An Ergonomic Investigation of the Case-Packing Line at Company XYZ.

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Abstract

The continued occurrence of musculoskeletal disorders from manually loading bundles of collapsed cardboard boxes onto a case-packing machine at Company XYZ places the organization at risk for incurring continued employee injuries, other production/quality losses, and financial loss. The results of the Rapid Upper Limb Assessment (RULA) and Rapid Entire Body Assessment (REBA), and the past four years of OSHA recordable injury reports were analyzed to recognize and remediate measures for reducing musculoskeletal disorders (MSDs). The research results indicate that awkward postures, high repetition, and small-range motions are all present at the case-packing line. The case-packing line currently has several administrative and engineering controls in place to prevent the occurrence of cumulative trauma disorders (CTDs) and MSDs, but for the most part, ergonomic improvements to the line have been ignored. The primary recommendations of this research are that administrative and engineering controls need to be implemented to remove ergonomic-related risk factors while workers perform the case-packing process.

Table of Contents

List of Tables

List of Figures

Chapter I: Introduction

Ergonomics is the study of the relationship of man with machine by designing the work environment to "fit" the physical and mental characteristics of the worker (Bird & Germain, 1985). According to Krieger, Montgomery, & Laing (1997), when workers and their environment are mismatched, injury levels rise, production is inefficient, and other incidents occur that detract from organizational efficiency and worker welfare. In most instances, poor ergonomic techniques will lead to musculoskeletal disorders (MSDs) and cumulative trauma disorders (CTDs).

There are several factors that move individuals towards ergonomic disorders when working at a workstation. Krieger, et al. (1997) stated that the three primary factors consist of physical, environmental, and mental demands. The first factor is physical demands which are those placed on the musculoskeletal system of the body. Some examples are lifting, pushing, pulling, reaching, exerting force to perform a task, and the effort required to do the job. The second factor is the environmental demands placed on a worker in the workplace such as vibration, temperature, humidity, noise, and lighting levels. Also included in environmental demands would be the psychosocial environment that one works in, including such factors as the work organization, pace, shift schedule, and the need for overtime. The third factor is mental demands and includes the information needed to perform a particular task such as mental calculations or computations, any short-term memory demands, information processing, and decision making. All of these can alternately lead to production/quality, accidents, and even financial losses. There are a number of ways that will help remove the strain of the worker. This would be done by redesigning and making adjustments to the workstation, varying tasks throughout the day, and by fitting the job to the worker.

Company XYZ Background

Creativity and organization were key components in bringing together wheat farmers and manufacturing professionals to build a state-of-the-art pasta processing operation in North Dakota. The project began in the early 1990s and started with the organizing of more than 1100 wheat farms throughout the Midwest. From these efforts, Company XYZ was able to become established. Company XYZ put a plan together to build wheat growers and operations began in 1993. As Company XYZ expanded their operations which included a durum mill and a pasta processing plant in North Dakota, they also acquired a pasta processing plant in Minnesota. Company XYZ was now recognized as one of the larger pasta manufactures in North America and was ranked as a supplier of premium quality pasta products. Their primary markets are input ingredients, food service, and retail markets. Company XYZ became a common stock corporation in 2002.

Company XYZ continued to evolve as a thriving enterprise as they expanded to meet the needs of their customer base. They were recognized as ranking durum wheat growers and expanded on their credibility by working directly with grower - shareholders to continue the production of high quality durum. With consistent high quality input, Company XYZ was able to maintain quality control over the firmness, texture, color, and taste of the pasta along with the improved ability to reheat the pasta and also its durability. They milled 100% of the raw material input for the pasta. Company XYZ promoted a "Better-For-You" formula which was and still is available in most popular shapes of which they now produce over 100 shapes. Pasta by Company XYZ was and still is sold under private label to retailers and is widely used by restaurants and a variety of food processors for frozen foods, dry mix foods, and prepared meals. The pasta is distributed throughout the United States and the world.

Ergonomic Problems at Company XYZ

After completing a preliminary ergonomic assessment it has been determined that there are noticeable risk factors in the current packaging process. These risk factors were determined by the safety manager and are likely the cause of high ergonomic incident rates, and an increase in workers compensation costs. More specifically, the risk factors consisted of flexing of the back, extraction of the arm, excessive variation of wrist movement, and a high level of repetition. Prolonging these risk factors would alternately lead to more musculoskeletal disorders (MSDs) and cumulative trauma disorders (CTDs). The investigation of ergonomic case-packing problems has the potential of reducing ergonomic-based problems throughout the company.

Statement of the Problem

The continued occurrence of musculoskeletal disorders from manually loading bundles of collapsed cardboard boxes onto a case-packing machine at Company XYZ places the organization at risk of incurring continued employee injuries, other production/quality losses, and financial loss.

Purpose of the Study

The purpose of this study was to analyze the causes and effects of ergonomic risks at Company XYZ for the task of manually loading bundles of collapsed cardboard boxes onto a case-packing machine. The intent was to make recommendations on how to lower the ergonomic risk factors involved with the process.

Significance of the Study

Since the beginning of 2006, there have been seven recordable injuries associated with the case-packing line at Company XYZ. These injuries all have symptoms relating to musculoskeletal disorders (MSD). This study had the potential to reduce the amount of injuries through the identification of the hazard causing factors. Positive effects on productivity and quality may also be noticed through the improvement of existing workstations and overall employee safety.

Methods

The qualitative study consisted of the rapid upper limb assessment (RULA) and the rapid entire body assessment (REBA). The RULA is a quick and systematic assessment that assesses primarily the upper limbs for postural risks. The REBA is a quick and systematic assessment that assesses the entire body for postural risks. These two methods make use of a diagram of body postures and three scoring tables to provide an evaluation of exposure to risk factors. It is also crucial to review injury records and determine all ergonomic-based injuries that are associated with the packaging process.

Assumptions of the Study

The following five assumptions will be found spread throughout the research paper; but they are localized here for clarity and future reference.

1. The sample represented the population.
2. All workers are in good physical health at the time of the survey.
3. The workers communicated truthfully to the respondent.
4. Procedures and measurements used in the study were valid.
5. Records that have been maintained on injuries were accurate.

Definition of Terms

Cumulative trauma disorders (CTD). CTDs are disorders of the soft tissues in the upper extremities, including the fingers, the hand and wrist, the upper and lower arms, the elbow, and the shoulder (Wickens, Lee, Liu, &Gordon Becker, 2004).

Environmental demands. Examples would be vibration, temperature, humidity, noise, and lighting levels (Krieger, Montgomery, & Laing, 1997).

Ergonomics. Ergonomics is a study of the relationship of man with machine by designing the work environment to "fit" the physical and mental characteristics of the work (Bird & Germain, 1985).

Mental demands. Examples would be the information needed to perform a particular task, mental calculations or computations, any short-term memory demands, information processing, decision making (Krieger, Montgomery, & Laing, 1997).

Musculoskeletal disorders (MSD). Refers to conditions that involve the nerves, tendons, muscles, and supporting structures of the body (National Institute for Occupational Safety and Health, 1997).

Physical demands. Examples are lifting, pushing, pulling, reaching, exerting force to perform a task, and the effort required to do this job (Krieger, Montgomery, & Laing, 1997).

Limitations of the Study

1. Varity of different employees who worked on the machine.
2. Physical time at the workstation was limited.
3. Lack of knowledge in available design of better workstations.
4. Communicating with the workers.
5. Sampling techniques that were involved.
6. The analysis only pertains to a specific workstation.

Chapter II: Literature Review

The purpose of this study was to analyze the packaging line at Company XYZ to determine the magnitude of ergonomic risk factors that were present. Employees in this process were being exposed to ergonomic risks that could cause musculoskeletal injuries. In this chapter, the researcher presents a review of literature including the explanation of the cost benefits of ergonomics, risk factors associated with ergonomics, musculoskeletal disorders and illnesses, and tools or controls which were used to implement the best technique for correction.

Benchmarking/Cost Benefits of Ergonomics

The two primary reasons for developing programs and analyzing ergonomics are the potential cost benefits for the employer and creating a safe workplace for employees. In the American workplace, the total number of work-related musculoskeletal disorders is increasing, as are the associated medical costs and workers compensations costs (Okoronkwo, 2001). There are three negative factors that can occur when poor ergonomic conditions exist in organizations. The factors are high worker compensation costs, decreased productivity, and poor quality of work. These three factors can decrease the profitability of an organization.

One of the methods for recognizing the potential presence of uncontrolled ergonomic risk factors is through the benchmarking of ergonomic loss. Ergonomic losses are benchmarked into two categories, reactive and proactive. These two benchmarking methods are used in an effective manner before and after potential losses which can help determine employee exposure. The first benchmarking method is reactive, which is used in industry as a basis on which to estimate the effectiveness of risk prevention programs. The reactive method analyzes losses that have already occurred and determines whether they were due to an equipment failure or human error. This method is not a transferable practice for correcting issues, because it only identifies and solves one specific problem before its usefulness is exhausted (Chengular, et al., 2004). There are numerous reactive measurement-based rates that quantify the company's past safety record. One of these measurement methods is the OSHA recordable incident rate. The OSHA rate calculation describes the number of employees per 100 full-time employees who have been involved in a recordable injury or illness (OSHA, 2009). The rates are easily calculated and compared to OSHA, industry, and from one company to another.

In 1997, the National Institute for Occupational Safety and Health (NIOSH) explained that proactive approaches to workplace ergonomics programs emphasize prevention of workplace musculoskeletal disorders (WMSDs) through recognizing, anticipating, and reducing risk factors in the planning stages of new work processes (NIOSH, 1997). This is accomplished by having the appropriate person or system apply ergonomic principles in designing the products, workstations, work area, plants, systems, and programs (Chengular, et al., 2004).

There are several methods used in the proactive approach for preventing injuries in the workplace; questionnaires and surveys, routine workplace assessments, and routine employee training. A questionnaire is a reliable instrument when it elicits the same responses when it is completed by the same person under the same conditions. As an important part of the proactive approach, routine workplace assessments refer to the evaluation of day-to-day working practices in the work environment. The purpose of the assessments is to qualitatively evaluate worker exposures to hazards during various jobs, the adequacy of work-place controls, and worker exposure patterns. The essential component of the comprehensive ergonomics and injury prevention and management program is training (Lunda & Peate, 2002). The purpose of training and education is to provide managers, supervisors and employees with enough relevant information so that they can take an active role in the prevention of ergonomic-related injuries.

Ergonomic Risk Factors

There are five primary risk factors that lead to the development of musculoskeletal illnesses; awkward postures, excessive forces, high repetition, temperature extremes, and vibration (ErgoWeb, 2010). Awkward postures occur when the positioned joints of the body are being deviated from their neutral positions (Michael, 2002). These postures can affect the body when individuals flex down too far, reach long distances, and twist their spines when completing tasks. Common examples of awkward postures are extending, flexing, twisting, reaching, and altering different parts of the body.

Force is the amount of muscular effort required to perform a task. Studies show that the greater the amount of force, the greater the degree of risk will be for that particular task. According to Drury (2005), an increase in object handling typically results in an increase in force exerted. The affect realized from force depends on type of grip, weight of object, temperature, and weight of task. Forces that are exerted in a task will vary, but when force is held for long periods of time, it causes fatigue which requires the body to compensate resulting in the potential of cumulative trauma disorders (CTDs) (Schoenmarklin, Marras, & Leurgans, 1994).

Repetition is the number of related exertions done during a particular task. When extreme levels of repetition occur, individuals can suffer injuries in the musculoskeletal system that could affect the nerves, tendons, ligaments, joints, and the spinal disks. High frequencies of repetition, even with small force, can cause or contribute to the development of cumulative trauma disorders (CTDs) (Tayyari & Smith, 1997).

According to Yale Environmental Health and Safety (2009), temperature extremes can be problematic and can cause trouble in breathing, fatigue, reduced dexterity, sensory sensitivity, and reduced grip strength. Temperature extremes happen when the temperature drops below or rises above the comfort zone which is defined as 55 degrees to 85 degrees. Hot and cold temperatures can occur in outdoor and indoor environments which means that workers are always at risk.

Vibration occurs in the occupational setting when the body is exposed to pulsation, shaking, or tremor which is usually due to a vibrating object such as a power tool. Hand-transmitted vibrations (HTV) are known by workers to cause tingling, numbness, reduced tactile discrimination, and impaired manipulative dexterity (Rui, D'Agostin, Negro, & Bovenzi, 2008). Traditionally, the main industrial tools that cause vibration consists of power tools such as grinders, sanders, and chainsaws.

Forms of Ergonomic Injuries/Illnesses

The term musculoskeletal disorders (MSDs) is defined as the deviation of muscles, tendons, joints, ligaments, cartilage, nerves, blood vessels, or spinal discs. To reduce MSD injuries, it is apparent that the building of workstations, tools, and equipment must be designed to fit the worker (Craven, 2003). They also state that the common causes of MSDs are exerting excessive forces, repetitive movements, awkward postures, static postures, excessive vibrations, and temperature extremes. Even though the industry has shifted its manufacturing processes from a more physical based system to a more mechanized system, it is unlikely to completely mechanize the processes so that human interaction is completely removed from the hazardous environment.

Back pain is a result from injuries to the spine, muscles, nerves or other structures in the back. The symptoms include tingling, burning sensation, dull ache, sharp pain and weakness in legs or feet (Environmental Health & Radiation Safety, 2008). Back pain is not always caused by one event and may be the result of improper postures or lifting over extended periods of time.

Injury to the lumbar region of the back occurs in the lower portion of the back. This made it necessary to look in-depth at cumulative trauma disorders that better define MSDs.

Cumulative Trauma Disorders (CTDs) are repetitive-motion injuries that occur to upper extremities. To be more specific, these injuries primarily affect the hand, wrist, or the forearm. Mraz and Weigel (1998), state that the risk of receiving a CTD depends on the force, precision, and degree of repetition of the specific task. Typically the most common CTDs are carpal tunnel syndrome and tendinitis.

Some form of a CTD occurs in most workers, and yet many individuals might not distinguish the symptoms that correspond with the illnesses. These basic symptoms typically include soreness and pain, limited range of motion, stiffness in joints, tingling and numbing, popping or cracking joints, burning sensations, swelling and redness, or weakness and clumsiness. CTDs are relatively widespread in the general population. Most people have experienced this ailment at a point in their lives in at least a mild form, such as low back pain (MacLeod, 1995).

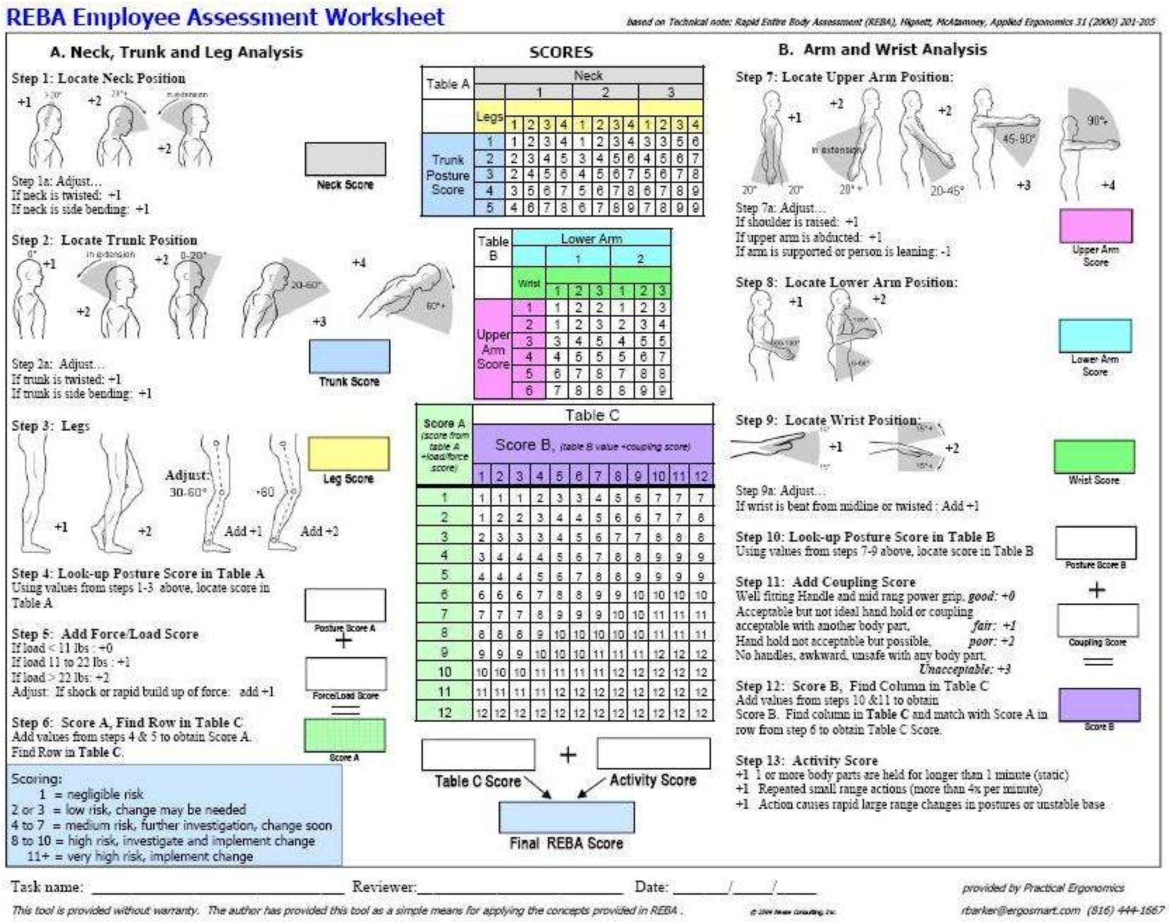
Ergonomic Assessment Tools

There are several tools used to assess ergonomic issues. Two of the tools are the Rapid Entire Body Assessment (REBA) and Rapid Upper Limb Assessment (RULA).

Rapid entire body assessment (REBA). According to Cornell University Ergonomics Web, (2010), the REBA was developed in 1993 by Hignett and McAtamney, Ergonomists from the University of Nottingham in England. REBA is a quick and systematic assessment that assesses the entire body for postural risks. It was determined that REBA is an excellent tool for assessing lower back postures and is ideal for the postural changes on the entire body (Pillastrini, et al., 2007). According to Hignett and McAtamney the development of REBA was designed to:

- Develop a postural analysis system delicate to musculoskeletal risks in a variety of different tasks.
- Divide the body into segments to be coded individually, with reference to movement planes.
- Provide a scoring system for muscle activity caused by static, dynamic, rapid changing, or unstable postures.
- Reflect that coupling is important in the handling of loads but may not always be via the hands.
- Give an action level with an indication of urgency.
- Require minimal equipment – pen and paper method (Hignett & McAtamney, 2000).

The REBA worksheet is a practical tool for evaluating a variety of body movements used in performing specific job tasks. However, the worksheet's deficiencies comes from only allowing for minimal input when it considers operations like seated work and twisting of the spine. The REBA however, does place a considerable amount of emphasis on evaluating the extremities such as the wrists, arms, and legs. The numbering system that is used to rank the severity of potential ergonomic hazards appears to work well with this assessment methodology as long as the calculated values are only used for evaluating the applicable job. This tool may or may not take into account all aspects of the task being performed, but it will give the researcher a great sense as to where the highest potential for injury occurs. Following is an example of the worksheet used for the REBA:



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

+1 +2 +2

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

Neck Score

Step 2: Locate Trunk Position

+1 +2 +2 +3 +4

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

Trunk Score

Step 3: Legs

+1 +2 Adjust: 30-60° Add +1 +60 Add +2

Leg Score

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

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

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**.

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				2				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			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 + Activity Score

Final REBA Score

B. Arm and Wrist Analysis

Step 7: Locate Upper Arm Position:

+1 +2 +2 +3 +4

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

Step 8: Locate Lower Arm Position:

+1 +2

Lower Arm Score

Step 9: Locate Wrist Position:

+1 +2

Wrist Score

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

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

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

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: ____________ Reviewer: ____________ Date: ___/___/___

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

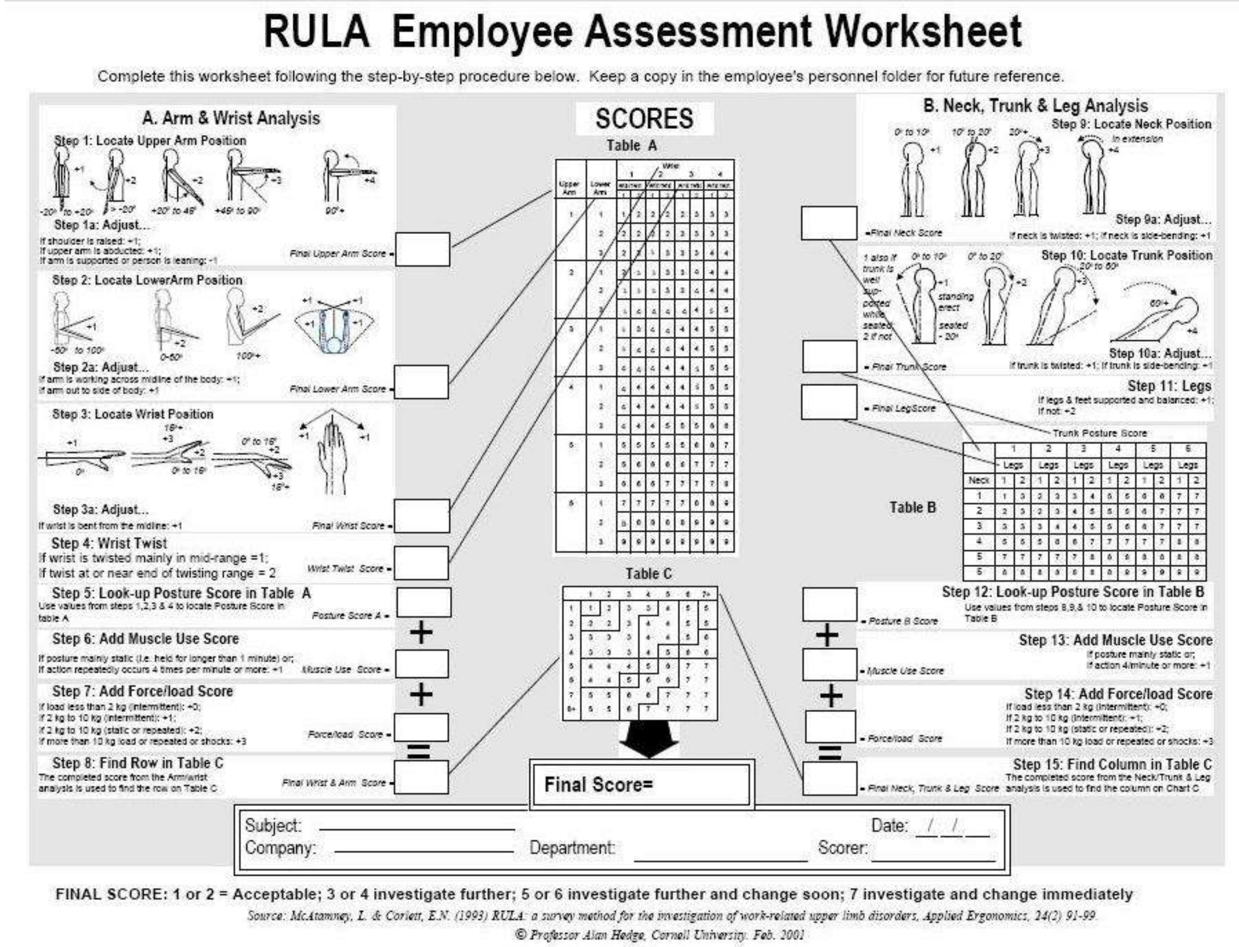
[1]From “REBA: A Survey Method for the Investigation of Work-Related Upper Limb Disorders,” by Hignett, S. and McAtamney, L. (2000), *Applied Ergonomics*, (31), p. 201-205.

Figure 1. Rapid Entire Body Assessment Worksheet[1]

Rapid upper limb assessment (RULA). According to Cornell University Ergonomics Web, (2010), the RULA was developed by McAtamney and Corlett, Ergonomists from the University of Nottingham in England. RULA is a quick and systematic assessment that assesses primarily the upper limbs for postural risks. For example, according to Bao, Howard, Spielholz, & Silverstein (2007), RULA calculates scores for the upper arm, hand/wrist, and lower extremity by taking various body postures combined with force and repetition estimates. The method uses diagrams of body postures and three scoring tables to provide an evaluation of exposure to risk factors. The risk factors under investigation can consist of:

- Numbers of movements
- Static muscle work
- Force
- Work postures determined by the equipment and furniture
- Time worked without a break (McAtamney & Corlett, 1993).

The RULA assessment provides a method of quickly assessing posture whether seated or standing, paying specific attention to the neck, trunk, and upper limb segments. Furthermore, it assesses the contribution of the muscular effort, whether arising from exerting external force, from the postural effort, or from muscle loading in the task activities such as holding tools (Haslegrave & Corlett, 1995). Based on observation of exact work cycles, the investigator records the positions of the upper arm, lower arm, neck, wrist, and lower back in order to associate a number with each body section. The final score is a combination of an added number from each bodily section which is then put into the final table to determine the scoring level. Following is an example of the worksheet used for the RULA:



[2]From "RULA: A Survey Method for the Investigation of Work-Related Upper Limb Disorders," by L. McAtamney and E.N. Corlett, 1993, *Applied Ergonomics*, (24)2, p. 91-99.

Figure 2. Rapid Upper Limb Assessment Worksheet[2]

Ergonomic Control Measures

A control is a strategy for controlling workplace hazards, including ergonomics. In the manufacturing industry, there are three primary types of controls; administration controls, engineering controls, and personal protective equipment (PPE). These three controls are the widely accepted strategy for controlling workplace hazards. According to Chen, et al. (1997) these three approaches can assist with:

- Reducing or eliminating potentially hazardous conditions using engineering controls.

- Changes in work practices and management policies, sometimes called administrative controls.
- Use of personal protective equipment (Chen, et al., 1997, p. 31).

Through the use of engineering controls, typically an engineer eliminates the hazard through redesigning the equipment or process to fit the employee. Administration controls take a different path compared to engineering controls in that they attempt to remove the worker from the process or limits the exposure time that a worker receives from each job task. The use of personal protective equipment reduces hazardous conditions, but is generally designed to reduce hazards when employees are unprotected.

Administration controls. Administration controls are management policies and work practices used to minimize the exposure to ergonomic risk factors. Administrative control strategies included changes in procedures and job rules, such as scheduling more rest breaks, using rotation for tasks that are physically demanding or tiring, and training workers to understand risk factors and to learn or reinforce techniques for reducing stress and strain while performing their tasks (Chen, et al., 1997). Since administrative controls are only temporary, they do not eliminate the hazard so management must make sure that the policies and procedures are developed and followed. There are several examples of administrative controls:

- Reducing the total shift length or restricting the amount of overtime.
- Rotating workers through several dissimilar jobs with different physical demands to reduce the stress on limbs and other body regions.
- Scheduling more breaks throughout the work day to allow for rest and recovery.
- Broadening or varying the job content to offset certain risk factors (e.g., repetitive motions, static and awkward postures).

- Adjusting the work pace to relieve repetitive motion risks and give the worker more control of the work process.
- Training to recognize risk factors for work-related musculoskeletal disorders (WMSDs) and instruction in work practices that ease the task demands or burden (Chen, et al., 1997, p. 34).

Through the proper oversight from management and supervisors and the correct training measures implemented is likely that administrative controls will temporarily eliminate hazards until permanent measures can be presented.

Engineering controls. An engineering control reduces and eliminates potential equipment hazards in the workplace. This will be accomplished by using engineering to design a workstation to completely eliminate the risk factors or hazards. Engineering control strategies to reduce ergonomic risk factors include the following:

- Changing the way materials, parts, and products can be transported for example, using mechanical assist devices to relieve heavy load lifting and carrying tasks or using handles or slotted hand holes in packages requiring manual lifting.
- Changing the process or product to reduce worker exposures to risk factors; examples include maintaining the fit of plastic molds to reduce the need for manual removal of flashing, or using easy-connect electrical terminals to reduce manual forces.
- Modifying containers and parts presentation, such as height adjustable material bins.
- Changing workstation layout, which might include using height-adjustable workbenches or locating tools and materials within short reaching distances.
- Changing the way parts, tools, and materials are to be manipulated, for example using fixtures to hold pieces to relieve the need for awkward hand and arm positions.

- Changing assembly access and sequence (Chen, et al., 1997).

Engineering controls are implemented and developed to reduce or remove a hazard in a process. This can be done by changing the chemical makeup of a product, using mechanical lifting devices, or changing a process to reduce or limit worker exposure to ergonomic hazards. These methods will allow the process to protect the employee from potential hazards conducive of that process.

Personal protective equipment (PPE). Personal protective equipment (PPE), including gloves, clothing, or equipment, will help to minimize risk factors in the workplace. Ear plugs, safety goggles, respirators, chemical aprons, safety shoes, and hard hats are all examples of PPE. A drawback of PPE is that employees need training as to why the PPE is necessary and how to properly use and maintain it (OSHA, 2009). Another important aspect to know about PPE is that it is not suitable for every situation (OSHA, 2009). This is often considered the last line of protection because the barrier separating the employee from the health hazard must be worn.

Evaluation and testing of the ergonomic control measures will verify that the proposed solution actually works and identifies any additional modifications that may be needed in the future. The employees who perform the evaluated task can provide valuable input into the testing and evaluation process. Worker acceptance of the changes put into place is important to the success of the intervention (Chen, et al. 1997).

Summary

Risk factors such as force, awkward postures, repetition, temperature extremes and vibrations each affect the human body differently, however they are each associated with musculoskeletal disorders that affect the workforce in highly repetitive jobs. There are several recognized ergonomic tools that can be used in the workplace to identify and analyze risk factors or health hazards. Ergonomic tools establish the severity of the risk and help determine which risk factor should be remediated first. It is essential that an assessment be performed using the proposed ergonomic tools in order to evaluate the extent of ergonomic exposure to which the case-packing workers are subjected. With the aid of assessments and proper training, MSDs and CTDs should be reduced in the workplace. When the exposures have been evaluated, it will be possible to establish the hierarchy of controls needed to eliminate or reduce the existence of the risk factors. The control hierarchy includes administrative controls, engineering controls, and personal protective equipment. In order to reduce the potential for exposure to risk factors, recommendations must be established from the qualitative assessments.

Chapter III: Methodology

The purpose of this study was to analyze the sources of ergonomic risks at Company XYZ while employees manually loaded bundles of collapsed cardboard boxes onto a case-packing machine. The intent was to make recommendations on how to lower the ergonomic risk factors involved with the process. In order to assess the ergonomic risks of the packaging line, several tools were used to determine the extent of awkward postures, forces applied, excessive repetition, and the temperature extremes of the task.

Subject Selection and Description

The three subjects of this study were selected by the safety manager of Company XYZ. At Company XYZ the process of manually loading bundles of corrugate onto a machine was typically performed by three to six workers. The excessive forces and amounts of repetition required in the process were of concern, potentially exposing employees to ergonomic risk factors. Before conducting any assessments, the researcher clearly notified all participating workers of the study. The researcher explained the entire process to the subjects and mentioned that participation was voluntary. The researcher and subjects reviewed the observation schedule, assessments, and equipment used to conduct the study. The subjects were encouraged to ask additional questions before agreeing to participate in the study.

Instrumentation

A review of literature was conducted to identify key components and benefits of an ergonomic analysis. From the key components and benefits found in the review of literature, it was possible to determine the proper tools to be used in order to obtain the data needed to effectively analyze the ergonomic hazards. The specific tools used in this study included the RULA assessment and the REBA assessment.

The RULA assessment tool effectively assessed the movements and postures of the body while completing the task. The completion of this assessment tool did provide a specific score for the entire upper body or upper limb while delineating sections for arms, wrist, shoulder, neck, and the trunk of the body. The RULA took into account the force, repetition, and awkward positions held by the employee. The final score of this tool helped determine the potential for CTDs and help the researcher rank the score based on other tools used.

The REBA assessment tool focuses on many of the same body functions as the RULA, except the scoring process is slightly different. The REBA focus was on the entire body versus just the upper limb. The final scoring system of each tool provides different numbers and scoring categories, but they did conclude similar recommendations and outcomes.

Data Collection Procedures

Completing the RULA survey:

1. Observed the entire task cycle to become familiar with the postures and work practices.
2. A part of the task cycle was identified that included postures to analyze.
3. Scored the postures and forces on the diagrams of the RULA worksheet for each body part in chosen postures.
4. Scores were put into a table by following the instruction on the score sheet.
5. Intervention, action levels, or the types of investigation needed were determined by the final score.

Completing the REBA survey:

1. Observed the entire task cycle to become familiar with the postures and work practices.
2. Repetitions, postures, and muscular activity involved in completing the task were selected and recorded in the proper sections.

3. Postures were then scored and totaled for sections A and B.
4. A single score was then calculated from the two sections.
5. An activity score was calculated with the REBA score provided a final score.
6. Interventions, action levels, or the types of investigation needed were determined by the final score.

Data Analysis

Through a review of the data collected during the task analysis, the researcher was able to identify which potential risk factors are most severe in the packaging line. The data collected from the ergonomic surveys RULA and REBA was evaluated for their potential risk factors. The RULA and REBA identify the joint angles that need to be compared to anthropometric data. This was accomplished by determining the acceptable limits and joint angles for the ninety-fifth percentile and comparing the measurements of this study to the anthropometric data. The tables given at the end of each tool were used to give quantitative proof that risk factors are present.

Limitations

The limitations of this study include:

1. The employee's willingness to participate with this study could alter the results.
2. The analyzed process, conclusions, and recommendations for this study were only applicable to the packaging line at Company XYZ.

Chapter IV: Results

The purpose of this study was to analyze the causes and effects of ergonomic risks at Company XYZ while manually loading bundles of collapsed cardboard boxes onto a case-packing machine. The intent was to make recommendations on how to lower the ergonomic risk factors involved with the process. The goals of the study were to:

1. Perform a task analysis for the existing case-packing line using qualitative-based tools.
2. Review injury records to determine all ergonomic-based injuries that were associated with the case-packing process.

The methodology used to collect data for the Rapid Upper Limb Assessment (RULA) and the Rapid Entire Body Assessment (REBA) assessment techniques were performed by observing the participants. While observing the participants, questions were asked about production rates, and about inputting the identified force and posture angles into the previously mentioned assessments.

Work Activity Description

To load bundles of corrugated onto a case-packing machine, the workers start by removing shrink wrap from a pallet which is holding the boxes together. Each pallet has 30 boxes stacked on it and each box can be anywhere from six inches to four feet off the ground. Every box is filled with one bundle of corrugate. While the workers remove the shrink wrap which holds the boxes in place on the pallet, the workers flex their trunk and neck approximately 20 degrees and perform a radial deviation in their wrist. Next, the workers remove a box from the pallet and place it on their shoulder. When placing the box on their shoulder, the workers abduct their shoulder and swivel their lower arm into an upward position, which secures the box. Once the 27 pound box is in place, the workers walk it approximately 18 feet. The box is then placed onto a wheeled cart which is located next to the machine. After the box is in place on the cart, the workers open the box with a putty knife and place a divider tool into the box which holds the corrugate in place. To remove the corrugate from the box, the workers rotate the box over onto the cart. During the rotation of the box, it was observed that the workers are performing radial deviations on their wrist and flex the spine forward. At this time, the workers use a pronation with the forearm when placing corrugate onto the machine. These actions are repeated once every two to three minutes.

Analysis of Collected Data

Goal number one. The first goal of this study was to perform a task analysis for the existing case-packing line using qualitative-based tools. The RULA and REBA assessment methods were used to produce quantitative data on the workers who were performing the packing on the case-packing line.

Rapid upper limb assessment (RULA). The researcher used the RULA assessment tool to assess the movements and postures of the worker’s body during completion of the task. The RULA assessment tool was used through observation of the worker to assess the forces, repetitions, and postures assumed to perform the case-packing task. The RULA assessment tool was suitable for this application because it focused on the neck, trunk, and upper extremities.

Table 1 below identifies the RULA assessment score that was generated for the worker performing the case-packing:

Table 1

RULA Assessment Scoring Table

RULA	Arm & Wrist Score	Neck, Trunk, & Leg Score	Table C Score	Final Score
Case-Packing	7	7	7	7

Table 1 indicates a final score of seven for the worker performing the case-packing process. The arm and wrist score was a seven on a scale of eight indicating that there is a high risk associated with the positioning of the upper extremities. The neck, trunk, and leg score was a seven on a scale of seven indicating that there was a high risk associated with the postures. The Table C score was a combination of the upper and lower extremity scores which determined the final RULA score. The RULA score of seven determined that the process needed to be investigated and there was a need for implemented changes. The completed RULA survey can be found in Appendix A.

Rapid entire body assessment (REBA). The researcher used the REBA assessment tool to assess the movements and postures that the body performed while completing the task. Forces, repetitions, and awkward postures were all considered when determining the final score for the REBA assessment. The researcher examined the case-packing process in the case-packing line through observation. Through the use of observation, it was possible for the researcher to assess the repetition involved in the task and the postures assumed to move the packages. The REBA assessment was appropriate for this application because it specifically takes into account the neck, trunk, arms, wrist, and leg placement.

Table 2 below identifies the REBA assessment score that was generated from the worker performing the case-packing:

Table 2

REBA Assessment Scoring Table

REBA	Neck, Trunk, & Leg Score	Arm & Wrist Score	Table C Score	Activity Score	Final Score
Case-Packing	6	6	8	2	10

Table 2 above indicates a final score of ten for the worker performing the case-packing process. The neck, trunk, and leg score was a six on a scale of nine indicating there is a medium risk associated with the positioning of these body parts. The arm and wrist score was a six on a scale of twelve suggesting that there was a medium risk associated with the positioning of the upper extremities. The Table C score was an eight on a scale of twelve which indicates high risk with the combination of the lower and upper extremity scores. The activity score was added to the Table C score giving a final score of ten due to the repeated small-range actions and large-range changes more than four times per minute. The score of ten determined that the process is high risk and it should be investigated for implementing changes. The completed REBA survey which reflects the above table can be found in Appendix B.

Goal number two. The second goal of this study was to review injury records and determine all ergonomic-based injuries that were associated with the case-packing process. Once the review of injury records was completed, it was determined since 2006, thirteen ergonomic-based injuries had occurred on the case-packing line. These injures were symptomatic of an increased need for more product needing the case-packing process to be performed. The focus of this study was to examine the effects of the case-packing after the introduction of new technologies on the case-packing line. The new robots further down the production line produced a larger demand for the case-packing when the need was compared to the demand in the years leading up to the use of new robots. Prior to the addition of new product being introduced, there were several OSHA recordable injuries that related to high repetitions and awkward postures while performing the case-packing process. However, after the new technologies were introduced, from 2006 to 2010, there were seven OSHA recordable injuries that were classified as severe. Four of the injuries were unexpected accidents, whereas, the other three were connected to chronic, ergonomic-based injuries that were introduced slowly over time due to the exposure of high repetition, awkward postures, and vibration. Using the analysis of injury records, the researcher developed Table 3 to illustrate the injuries that have occurred since the year 2006:

Table 3

Recordable Injuries in the Packaging Department (2006-2010)

Employee	Wrist	Back	Forearm
An X will mark each injury the employee has had occur			
1			X
2	X		
3		X	
4		X	
5		X	
6	X		
7	X		

Table 3 indicates that the most common injuries occurring in the past four years are associated with the wrist and back. Three of the back injuries resulted from improper lifting techniques which are directly associated with musculoskeletal disorders. The three wrist injuries and one forearm injury were diagnosed as cumulative trauma disorders. The wrist injuries were related to classic carpal tunnel syndrome and had side effects such as pain and numbness. The forearm injury was diagnosed as tendonitis and caused discomfort in both arms. These injuries were all significant because they resulted in lost time away from work.

It appeared from the data collected through the review of injury records that Company XYZ should be concerned about upper extremity injuries that was occurring from performing the case-packing process. There was an indication, based on the injury record review and the analysis of the ergonomic-assessment methods from goal one, that the upper extremity injuries that occurred were related to workers performing repetitive motion-based activities for multiple years. The injury analysis of the case-packing line at Company XYZ can be found in Appendix C.

Discussion

The results of the methodology used in this study indicate that there were a variety of risks involved when the workers performed the case-packing at Company XYZ. Although Company XYZ had administrative controls and some engineering controls in place, the workers were still feeling distress in their upper extremities. The RULA and REBA assessment methods and a review of injury records demonstrated close correlation of data from each method.

The RULA and REBA both identified that the arms, wrists, and elbows were at a high risk for developing CTDs due to the abducted arm postures, the repeated small-range actions, and the flexion and extension of the wrists involved when the workers perform the case-packing process. The risk factors that were identified by both assessment methods correlates with the information discussed in Chapter II of this study. The outcomes of both the RULA and REBA assessments indicate that there was a high risk of developing CTDs and MSDs. The process needs to be investigated further, and changes must be implemented to protect the workers.

An injury record review identified that over the past four years, seven injuries had occurred. This was significant because the amount of case-packing also increased due to the introduction of new technologies. The higher demand in production increased the likelihood of an injury from an OSHA recordable standpoint. Since 2006, the increased demand for corrugate required the case-packing increase which required workers to perform additional repetitions involving small-range motion. The injury review aligns with the data collected from the RULA and REBA assessments that each method identified awkward postures and high repetitions in the arm, wrist, and elbow locations which contributed to the reported injuries.

Tayyari and Smith (1997), indicated that the four major risk factors which contribute to the development of CTDs included awkward postures, excessive forces, high repetitions, and vibration. Examples of awkward postures included upper extremity postures such as excessive shoulder elevation, deviated wrists, and extreme elbow posture. When comparing the data collected to the information presented in Chapter II, there appeared to be a relationship between the injuries that the workers sustained in the case-packing and the work that they performed. As identified in the data collected and the review of literature, the case-packing process was placed in the high risk category for the development of CTDs and MSDs. Change would need to be implemented.

Chapter V: Conclusions and Recommendations

The continued occurrence of arm and wrist-oriented musculoskeletal disorder risk factors on the case-packing line at Company XYZ was placing the organization at risk of incurring continued employee illness and other production/financial forms of loss. Therefore, the purpose of this study was to analyze the case-packing line at Company XYZ in order to determine the extent that ergonomic-based risk factors were present. In order to achieve this purpose, two goals were developed:

1. To perform a task analysis for the existing case-packing line using qualitative-based tools.
2. To review injury records to determine all ergonomic-based injuries that was associated with the case-packing process.

The methodology used to collect data for the Rapid Upper Limb Assessment (RULA) and the Rapid Entire Body Assessment (REBA) assessment techniques were performed by observing the participants. While observing the participants, questions were asked about production rates, and about inputting the identified force and posture angles into the previously mentioned assessments.

Major Findings

The RULA assessment tool used in the study produced a final score of seven, which demonstrates that the process needed to be investigated and there was a need for implemented changes to minimize upper extremity exposures. The REBA assessment tool produced a final score of ten, which demonstrates that the process was high risk and it should be investigated for implementing changes. Company XYZ’s past loss experience indicated that upper extremity injuries were the primary injury suffered by employees working on the case-packing line over the past four years.

Conclusions

Based on the data collected in this study, the following conclusions can be made about the workers performing the case-packing on the case-packing line at Company XYZ:

- The RULA/REBA assessment tools used in this study identified that the case-packing line process is at high risk for the occurrence of MSDs. The case-packing process should be further investigated in order to implement changes that will reduce the ergonomic risk factors currently present. The conclusions were drawn from the incidents of workers packing with high repetition, loading corrugate with deviated wrists, separating the corrugate with abducted arms, and repeating small-range motions to perform the case-packing.
- Reviewing the injury loss records indicated that the injuries in the past four years had occurred at a steady pace compared to the years prior to 2006. This increase in injury occurrence is attributed to the increase in production rates based on the introduction of new technologies further up the case-packing line.
- The review of injury loss records also determined that upper extremity injuries are the only injuries occurring on the case-packing line. Performing the case-packing process is an exhaustive task where the arms are unsupported, the hands and wrists are performing small-range motions, and the production rates are causing high repetition. These risk factors were found throughout the study, so it should be concluded that they are contributing to the development of MSDs.

- Based on the RULA/REBA assessment methods and the loss data collected the risks associated with the case-packing line are repetitive motions, small-range motions, and awkward postures. Through the identification of past injuries, present risk factors, and the ergonomic assessment tools it is possible to conclude that ergonomic issues are present in the case-packing line.
- While examining the process of loading corrugate bundles at the case-packing line, many risk factors were identified. A primary risk factor is an awkward posture of the body which occurs when the workers lift a box of corrugate onto their shoulder using dynamic effort and thus compresses discs in the spine. Repeating these small-range actions once every two to three minutes causes extreme exhaustion to the workers due to the pronation of the forearm and shoulder abduction. Also, temperature extremes can potentially place the body at risk for heat stress. These risk factors are placing the workers at risk for MSDs and CTDs.

Recommendations

Based on the conclusions of this study and the hierarchy of controls, the following control measures are recommended to reduce the exposure of ergonomic-based risk factors and the occurrence of musculoskeletal disorders while performing the case-packing process at Company XYZ:

Engineering Controls.

- Work with management to purchase an automatic pallet riser that will help place the packages of corrugate at a suitable level. The low profile scissor lifts or pallet risers cost approximately $3,500.00. This will allow the case-packing workers to take a package without flexing downward and using awkward postures. This will reduce the potential for back injuries because the frequency of flexing downward will be reduced. The workers will be trained on how to operate the pallet riser.

- Develop a process to place the pallet full of packages directly next to the case-packing machine. This will eliminate the need for the workers to walk each package 18 feet once removed from the pallet. This will reduce the stress and strain of walking the 27 pound box several times over a short period of time which will decrease MSDs.
- Provide enough room so that the worker can wheel a cart over to a pallet and load the boxes of corrugate onto the cart. Once the cart is loaded, the workers can push the cart to the machine. Using a cart would eliminate the need for carrying a box in hand or on the shoulder and will be more efficient.

Administration Controls.

- Train the case-packing line workers about the benefits of proper stretching and implement a system to ensure the stretching is performed. Company XYZ has attempted to promote a stretching program, but there has not been a system in place to guarantee the stretching is performed.
- Implement a short stretching routine with the rest break between every one hour station rotation to promote rest cycles so the packing line worker's body can recover from the high demands of the packing process.
- Develop a rotation schedule that rotates workers from other departments in and out of the case-packing line. This rotation would allow the packing line workers to perform tasks that will require different physical demands than those needed to perform the packing tasks.

- Train the packing line workers to recognize risk factors for work-related musculoskeletal disorders and instruct them in work practices that can ease the demands of particular tasks. The workers will also be trained to use correct procedures and minimized awkward postures while performing the task at hand. During the training it will be important to stress the benefits and importance of following correct procedures.
- Develop a testing and evaluation process that utilizes worker feedback to verify that the proposed solution actually works and which would identify whether any additional enhancements or modifications may be needed.

Areas of Further Research

The scope of this study was relatively narrow; consequently a few areas have been identified for further research. The following areas should be considered for further investigation to identify the ergonomic-based risk factors that are present:

- Perform loss analysis research to determine the true costs of lost time away from work due to upper extremity injuries in the case-packing line.
- Research what other pasta companies are using for their case-packing tasks in the packaging department.

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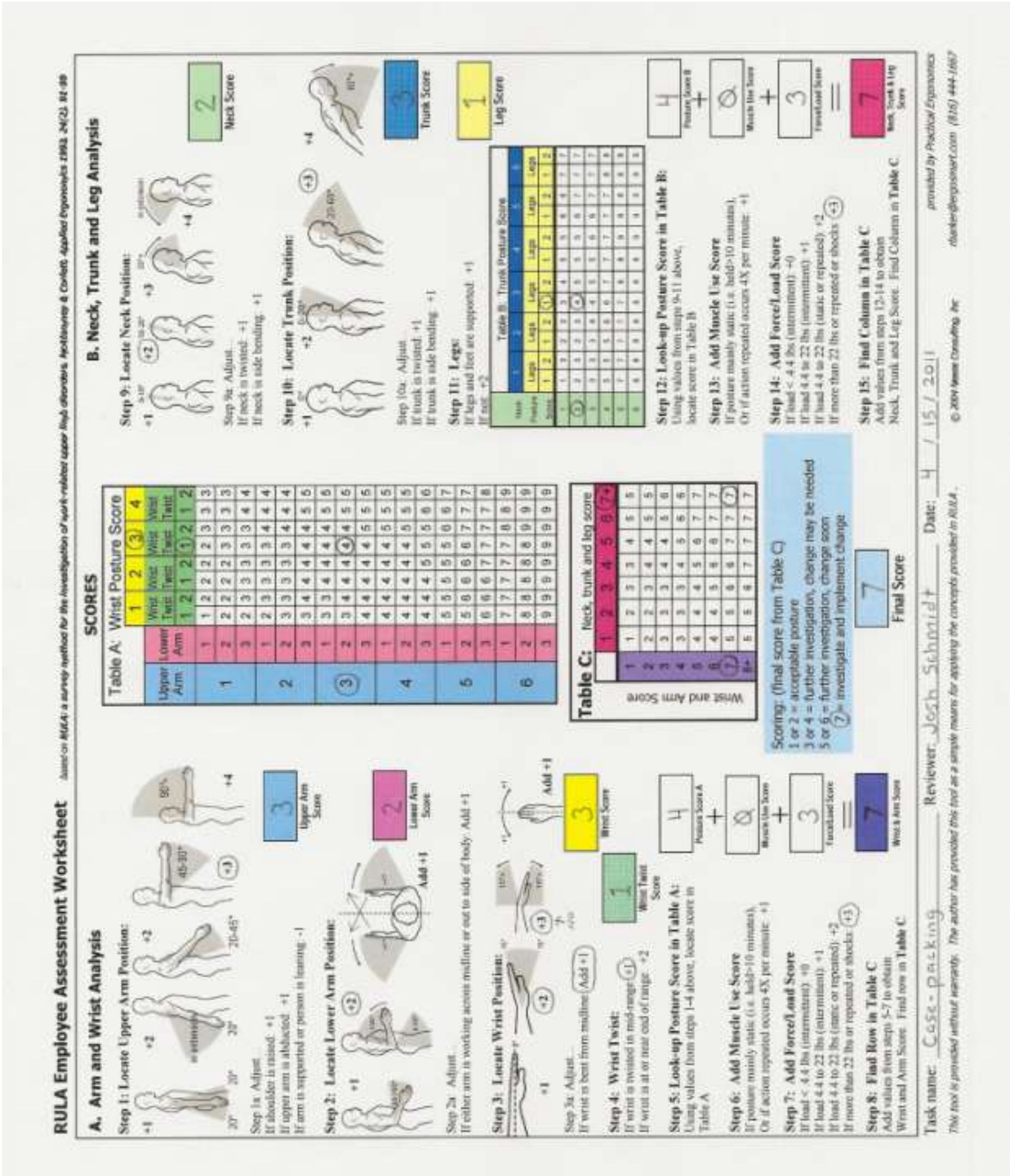
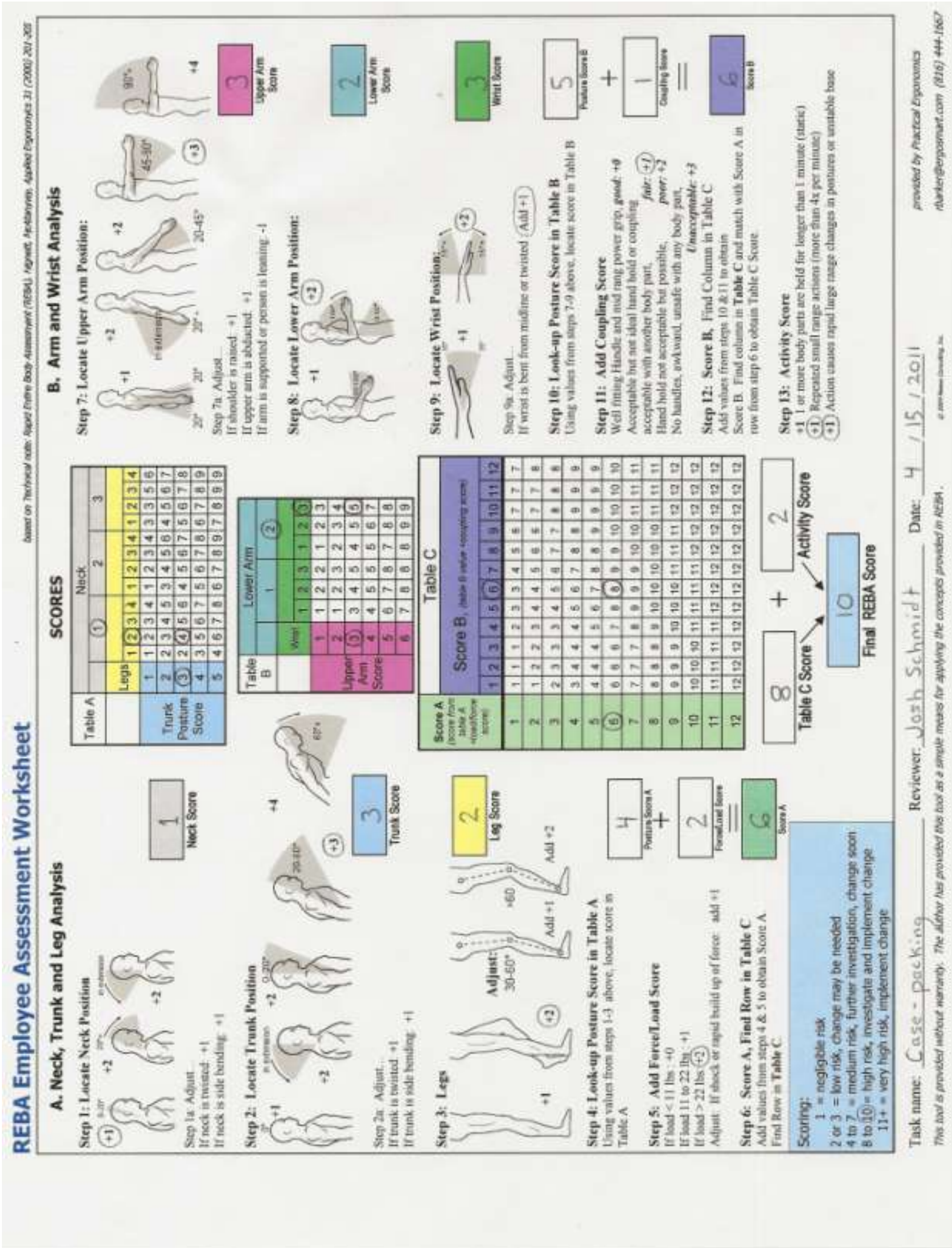
Appendix A: RULA Assessment of Case-Packing Line



Appendix B: REBA Assessment of Case-Packing Line



Appendix C: Injury Analysis of the Case-Packing Line

Company XYZ Case-Packing Incident Summary

Incident Date Range: 01/01/2006 to 08/05/10

Incident Date	Incident Description	Injury Type Description	OSHA Recordable	Workers Compensation	Cost
11/24/2006	Employee was lifting a pile of corrugate (11-30 lbs.) to load into the case packer and felt her back go out of place. She was using improper lifting techniques.	Injury	Yes	Approved	$8,261.00
12/31/2006	The employee bent over to pick up a box of cartons (approx. 20-30 lbs.) and as he was lifting the case of cartons he twisted his upper body, resulting in a strained back.	Injury	Yes	Approved	$916.00
7/24/2007	Employee lifted a case of cartons from the bottom row of a pallet and felt a pop in his low back.	Injury	Yes	Approved	$8,428.00
10/8/2007	After lifting large bundles of corrugate for 2 day he reported pain in his low back. He reported it 4 days late.	First Aid	No	No	$0
4/1/2008	When employee was lifting up a full box of cartons, picked it up incorrectly and felt pull in left groin area.	Injury	Yes	Approved	$2,700.00

7/15/2008	Employee picked up box of cartons from bottom layer on pallet and turned to place on table next to carton in feed and strained his low back.	First Aid	No	No	$0

Company XYZ Case-Packing Incident Summary

Incident Date Range: 01/01/2006 to 08/05/10

Incident Date	Incident Description	Injury Type Description	OSHA Recordable	Workers Compensation	Cost
1/21/2010	Employee reported pain/numbness in both hands/wrists due to prolonged handling of cartons over several months.	Injury	Yes	Approved	$24,783.00
3/29/2010	While lifting and twisting with a load of corrugate/cartons the employee strained a previous/ongoing, non-work related back injury.	First Aid	No	No	$0
5/1/2010	Employee reported lifting four 10 lbs cases while operating WB0, the next day he had severe pain in his left shoulder to left side of neck/back.	Injury	Yes	Approved	$1,341.00
9/22/2006	Employee reported pain in both arms that has escalated over the past two months.	Injury	Yes	Approved	$9,700.00
5/23/2007	Employee reported pain in both elbows due to overuse when loading cartons in packaging machines.	First Aid	No	No	$0

11/15/2007	Employee has been feeling pain in both wrists due to working for years, using hands for grasping, twisting and repetitive motion.	First Aid	No	Approved	$3,137.00
3/29/2010	Years of repetitive motion duties of a Machine Operation have caused pain and numbness in both hands/wrist.	First Aid	No	No	$0

Company XYZ Case-Packing Incident Summary

Incident Date Range: 01/01/2006 to 08/05/10

Incident Date	Incident Description	Injury Type Description	OSHA Recordable	Workers Compensation	Cost

		Injuries	**Recordable**	**Claims**	**Costs**
Totals		7	7	8	$59,266.00

Appendix D: Human Subject Implied Consent Form

Title: An Ergonomic Investigation of the Case-Packing Line at Company XYZ.

Investigator:
Joshua Schmidt
515 21st Ave E. Apt. 115
Menomonie, WI 54751
Phone: 320-290-9412

Research Sponsor:
Dr. Bryan Beamer
Email: beamerb@uwstout.edu

Description:
The primary objective of this research paper is to provide recommendations that would reduce the overall number of ergonomic injuries within the case-packing line at Company XYZ. The author will determine if the ergonomic risks can be located, reduced, and eliminated. Once the risks are located, can their root causes be determined so the risks can be eliminated or reduced. By eliminating or reducing the ergonomic risk factors the cost of workers compensation can be reduced tremendously.

Risks and Benefits:
Participants are only doing their typical work at Company XYZ. There are no known risks beyond any risks already part of their regular work. Recommending corrective measures for ergonomics at Company XYZ may reduce ergonomic injuries in the future, save money for the company and increase worker productivity and product quality.

Time Commitment:
The expected time commitment for this meeting will be approximately one hour.

Confidentiality:
Your name will not be included on any documents. We do not believe that you can be identified from any of this information. The researcher is only making observations with notes. No identifying information will be taken during the entire process. In a way it is only the job that is being studied and not any particular worker.

Right to Withdraw:
Your participation in this study is entirely voluntary. You may choose not to participate without any adverse consequences to you. However, should you choose to participate and later wish to withdraw from the study, there is no way to identify your anonymous document after it has been turned into the investigator.

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 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 taking part in this meeting you agree to participate in the project entitled, An Ergonomic Investigation of the Case-Packing Line at Company XYZ.