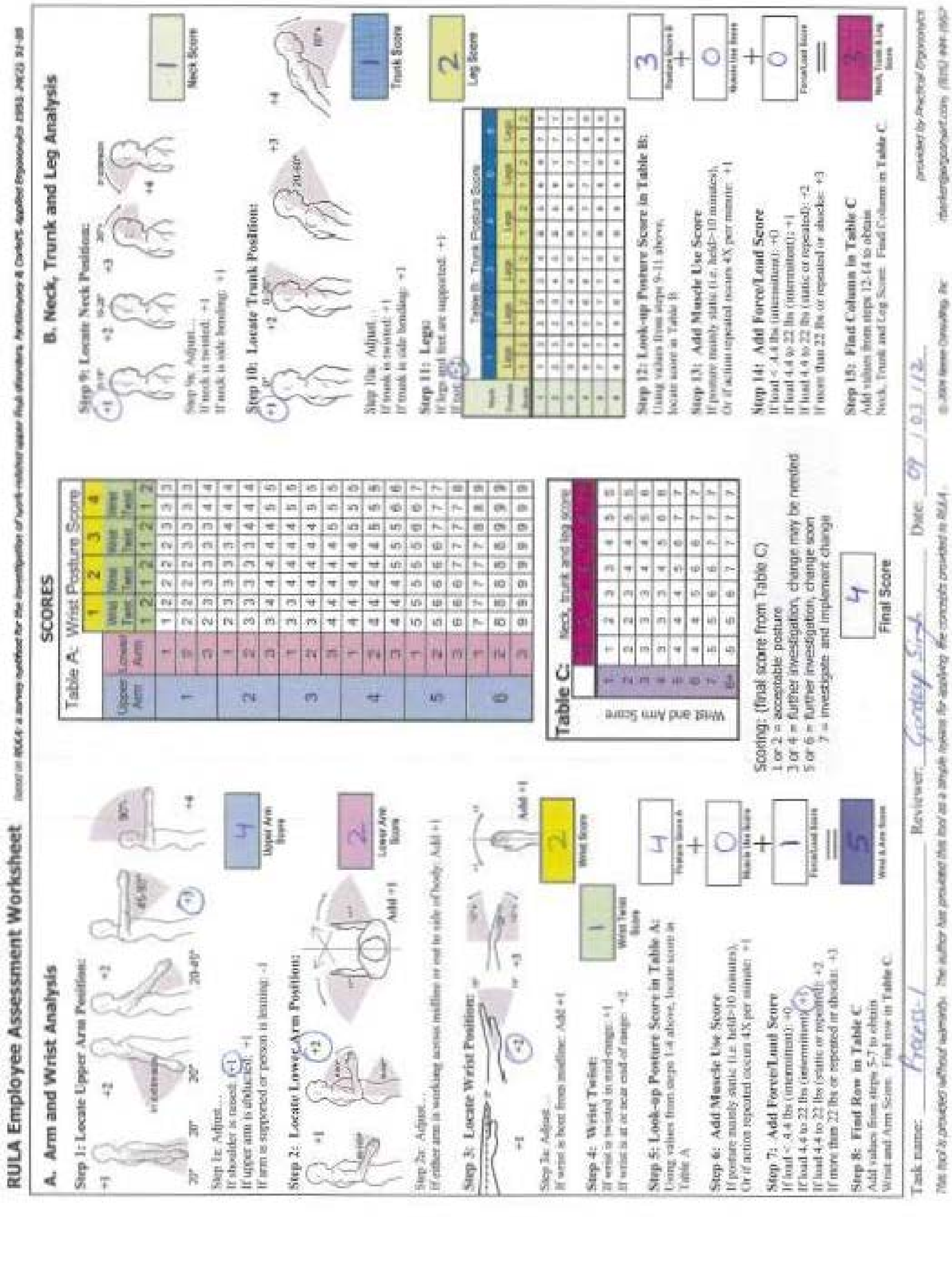
Step 13: Activity Score
+1 1 or more body parts are held for longer than 1 minute (static)
(+1) Repeated small range actions (more than 4x per minute)
(+1) Action causes rapid large range changes in postures or unstable base

Task name: Process - 3   Reviewer: Gurdeep Singh   Date: 08 / 24 / 12

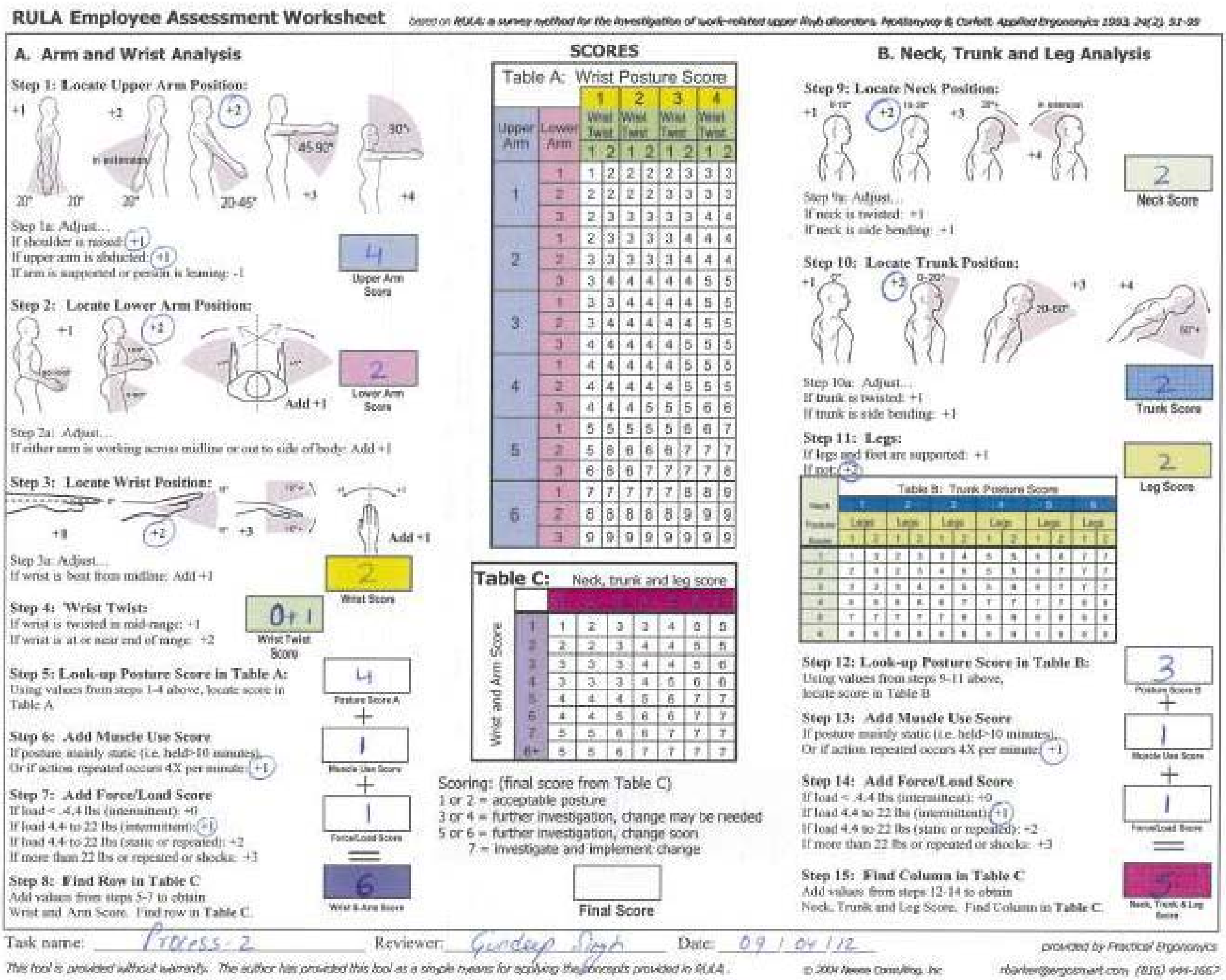
provided by Practical Ergonomics
rbarker@ergosmart.com (816) 444-1667

Appendix B: ***RULA Assessment of Packaging Process.***

Process 1



Process 2



RULA Employee Assessment Worksheet

based on RULA: a survey method for the investigation of work-related upper limb disorders, McAtamney & Corlett, Applied Ergonomics 1993, 24(2), 91-99

A. Arm and Wrist Analysis

Step 1: Locate Upper Arm Position:

Step 1a: Adjust…
If shoulder is raised: +1
If upper arm is abducted: +1
If arm is supported or person is leaning: -1

4 — Upper Arm Score

Step 2: Locate Lower Arm Position:

Step 2a: Adjust…
If either arm is working across midline or out to side of body: Add +1

2 — Lower Arm Score

Step 3: Locate Wrist Position:

Step 3a: Adjust…
If wrist is bent from midline: Add +1

2 — Wrist Score

Step 4: Wrist Twist:
If wrist is twisted in mid-range: +1
If wrist is at or near end of range: +2

0+1 — Wrist Twist Score

Step 5: Look-up Posture Score in Table A:
Using values from steps 1-4 above, locate score in Table A

4 — Posture Score A

+

Step 6: Add Muscle Use Score
If posture mainly static (i.e. held>10 minutes),
Or if action repeated occurs 4X per minute: +1

1 — Muscle Use Score

+

Step 7: Add Force/Load Score
If load < 4.4 lbs (intermittent): +0
If load 4.4 to 22 lbs (intermittent): +1
If load 4.4 to 22 lbs (static or repeated): +2
If more than 22 lbs or repeated or shocks: +3

1 — Force/Load Score

=

Step 8: Find Row in Table C
Add values from steps 5-7 to obtain Wrist and Arm Score. Find row in **Table C**.

6 — Wrist & Arm Score

SCORES

Table A: Wrist Posture Score

Upper Arm	Lower Arm	1 Wrist Twist 1	1 Wrist Twist 2	2 Wrist Twist 1	2 Wrist Twist 2	3 Wrist Twist 1	3 Wrist Twist 2	4 Wrist Twist 1	4 Wrist Twist 2
1	1	1	2	2	2	2	3	3	3
	2	2	2	2	2	3	3	3	3
	3	2	3	3	3	3	3	4	4
2	1	2	3	3	3	3	4	4	4
	2	3	3	3	3	3	4	4	4
	3	3	4	4	4	4	4	5	5
3	1	3	3	4	4	4	4	5	5
	2	3	4	4	4	4	4	5	5
	3	4	4	4	4	4	5	5	5
4	1	4	4	4	4	4	5	5	5
	2	4	4	4	4	4	5	5	5
	3	4	4	4	5	5	5	6	6
5	1	5	5	5	5	5	6	6	7
	2	5	6	6	6	6	7	7	7
	3	6	6	6	7	7	7	7	8
6	1	7	7	7	7	7	8	8	9
	2	8	8	8	8	8	9	9	9
	3	9	9	9	9	9	9	9	9

Table C: Neck, trunk and leg score

Wrist and Arm Score	1	2	3	4	5	6	7+
1	1	2	3	3	4	5	5
2	2	2	3	4	4	5	5
3	3	3	3	4	4	5	6
4	3	3	3	4	5	6	6
5	4	4	4	5	6	7	7
6	4	4	5	6	6	7	7
7	5	5	6	6	7	7	7
8+	5	5	6	7	7	7	7

Scoring: (final score from Table C)
1 or 2 = acceptable posture
3 or 4 = further investigation, change may be needed
5 or 6 = further investigation, change soon
7 = investigate and implement change

Final Score

B. Neck, Trunk and Leg Analysis

Step 9: Locate Neck Position:

Step 9a: Adjust…
If neck is twisted: +1
If neck is side bending: +1

2 — Neck Score

Step 10: Locate Trunk Position:

Step 10a: Adjust…
If trunk is twisted: +1
If trunk is side bending: +1

2 — Trunk Score

Step 11: Legs:
If legs and feet are supported: +1
If not: +2

2 — Leg Score

Table B: Trunk Posture Score

Neck Posture Score	1 Legs 1	1 Legs 2	2 Legs 1	2 Legs 2	3 Legs 1	3 Legs 2	4 Legs 1	4 Legs 2	5 Legs 1	5 Legs 2	6 Legs 1	6 Legs 2
1	1	3	2	3	3	4	5	5	6	6	7	7
2	2	3	2	3	4	5	5	5	6	7	7	7
3	3	3	3	4	4	5	5	6	6	7	7	7
4	5	5	5	6	6	7	7	7	7	7	8	8
5	7	7	7	7	7	8	8	8	8	8	8	8
6	8	8	8	8	8	8	8	9	9	9	9	9

Step 12: Look-up Posture Score in Table B:
Using values from steps 9-11 above, locate score in Table B

3 — Posture Score B

+

Step 13: Add Muscle Use Score
If posture mainly static (i.e. held>10 minutes),
Or if action repeated occurs 4X per minute: +1

1 — Muscle Use Score

+

Step 14: Add Force/Load Score
If load < 4.4 lbs (intermittent): +0
If load 4.4 to 22 lbs (intermittent): +1
If load 4.4 to 22 lbs (static or repeated): +2
If more than 22 lbs or repeated or shocks: +3

1 — Force/Load Score

=

Step 15: Find Column in Table C
Add values from steps 12-14 to obtain Neck, Trunk and Leg Score. Find Column in **Table C**.

5 — Neck, Trunk & Leg Score

Task name: Process-2 Reviewer: Gurdeep Singh Date: 09/04/12

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Process 3

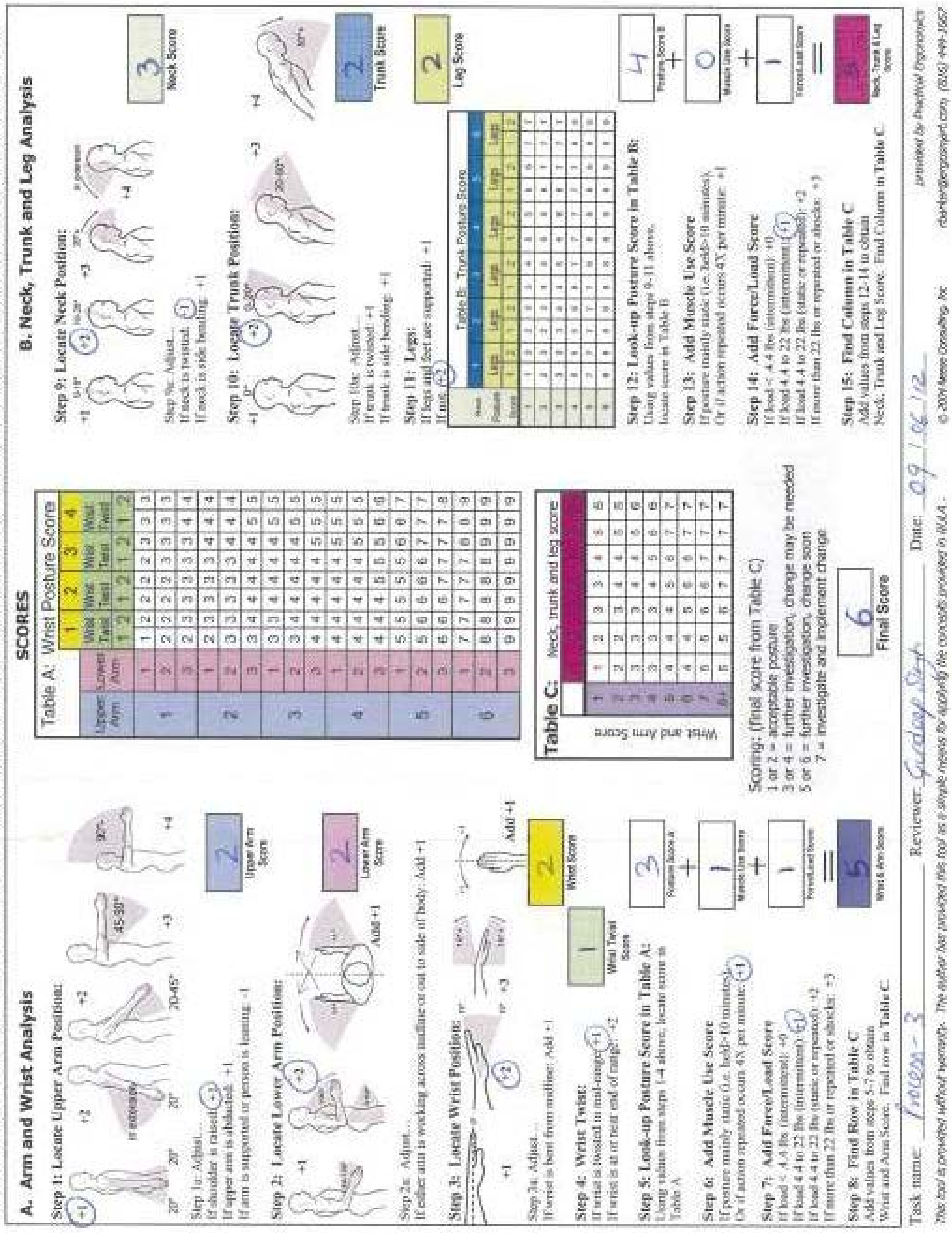

Table A: Wrist Posture Score

Upper Arm	Lower Arm	1 Wrist Twist 1	1 Wrist Twist 2	2 Wrist Twist 1	2 Wrist Twist 2	3 Wrist Twist 1	3 Wrist Twist 2	4 Wrist Twist 1	4 Wrist Twist 2
1	1	1	2	2	2	2	3	3	3
	2	2	2	2	2	3	3	3	3
	3	2	3	3	3	3	3	4	4
2	1	2	3	3	3	3	4	4	4
	2	3	3	3	3	3	4	4	4
	3	3	4	4	4	4	4	5	5
3	1	3	3	4	4	4	4	5	5
	2	3	4	4	4	4	4	5	5
	3	4	4	4	4	4	5	5	5
4	1	4	4	4	4	4	5	5	5
	2	4	4	4	4	4	5	5	5
	3	4	4	4	5	5	5	6	6
5	1	5	5	5	5	5	6	6	7
	2	5	6	6	6	6	7	7	7
	3	6	6	6	7	7	7	7	8
6	1	7	7	7	7	7	8	8	9
	2	8	8	8	8	8	9	9	9
	3	9	9	9	9	9	9	9	9

Table C: Neck, trunk and leg score

Wrist and Arm Score	1	2	3	4	5	6	7+
1	1	2	3	3	4	5	5
2	2	2	3	4	4	5	5
3	3	3	3	4	4	5	6
4	3	3	3	4	5	6	6
5	4	4	4	5	6	7	7
6	4	4	5	6	6	7	7
7	5	5	6	6	7	7	7
8+	5	5	6	7	7	7	7

Appendix C: *Moore-Garg Strain Index Assessment of the Packaging Process.*

Process 1

Job / Task: Process 1

Date: 9/11/2012

Analyst: Gundeep Singh

SI Score	Interpretation
< 3	Safe
3-5	Uncertain
5-7	Some Risk
> 7	Hazardous

Product of all multipliers

SI = **4.5**

Variable	Rating Criterion	Observation	Variable Multiplier	Enter Multiplier
Intensity of Exertion	Light	Light: Barely noticeable or relaxed effort (BS: 0-2)	1	
	Somewhat Hard	Somewhat Hard: Noticeable or definite effort (BS: 3)	3	
	Hard	Hard: Obvious effort; Unchanged facial expression (BS: 4-5)	6	
(BS is Borg Scale)	Very Hard	Very Hard: Substantial effort; Changes expression (BS: 6-7)	9	6
	Near Maximal	Near Maximal: Uses shoulder or trunk for force (BS: 8-10)	13	
Duration of Exertion (% of Cycle)	< 10%		0.5	
	10-29%		1.0	
	30-49%		1.5	
	50-79%		2.0	1.0
	> 80%		3.0	
Efforts Per Minute	< 4		0.5	
	4 - 8		1.0	
	9 - 14		1.5	
	15 - 19		2.0	0.5
	> 20		3.0	
Hand/Wrist Posture	Very Good	Perfectly Neutral	1.0	
	Good	Near Neutral	1.0	
	Fair	Non-Neutral	1.5	
	Bad	Marked Deviation	2.0	1.5
	Very Bad	Near Extreme	3.0	
Speed of Work	Very Slow	Extremely relaxed pace	1.0	
	Slow	Taking one's own time	1.0	
	Fair	Normal speed of motion	1.0	
	Fast	Rushed, but able to keep up	1.5	1.0
	Very Fast	Rushed and barely/unable to keep up	2.0	
Duration of Task Per Day (hours)	<1		0.25	
	1 - 2		0.50	
	2 - 4		0.75	
	4 - 8		1.00	1.00
	> 8		1.50	

Note: This worksheet was adapted and interpreted by the USF investigators. No warranty is offered.

Reference: J. Steven Moore & Arun Garg. The Strain Index: A Proposed Method to Analyze Jobs For Risk of Distal Upper Extremity Disorders; Am. Ind. Hyg. Assoc. J. 56:443-458 (1995)

Partial support from
UAW-Ford NJCHS
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Process 2

Job / Task: Process 2

Date: 9/14/2012

Analyst: Gundeep Singh

SI Score	Interpretation
< 3	Safe
3-5	Uncertain
5-7	Some Risk
> 7	Hazardous

Product of all multipliers

SI = 13.5

Variable	Rating Criterion	Observation	Variable Multiplier	Enter Multiplier
Intensity of Exertion	Light	Light: Barely noticeable or relaxed effort (BS: 0-2)	1	
	Somewhat Hard	Somewhat Hard: Noticeable or definite effort (BS: 3)	3	
	Hard	Hard: Obvious effort; Unchanged facial expression (BS: 4-5)	6	
(BS is Borg Scale)	Very Hard	Very Hard: Substantial effort; Changes expression (BS: 6-7)	9	6
	Near Maximal	Near Maximal: Uses shoulder or trunk for force (BS: 8-10)	13	
Duration of Exertion (% of Cycle)	< 10%		0.5	
	10-29%		1.0	
	30-49%		1.5	
	50-79%		2.0	1.5
	> 80%		3.0	
Efforts Per Minute	< 4		0.5	
	4 - 8		1.0	
	9 - 14		1.5	
	15 - 19		2.0	1.0
	> 20		3.0	
Hand/Wrist Posture	Very Good	Perfectly Neutral	1.0	
	Good	Near Neutral	1.0	
	Fair	Non-Neutral	1.5	
	Bad	Marked Deviation	2.0	2.0
	Very Bad	Near Extreme	3.0	
Speed of Work	Very Slow	Extremely relaxed pace	1.0	
	Slow	Taking one's own time	1.0	
	Fair	Normal speed of motion	1.0	
	Fast	Rushed, but able to keep up	1.5	1.0
	Very Fast	Rushed and barely/unable to keep up	2.0	
Duration of Task Per Day (hours)	<1		0.25	
	1 - 2		0.50	
	2 - 4		0.75	
	4 - 8		1.00	0.75
	> 8		1.50	

Note: This worksheet was adapted and interpreted by the USF investigators. No warranty is offered.

Reference: J. Steven Moore & Arun Garg. The Strain Index: A Proposed Method to Analyze Jobs For Risk of Distal Upper Extremity Disorders; Am. Ind. Hyg. Assoc. J. 56:443-458 (1995)

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No Warranty: Expressed or Implied.

Process 3

Job / Task: Process 3

Date: 9/18/2012

Analyst: Gundeep Singh

SI Score	Interpretation
< 3	Safe
3-5	Uncertain
5-7	Some Risk
> 7	Hazardous

Product of all multipliers

SI = 6.8

Variable	Rating Criterion	Observation	Variable Multiplier	Enter Multiplier
Intensity of Exertion	Light	Light: Barely noticeable or relaxed effort (BS: 0-2)	1	
	Somewhat Hard	Somewhat Hard: Noticeable or definite effort (BS: 3)	3	
	Hard	Hard: Obvious effort; Unchanged facial expression (BS: 4-5)	6	
(BS is Borg Scale)	Very Hard	Very Hard: Substantial effort; Changes expression (BS: 6-7)	9	6
	Near Maximal	Near Maximal: Uses shoulder or trunk for force (BS: 8-10)	13	
Duration of Exertion (% of Cycle)	< 10%		0.5	
	10-29%		1.0	
	30-49%		1.5	
	50-79%		2.0	1.5
	> 80%		3.0	
Efforts Per Minute	< 4		0.5	
	4 - 8		1.0	
	9 - 14		1.5	
	15 - 19		2.0	0.5
	> 20		3.0	
Hand/Wrist Posture	Very Good	Perfectly Neutral	1.0	
	Good	Near Neutral	1.0	
	Fair	Non-Neutral	1.5	
	Bad	Marked Deviation	2.0	1.5
	Very Bad	Near Extreme	3.0	
Speed of Work	Very Slow	Extremely relaxed pace	1.0	
	Slow	Taking one's own time	1.0	
	Fair	Normal speed of motion	1.0	
	Fast	Rushed, but able to keep up	1.5	1.0
	Very Fast	Rushed and barely/unable to keep up	2.0	
Duration of Task Per Day (hours)	<1		0.25	
	1 - 2		0.50	
	2 - 4		0.75	
	4 - 8		1.00	1.00
	> 8		1.50	

Note: This worksheet was adapted and interpreted by the USF investigators. No warranty is offered.

Reference: J. Steven Moore & Arun Garg. The Strain Index: A Proposed Method to Analyze Jobs For Risk of Distal Upper Extremity Disorders; Am. Ind. Hyg. Assoc. J. 56:443-458 (1995)

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Appendix D: *Ergonomic Symptom Survey Form.*

Job Name or Workstation: ____

Shift: __________ Hours worked/week: ____________ Time on this job: __________

Have you ever had any pain or discomfort while performing the task? ________________

Check the areas where you experienced pain or discomfort while performing the task:

Neck: [ ] Shoulder: [ ] Elbow/forearm: [ ] Hand/wrist: [ ] Fingers: [ ] Upper Back: [ ] Lower Back: [ ]
Thigh/knee: [ ] Low Leg [ ] Ankle/foot [ ]

Put a check by the word(s) that best describe your problem:

Aching: [ ] Burning: [ ] Cramping: [ ] Loss of Color: [ ] Numbness (asleep): [ ] Pain: [ ] Swelling: [ ]
Stiffness: [ ] Tingling: [ ] Weakness: [ ]

Other: ____

When did you first notice the problem? ____________________________________

How long does each episode last? ____

How many separate episodes have you had in the past year? ______________________

What do you think caused the problem? _____________________________________

Have you had this problem in the last 7 days? _________________________________

How would you rate this problem? (Rate this problem on a scale of 1-10; 1=no pain &
10=unbearable)____

When it is the worst? ____

Have you had medical treatment for this problem? _____________________________

If no, why not? ____

If yes, what kind of treatment did you receive? _______________________________

Did the treatment help? ____

How much time have you lost in the last year because of this problem? ______________

How many days in the last year were you on restricted or light duty because of this problem? __

Appendix E: *Human Subject Implied Consent Form.*

Title:
An Ergonomic Analysis of the Current Packaging Process at Company XYZ

Research Sponsor:
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Jarvis Hall Science Wing Menomonie, WI
54751
715-232-1422

Investigator:
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Description:
The purpose of this study will be to analyze the current workplace conditions and ergonomic practices that are being performed by employees in the packaging line at the shipping department within Company XYZ. In order to meet this purpose, an ergonomic symptom survey needs to be completed, which is structured to collect both quantitative and qualitative data that may be missed in general medical exams and reports. Your participation involves completing a symptom survey form to your best knowledge and submitting the completed survey in a confidential manner on the same day before leaving from work. The survey forms will be provided and administered by the investigator only. The data gathered in the survey will be analyzed and used to identify the baseline for the study.

Risks and Benefits:
Participation in completing the ergonomic symptom survey presents no inherent risks to the employee, as the forms will remain anonymous. The benefits of this study may include a reduction in musculoskeletal injuries, employee lost time, cost and increased productivity at the workplace.

Time Commitment:
It is estimated that the ergonomic symptom will take a total of 5-10 minutes to complete depending on the length of the open-ended questions.

Confidentiality:
To retain confidentiality, all surveys filled out will remain anonymous. Employees will not include their name on the ergonomic symptom survey form, and once completed, the forms are to be printed and placed in a locked drop box located outside the investigators' cubical. Surveys will be kept in a secured location when the researcher is not using them. At the conclusion of the study, the completed survey forms will be destroyed.

Right to Withdraw:
Your participation in this study is entirely voluntary. You may choose not to participate without any adverse consequences to you. Should you choose to participate and later wish to withdraw from the study, you may discontinue your participation at this time without incurring adverse consequences.

IRB Approval:
This study has been reviewed and approved by The University of Wisconsin-Stout's Institutional Review Board (IRB). The IRB has determined that this study meets the ethical obligations required by federal law and University policies. If you have questions or concerns regarding this study, please contact the Investigator or the Advisor. If you have any questions, concerns, or reports regarding your rights as a research subject, please contact the IRB Administrator.

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Statement of Consent:
By completing the following, ergonomic symptom checklist survey, you agree to participate in the project entitled, **An Ergonomic Analysis of the Current Packaging Process at Company XYZ**.