**Author:** **Tekin, Ahmet**
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**Research Advisor:** **Bryan Beamer, Ph.D.**

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**STUDENT**:

**NAME:** **Ahmet Tekin** **DATE: 06/05/2014**

**ADVISOR:** (Committee Chair if MS Plan A or EdS Thesis or Field Project/Problem):

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**Tekin, Ahmet.** ***An Ergonomic Analysis of Employees working in a Multi-Screen Video Display Terminal***

## Abstract

Company XYZ is a North American paper manufacturing company located in Wisconsin. The employees who work at video display terminals of Company XYZ have pain and discomfort in the lower and upper back, neck and shoulder areas. The pain and discomfort may decrease the employee morale and cause a loss in productivity.

The purpose of this study was to identify the risk factors associated with the use of computers using an ergonomic analysis and to make recommendations to management in order to reduce the risks to an acceptable level. The objective of this research was to eliminate the WRMSD and complaints of employees who work in a control room at Company XYZ.

The researcher's analysis results indicated that the employees who work in multi-screen video display terminal are exposed to some of the primary ergonomic risk factors, resulting in WRMSDs. Therefore, a further investigation is needed, and change should be implemented.

Based on the results, the researcher concluded that effective control methods should be analyzed, selected and implemented in order to reduce the ergonomic-based risk factors that exist at Company XYZ's VDT. These conclusions were used to make recommendations to reduce the ergonomic-based risk factors at the multi-screen computer workstation.

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# Chapter I: Introduction

Company XYZ, a North American pulp and paper manufacturing Company located in Wisconsin that has over 550 employees, has experienced several work-related musculoskeletal disorder (WRMSD) injuries due to a fast-paced production environment.

Employees who work in the control rooms of Company XYZ have pain and discomfort in the lower and upper back, neck and shoulder areas. Poor office workstation design causes discomfort and pain among those employees. The pain and discomfort may reduce employee morale, productivity and engagement and cause a loss in productivity.

## Ergonomics History

"Ergonomics derives from two Greek words: 'ergon', meaning work, and 'nomoi', meaning natural laws, to create a word that means the science of work and a person's relationship to that work" (Adams, n.d., para 2).

> The goal of ergonomics is to reduce stress and eliminate injuries and disorders associated with the overuse of muscles, bad posture, and repeated tasks. This is accomplished by designing tasks, work spaces, controls, displays, tools, lighting, and equipment to fit the employee´s physical capabilities and limitations. (Ergonomics and musculoskeletal, 2013, para 1).

People whose jobs necessitate spending extended periods of time at a workstation are exposed to stressors that may result in to painful, draining conditions ("Ergonomic guide for," n.d.). Extended time of exposure to a non-ergonomic working condition may cause Cumulative Trauma Disorders, or CTD's ("Ergonomic guide for," n.d.). CTD's are problems that develop gradually and imperceptibly over time which can cause to injury or disability ("Ergonomic guide for," n.d.). Even small alterations to the workstation conditions can result in to greater comfort and minimize the chance of future injury happening ("Ergonomic guide for," n.d.).

Individuals who use computers for prolonged periods of time may have eye strain and soreness or discomfort in the hands, wrists, arms, shoulders, neck or back. This is usually induced by poor work habits, insufficient work station design or incorrect use of workstation components.

The employees who work within the control room at Company XYZ use multiple computers for extended periods of time. Recent complaints of muscle soreness by those employees indicate that necessary actions must be taken to prevent injuries.

**Significance**

Every year over 700,000 employees experience work-related musculoskeletal disorders in the United States, which is more than one-third of all work-related injuries and illnesses (Keeping workers safe, 2011). According to the U.S. Department of Health and Human Services (in Musculoskeletal diseases: Leading, n.d.) the estimated cost for treatment for musculoskeletal diseases and indirect lost wages was $950 billion a year for the years 2004 to 2006. Injuries and illnesses caused by repetitive motion including precise tasks resulted in workers being a median of 23 days away from work to recuperate in 2012 (Nonfatal occupational injuries, 2013, para 19). This was 14 days more than all other injuries that workers were away from work.

**Statement of the Problem**

Employees who work within the control room at Company XYZ recently reported complaints of muscle soreness in the spine as well as in the shoulders. These complaints are placing the organization at potential risk of incurring medical treatment, decreased product quality as well as legal-based losses.

**Purpose of the Study**

This study was aimed to identify the risk factors associated with the use of computers, to analyze a VDT (Video Display Terminal) using an ergonomic analysis and a computer

workstation ergonomic checklist, and to make recommendations to management in order to minimize and eliminate injuries such as a WRMSD and to reduce the risks to acceptable level.

**Objectives**

The objective of this research was to eliminate the WRMSD and complaints of employees who work in a control room at Company XYZ. The method that was used to identify and analyze the workstation was the rapid entire body assessment (REBA), the rapid upper limb assessment (RULA) and office ergonomic checklist.

**Assumptions of the Study**

1. This study was focused on the VDTs of the Company XYZ.
2. Answers from the employees for the ergonomic checklist are accurate.

**Definitions of Terms**

**Cumulative trauma disorder (CTD).** "A cumulative trauma disorder is a condition where a part of the body is injured by repeatedly overusing or causing trauma to that body part"(Adams, n.d., para 2).

**Video display terminal (VDT).** "Video display terminal is a computer terminal consisting of a screen on which data or graphics can be displayed" (Video display terminal, n.d., para 1).

**Work-related musculoskeletal disorders (WRMSD).** "Work-related musculoskeletal disorders are injuries or disorders of the muscles, nerves, tendons, joints, cartilage, and spinal discs" (Work-related musculoskeletal disorders, n.d., para 3).

## Chapter II: Literature Review

The control room operators at Company XYZ had recently complained about muscle soreness in the cervical and lumbar areas of the spine as well as in the shoulders. Those complaints place the company at a potential risk of subsidizing medical treatment and undermining-product quality. The purpose of this study was to perform the ergonomic risk assessment for the operators who work within the control room at the Company XYZ. The literature review covers understanding of the ergonomic related risk factors which are related to the use of computers, the types of injuries that may happen as a result of these risk factors, and the tools that can be used to perform an ergonomic risk assessment.

Ergonomics is basically the process of adapting a particular job to the requirements of the employee. Ergonomics can also be defined as "the study of the design of work in relation to the physiological and psychological capabilities of people" (Chengalur, Rodgers & Bernard, 2004). The goal of ergonomics is to design workstations where employees can perform their tasks comfortably, thereby decreasing the potential risk of injury or illness. "Adapting the job to fit the worker can help reduce ergonomic stress and eliminate many potential ergonomic disorders (e.g., carpal tunnel syndrome, trigger finger, tendonitis)" (Ergonomics, 2010, para 1).

Ergonomics has been used since the primitive man started making tools to make his life easier. Archeological findings from the ancient times of Greece and Egypt have shown that tools, household equipment, and other manmade devices were ergonomically designed (The history of, 2013,). After the Industrial Revolution factories and machinery were built and designed closer to what we consider today as ergonomic (The history of, 2013). However, most of these tools and machinery were designed to produce with higher speed and more efficiently, instead of designing for the ease and comfort of workers (The history of, 2013).

After World War II, ergonomics became more common as it was applied to newer technologies (The history of, 2013). Probably the computer work design considerations were the most important development in ergonomics, since the computer usage had significantly increased in the workplaces and at home (The history of, 2013).

The number of workers who works at a visual display unit (VDT) has increased significantly in the past twenty years, and computers have become crucial part of most office environments (Wahlström, 2005). Although using computers has many advantages, the increasing number workers of using computers has led to many musculoskeletal disorders and also caused to increase the prevalence of musculoskeletal disorders among the computer users. Those musculoskeletal disorders caused by awkward body posture of the individual, inappropriate office equipment, repetition, force and the duration of the task.

**General Ergonomic Related Risk Factors**

There are different types of risk factors that may cause illnesses such as work-related musculoskeletal disorders. The primary risk factors are force, repetition, duration, awkward posture and extreme temperatures. WRMSDs are the most common cause of loss by means of human, time and money in many industries and the risks factors must be analyzed and eliminated (Work-related musculoskeletal disorders, n.d., para 6).

**Force.** "The amount of muscular effort required to perform a task. Generally, the greater the force is, the greater the degree of risk" (Michael, 2010, para 11). Force is used in almost all type of activities and the amount of force depends on the type of grip, body posture, the weight of an object and the duration of the task. Static force refers to physical exertion of the body part while the posture is kept stable throughout the task. Static force causes more pressure on tendons and muscles which exacerbates the fatigue and increases the recovery time, because the static force blocks the blood flow that causes the muscles insufficient amount of oxygen and nutrition.

**Repetition.** Repetition can be defined as performing the same motion in a given time period. The amount of stress that may happen depends on the number of repetitive motion, the amount of force applied and the time that repetitive motion is being performed. Performing repeated motions frequently and for a long time periods may lead to muscle strain and fatigue because the repetition does not allow muscles to recover (Repetition, n.d.).

**Duration.** Duration is defined as the amount of time that elapsed when a specific task is performed. The greater duration of exposure to an ergonomic risk factor causes the greater amount of risk. Duration is an important ergonomic risk factor due to prolonged computer operations throughout the day. In combination with the other risk factors such as repetition, force, posture and temperature extremes may exacerbate the severity of ergonomic related injury or illness.

**Awkward posture.** **"**Posture describes the position of the body while performing work activities" (Hajic, para 1). Neutral posture refers to the body being in natural position in which there is the least stress on muscles, tendons and bones. Awkward posture refers to the body that is in a position in which it deviates from the neutral posture and this posture causes extreme forces, strain and stress on muscles and tendons. Flexing or extending body parts such as wrists, arms, shoulders, spine, and neck or twisting the body are some awkward posture examples.

**Extreme temperature.** It is apparent that extreme temperatures may cause various problems for humans. Cold temperatures cause less flexible muscles resulting in muscle strain and hot temperatures that may lead to dehydration and muscle fatigue. The combination of extreme temperatures with other risk factors can lead to more serious injuries or illnesses.

**Injuries Developed by Ergonomic Related Risk Factors**

Uncontrolled ergonomic based risk factors may lead to illnesses and injuries such as carpal tunnel syndrome, thoracic outlet syndrome, tendonitis, tendinitis, tenosynovitis, epicondylitis, bursitis and computer vision syndrome which are mostly caused by computer workstation operations.

**Carpal tunnel syndrome.** Carpal tunnel syndrome (CTS) is a type of cumulative trauma disorder (CTD) that impacts the hands and wrists (Carpal tunnel syndrome, n.d.). CTS can result from squeezing of the median nerve where it goes through the wrist into the hand in the carpal tunnel (Carpal tunnel syndrome, n.d.). The median nerve is the primary nerve that passes down the arm to the hand and gives the cutaneous sense in the thumb, index finger, middle finger, and half of the fourth, or ring, finger (Carpal tunnel syndrome, n.d.).

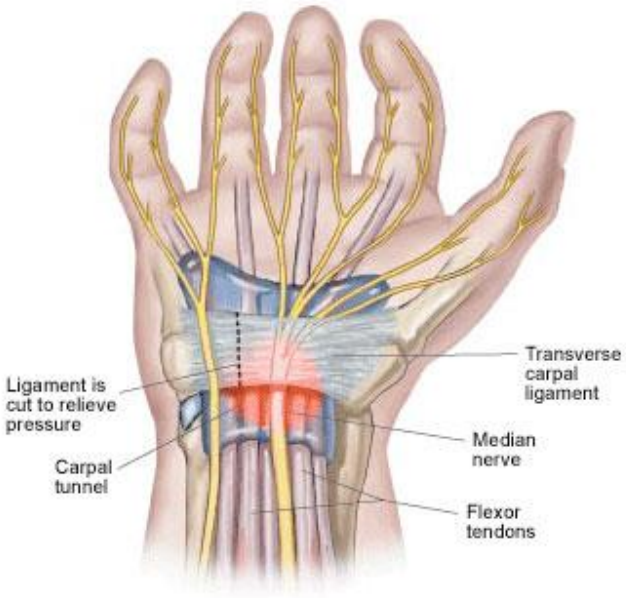



*Figure 1*. Image of the median nerve going through the carpal tunnel. MPS 1 – Mucopolysaccharidosis. (n.d.). MPSIDisease.com. Retrieved June 5, 2014, from http://www.mps1disease.com/patients/about/signs-and-symptoms/carpal-tunnel-syndrome.aspx

"When irritated, tendons housed inside the narrow carpal tunnel swell and press against the nearby median nerve" (Ergonomics, n.d., para 30). The force results in tingling, numbness, or extreme pain in the wrist and hand. The pain frequently occurs at night. The pressure also causes deficiency in power in the hand and the incapability to make a fist, hold objects, or do other manual tasks. If the pressure goes on, it can hurt the nerve, resulting in long-term loss of sensation and even partial paralysis.

"When the case becomes full-blown, there is constant fatigue and pain with no overnight recovery and disturbed sleep results" (Ergonomics, n.d., para 32). In this case an employee's work performance is reduced, and the employed will need more rest time. Most of the time employees do not relate their pain to their work since symptoms may only happen during evening or off-work hours. When medical assistance is needed, a surgical operation may be necessary, and the recovery may take more time than expected.

**Thoracic outlet syndrome.** "Thoracic outlet syndrome is a controversial cause of neck and shoulder pain due to complex mechanisms involving muscular dysfunction and nerve compression" (Laulan & Fouquet, 2012). According to Thoracic outlet syndrome, "symptoms arise from compressed or direct injury to nerves or blood vessels in the thoracic outlet" (Zwicky, 2010, p. 13).

**Tendinitis.** Tendinitis is an inflammation of a tendon that may occur by overusing of a muscle or tendon in wrist and shoulder (Ergonomics, n.d.). Further exertion may result in the tendon's fiber tearing apart (Ergonomics, n.d.). The tendon becomes irregular in shape and calcifies (Ergonomics, n.d.). Without rest and sufficient time for the tissues to heal, the tendon may become permanently damaged (Ergonomics, n.d.).

**Tendonitis.** "Tendinitis is tendon inflammation that occurs when a muscle or tendon is repeatedly tensed from overuse, vibration, or unaccustomed usage of the wrist and shoulder" (Ergonomics, n.d., para 26). With more stretch, some of the fibers of which the

tendon is comprised can actually wear out or tear apart. The tendon becomes thickened, bumpy, and irregular in particular areas of the body, such as the shoulder, and the injured area may calcify. The tendon may be further weakened if enough time is not taken to rest for healing the tissues.

**Tenosynovitis.** "Tenosynovitis is an inflammation or injury to the synovial sheath surrounding the tendon" (Ergonomics, n.d., para 27). These sheaths release synovial fluid which functions as a lubricant to minimize friction during motion. Using the hands and wrists by repetition may stimulate an extreme secretion of synovial fluid, causing the sheath to become swollen and painful. Repetitions of more than 1,500 to 2,000 per hour are known to create symptoms related with tendon sheath irritation in the hands.

**Epicondylitis.** Epicondylitis is also known as Tennis Elbow and is pain on the outer part of the elbow (Tennis elbow, 2013). It is the damage due to overuse and twisting of tendons that link muscles of the forearm to the elbow (Tennis elbow, 2013). Anyone may have tennis elbow, but it often happens in people in their 40's (Tennis elbow, 2013). It is more common among the tennis players but it also occurs in people who perform the other activities that use the same muscles (Tennis elbow, 2013).

**Bursitis.** "Bursitis is a painful condition that affects the small fluid-filled pads called bursae that acts as cushions among the bones, the tendons and the muscles near the joints" (Bursitis, 2011, para. 1). Inflamed bursae causes bursitis. Bursitis occurs mostly in the shoulder, elbow and hip (Bursitis, 2011).

**Computer vision syndrome.** Computer vision syndrome (CVS) is a group of eye and vision-related problems that result from computer use over an extended period of time (Computer vision syndrome, 2013). Symptoms of CVS's are eyestrain, headaches, blurred vision, dry or red eyes, double vision, light sensitivity, neck and shoulder pain (Computer vision syndrome, 2013). These symptoms may be induced by poor lighting, glare on the

computer screen, improper viewing distances, poor seating posture, uncorrected vision problems (Computer vision syndrome, 2013).

Studies have indicated that computer operators who work at visual display terminals reported more eye-related injuries than no-VDT employees, and visual symptoms occur in 75-90% of VDT employees (Computer vision syndrome, n.d.).

**Cost of MSDs in United States**

It is estimated that there are approximately 155 million civilian workers in the U.S., in 2012 (Baron, 2013, para 1). It is easy to estimate the direct cost of MSD which consist of workers' compensation, medical care expenditures. However indirect costs are difficult to estimate and consist of absenteeism, administration time, replacing the injured worker and training.

Rosenstock (1997) stated that:

> The precise cost of occupational musculoskeletal disorders is not known. Estimates vary depending on the method used. A conservative estimate previously published by NIOSH is $13 billion annually. Others have estimated the cost at $20 billion annually. Regardless of the estimate used, the problem is large both in health and economic terms. (para 15)

According to the U.S. Bureau of Labor Statistics, two-thirds of all reported injuries were induced by exposure to repeated trauma to employees' upper body ("National & international, n.d.).

**Ergonomic Assessment Tools**

In order to effectively perform an ergonomic risk analysis in a computer workstation area various types of assessment tools are used. Each of these tools will be used in this study.

**RULA.** The rapid upper limb assessment (RULA) , developed by McAtamney and Corlett, is used to identify the risks of work-related upper limb disorders (Rula worksheet,

n.d.). This analysis can be performed before and after a treatment to determine whether the treatment has lowered the risk of injury (Rula worksheet, n.d.). This assessment method evaluates the employees' exposure to forces, postures, duration and the muscle activities. Each body part is scored individually to determine the level of risk then each score is combined to produce a final score. The final risk score ranges from one to seven, where seven indicates significant level of risk.

**REBA.** Rapid entire body assessment tool is used to evaluate the risk of all body musculoskeletal disorders (Reba worksheet, n.d.). This tool uses a numerical system that assesses force, posture and type of movement. Each risk factor is scored and then combined to produce a final score. The final score ranges between from one which means acceptable risk, and up to eleven meaning significant level of risk.

**Video recorder.** A video recorder is a device that allows the researcher to record body posture and movements while the specific task is being performed by the employee. Then the video can be watched to analyze repetition, awkward posture, force and the duration of the task.

# Chapter III: Methodology

The purpose of this study was to identify the risk factors associated with the use of multi-screen video display terminals at Company XYZ and to analyze risk factors contributing to work-related musculoskeletal disorders.

## Subject Selection and Description

The subject selection process was based on the employees who work at multi-screen video display terminals. The company is in production for 24 hours a day, therefore there are three shifts for employees who work in the control room. Each shift is eight hours and shifts are 7 am-3 pm, 3 pm-11 pm and 11 pm-7 am. There are teams of 3 employees working in each shift. Six of the 12 employees were selected based on the complaints that they had and past recorded injuries to perform the assessment.

The researcher described the study and confirmed with each subject individually to agree participation in the study and received consent from each individual participant (See Appendix B).

All of the Company's policies including ergonomic policy can easily be accessed by all employees using a computer in the facility. The researcher analyzed the company's ergonomic policy to make recommendations eliminating the deficiencies if there is any, which helps reducing the possible WRMSD and complaints.

## Instrumentation

The instrumentation used to perform this study were a video recorder, picture analysis, a goniometer, office ergonomics checklist, RULA and REBA assessment tools.

**Video recorder.** A video recorder was used to record and then observe employee's postures, movements, repetition and duration of the tasks. The video recorder allowed the researcher to watch the movements multiple times to better analyze the awkward postures and movements. During recording the video researcher avoided capturing the participants'

faces and in some cases faces were blurred so that participants' faces cannot be recognized in the video.

The researcher recorded a video for each subject in order to determine the risk factors existing at the video display terminal for Company XYZ. The video helped the researcher to observe the most difficult postures and work tasks, the posture sustained for the longest period of time and the posture where the highest force loads occur. The most strenuous postures were observed in order to perform the pictorial analysis. This helped the researcher to measure the angles of the body parts in order to perform the RULA and REBA assessments.

**Picture analysis.** Several pictures were taken for each subject to analyze the deviations from the neutral postures. The pictures also included the workstation plan, computers', screens' and chairs' position. Participants' faces were blurred in the pictures so that they cannot be recognized. The picture analysis is critical when using the RULA and REBA assessment tools. There are illustrations in these assessment tools that show the angle of the different body parts from the neutral position. The pictures were used to measure the angles of the body parts by using a goniometer (fig 2). The picture analysis enables selecting the correct score when using the RULA and REBA assessment tools.

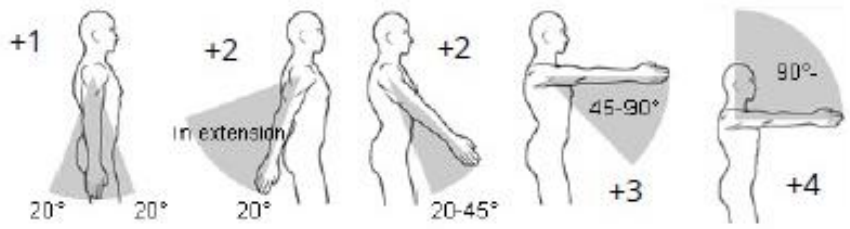



*Figure 2*. Deviations of the Upper Arm (RULA Worksheet). . (n.d.). . Retrieved June 5, 2014, from http://ergo-plus.com/wp-content/uploads/RULA.pdf

**Goniometer.** Goniometer was used to measure angles of the body parts' deviations observed on the pictures and to compare them to the neutral posture angles.

**Office ergonomics checklist.** An office ergonomics checklist was used to identify awkward postures, repetition and forces due to using keyboard, mouse, chair, monitor and telephone while working in the video display terminal (See Appendix E).

**RULA.** The rapid upper limb assessment tool, generated by McAtamney and Corlett, was used to assess upper and lower arm, neck and truck, static and dynamic forces/loads (See Appendix C).

The researcher first interviewed with the workers to have a better understanding of the job tasks and needs, and observed the workers' body postures, movements and forces. The researcher chose the most difficult body postures, the posture maintained for the longest period of time or the posture where the most amount of force occurs to obtain the most accurate results.

The researcher assessed each body part with a score. After completing the assessment the arm, wrist, neck and back, trunk scores are compared by using the final table which is the RULA Table C. The final table represents a final score ranging from 1 to 7. The score indicates as follows:

1-2 = Acceptable posture

3-4 = Further investigation, change may be needed

5-6 = Further investigation, change soon

7 = Investigate and implement change

The RULA directions can be found in Appendix F.

The researcher decided which control methods to implement and improve the workstation to minimize the complaints and injuries according to this score. The final score of 1 or 2 may cause an overlook of an awkward body posture, repetition, excessive twisting of the spine or duration which may cause a WRMSD. The researcher analyzed each factor

carefully and made the necessary recommendations to employees on changes to their work habits and to management to change workstation design.

**REBA.** The rapid entire body assessment tool was used to assess whole body postures, movements, forces/loads, coupling and repetition (See Appendix D). REBA is quite similar to RULA.

The researcher first interviewed with the workers to have a better understanding of the job tasks and needs, and observed the workers' body postures, movements and forces. The researcher chose the most difficult body postures, the posture maintained for the longest period of time or the posture where the most amount of force occurs to obtain the most accurate results.

The researcher scored for neck, trunk and leg position and compared that score to the arm, wrist position score to obtain overall REBA score. The overall REBA score ranges from 1 to 12. The score indicates as follows:

1 = Negligible risk

2-3 = Low risk. Change may be needed.

4-7 = Medium risk. Further investigate, change soon.

8-10 = High risk. Investigate and implement change.

11+ = Very high risk. Implement change.

The REBA directions can be found in Appendix G.

The researcher decided which control methods to implement and improve the workstation to minimize the complaints and injuries according to this score.

**Data Analysis**

The data collected by performing the analysis helped the researcher identify the potential risks at the multi-screen control room by means of awkward body postures, repetition, forces/loads and duration. The RULA and REBA assessment tools, office

ergonomic checklist, goniometer, video recorder and picture analysis were used to collect data and this data helped researcher to determine the control methods to apply.

# Chapter IV: Results

The purpose of this study was to identify the risk factors associated with the use of multi-screen video display terminals at Company XYZ and to analyze risk factors contributing to work-related musculoskeletal disorders using an ergonomic analysis and to make recommendations to management in order to minimize possible injuries.

The objective of this research was to eliminate the WRMSD and complaints of employees who work in a control room at Company XYZ. The methods and assessment tools that were used to identify and analyze the workstation were the rapid entire body assessment (REBA), the rapid upper limb assessment (RULA), office ergonomic checklist, a video recorder and picture analysis.

## Summary of Methods

The tools that were used to collect the data included RULA, REBA, office ergonomic checklist, a video recorder, picture analysis and a goniometer. The data collection started with selecting the subjects. The company is in production for 24 hours a day; therefore there are three shifts for employees who work in the control room. There are teams of 3 employees working in each shift. Each shift is eight hours and shifts are 7 am-3 pm, 3 pm-11 pm and 11 pm-7 am. Six of the 12 employees were selected to perform the assessment, based on the complaints that they had and past recorded injuries to perform the assessment. All selected subjects were in the age range of 40-60 and all six had been working at Company XYZ longer than one year.

## Data Collected

The data collected was used to interpret the information gathered and to determine the recommendations, which can be found in chapter 5.

**Video observation results.** The researcher was able to observe different body parts from various angles in order to determine the risk factors that were present. The neck, trunk,

upper arm and lower arm positions, along with legs flexion and extension were identified as risk factors. The ulnar-radial deviations in the wrist while using the mouse and flexion-extension of the wrist while using the keyboard were also identified as risk factors. The stress that comes from contact of the employees' arms and wrists against the hard edge of the work desk, along with the abduction of the upper arms while they are using the keyboard and mouse is another contributing factor to pain and discomfort among employees. It was also observed that slouching due to lack of back support from the chair causes stress on the spine; and inappropriate positions of screens result in neck extension. These factors indicate that corrective actions must be taken in order to minimize the risk factors that exist.

**Pictorial analysis**. Many pictures were taken for each subject from various different angles in order to measure the different body parts' angles that deviate from the neutral position. The pictorial analysis not only helped the researcher performing RULA and REBA assessment tools, but also gave an idea of how much deviation exists for each particular body part. For example, the pictorial analysis indicated that mouse usage causes extreme radial and ulnar deviations. The researcher measured 30°-45° ulnar wrist deviation from the neutral position, 15°-25° of wrist extension, 10°-20° of neck flexion, 0°-20° of trunk flexion, and 20°-45° of upper arm flexion. These angles of deviation indicate that ergonomic-based risk factors exist at the workstation and cause pain and discomfort among the employees.

**Office ergonomic checklist.** An office ergonomics checklist was used to identify awkward postures, repetition and forces due to using a keyboard, mouse, chair, monitor and telephone while working in the video display terminal. The tool was very effective for performing the assessment since it included various office equipment and factors that may contribute to WRMSD. These are the observations found after conducting the office ergonomic checklist:

- All chairs are comparatively large for employees, which causes inappropriate sitting postures and inadequate back support.
- Armrests of the chairs are not adjustable.
- The chair height is not properly adjusted for the person.
- There is no footrest and the employee's legs and feet are not properly positioned.
- The desk height is not adjustable, which causes improper height of working surface.
- Wrists usually deviate from the neutral position while using the keyboard and mouse.
- The monitor height is not properly adjusted, so the top of the screen is not below the eye level. The top line of the screen should be 2 inches below eye level.
- The employees do not take frequent breaks to stretch and rest.

**RULA.** The RULA is a quantitative assessment tool that each subject's posture was assessed by assigning a score to each body part. The RULA assessment tool was used to assess the subject's movements and body postures including neck, trunk, upper/lower arms, wrists and legs while they were using the screens, keyboard, mouse, desk and chairs. With the use of video recording and pictures, the researcher observed the awkward postures and then measured the angles of the body parts to see if they deviated from the neutral positions to complete the RULA. When the RULA assessment tool is completed there are four possible final scoring results that help to evaluate the potential ergonomic risks. The final scoring results are:

1. Score 1-2 = acceptable posture
2. Score 3-4 = further investigation, change may be needed
3. Score 5-6 = further investigation, change soon
4. Score 7 = investigate and implement change

The RULA assessment tool results for six employees are shown in Table 1 below. The first column represents each step on the RULA worksheet. The first step on the RULA worksheet is determination of the upper arm position. Depending on the determination, a score is assigned as an upper arm score. The first row represents the six employees. The employees are assigned as a number, 1-6. Employees' names are not included for anonymity. For employee #1, a score of 2 was assigned as an upper arm score. The completed RULA is located in Appendix H.

Table 1

*RULA Assessment Results*

| | Employee #1 | #2 | #3 | #4 | #5 | #6 |
|---|---|---|---|---|---|---|
| Arm and Wrist Analysis | | | | | | |
| 1. Upper Arm | 2 | 1 | 2 | 3 | 2 | 1 |
| 2. Lower Arm | 2 | 1 | 2 | 2 | 3 | 1 |
| 3. Wrist Position | 4 | 3 | 4 | 3 | 3 | 4 |
| 4. Wrist Twist | 1 | 1 | 1 | 1 | 1 | 1 |
| 5. Posture Score | 4 | 2 | 4 | 4 | 4 | 3 |
| 6. Muscle Use | 1 | 1 | 1 | 1 | 1 | 1 |
| 7. Force/Load | 0 | 0 | 0 | 0 | 0 | 0 |
| 8. Total Wrist/Arm | 5 | 3 | 5 | 5 | 5 | 4 |
| | | | | | | |
| Back, Trunk and Leg Analysis | | | | | | |
| 9. Neck | 3 | 2 | 3 | 4 | 1 | 2 |
| 10. Trunk | 2 | 2 | 3 | 2 | 1 | 1 |
| 11. Legs | 2 | 2 | 2 | 2 | 2 | 2 |
| 12. Posture Score | 4 | 4 | 5 | 6 | 3 | 3 |
| 13. Muscle use | 1 | 1 | 1 | 1 | 1 | 1 |
| 14. Force/Load | 0 | 0 | 0 | 0 | 0 | 0 |
| 15. Total Neck/Trunk/Legs | 5 | 5 | 6 | 7 | 4 | 4 |
| Final RULA Score | 6 | 4 | 7 | 7 | 5 | 4 |

As indicated in Table 1, high scores such as 5, 6 and 7s resulted due to the combination of high wrist, upper/lower arm and high neck posture scores. The wrist position score, which is step 3, has a rather high score for all 6 employees, because it was observed that there was both flexion and ulnar deviation in the wrists while utilizing the keyboard and mouse at the workstation. This combination of wrist deviations is the greatest contributor to high RULA scores. The neck and trunk scores also resulted in high final scores of the RULA assessment tool. Improperly positioned screens result in neck extension or flexion. Upper arm flexion and abduction also caused high RULA scores.

**REBA.** The researcher used the REBA assessment tool to assess the subject's movements and body postures, including neck, trunk, upper/lower arms, wrists and legs, while they were using the screens, keyboard, mouse, desk and chairs. With the use of video recording and pictures, the researcher observed the awkward postures and measured the angles of the body parts to see if they deviated from the neutral positions to complete the REBA. Each individual's body parts were observed and the deviations were measured by analyzing the pictures. A score was assigned to each body part to obtain the final REBA score. When the REBA assessment tool is completed there are five possible final scoring results, which help to evaluate the potential ergonomic risks. The final scoring results are:

1. Score 1 = negligible risk
2. Score 2-3 = low risk, change may be needed
3. Score 4-7 = medium risk, further investigate. change soon
4. Score 8-10 = high risk, investigate and implement change
5. Score 11 = very high risk, implement change

The REBA assessment tool results for six employees are shown in Table 2 below. The first column represents each step on the REBA worksheet. The first step on the REBA worksheet is determination of the neck position. After evaluating the neck position a score is

assigned as a neck score. The first row represents the six employees. The employees are assigned as a number, 1-6. Employees' names are not included for anonymity. For employee #4, a score of 3 were assigned as a trunk score. The completed REBA is located in Appendix I.

The scores of the REBA assessment tool are lower than the RULA assessment tool because the RULA assesses upper body, while the REBA assesses the entire body. The RULA and REBA scores indicate that upper body parts are more exposed to primary ergonomic risk factors. The most strenuous body postures that were used to complete the RULA assessment tool were also used to complete the REBA assessment tool. Improper wrist postures were the cause of high scores because the combination of ulnar deviation and flexion occurs while utilizing the keyboard and mouse at the workstation. The wrist position score at step 9 of the REBA tool caused higher final REBA scores. Inappropriately positioned screens result in neck extension and flexion. Upper arm flexion and abduction were also observed as contributing factors, resulting in high REBA scores.

Table 2

*REBA Assessment Results*

| | Employee #1 | #2 | #3 | #4 | #5 | #6 |
|---|---|---|---|---|---|---|
| Back, Trunk and Leg Analysis | | | | | | |
| 1. Neck | 2 | 2 | 2 | 2 | 2 | 1 |
| 2. Trunk | 2 | 2 | 2 | 3 | 3 | 1 |
| 3. Legs | 1 | 1 | 1 | 1 | 1 | 1 |
| 4. Posture Score | 3 | 3 | 3 | 4 | 4 | 1 |
| 5. Force/Load | 0 | 0 | 0 | 0 | 0 | 0 |
| 6. Total Neck/Trunk/Leg | 3 | 3 | 3 | 4 | 4 | 1 |
| | | | | | | |
| Arm and Wrist Analysis | | | | | | |
| 7. Upper Arm | 2 | 1 | 2 | 2 | 4 | 1 |
| 8. Lower Arm | 2 | 2 | 2 | 2 | 2 | 1 |
| 9. Wrist Position | 3 | 2 | 3 | 3 | 3 | 3 |
| 10. Posture Score | 4 | 2 | 4 | 4 | 7 | 2 |
| 11. Coupling Score | 0 | 0 | 0 | 0 | 0 | 0 |
| 12. Score B | 4 | 2 | 3 | 4 | 7 | 2 |
| 13. Activity Score | 1 | 1 | 1 | 1 | 1 | 1 |
| Final REBA Score | 4 | 4 | 4 | 5 | 8 | 2 |

# Chapter V: Conclusions and Recommendations

The purpose of this study was to identify the risk factors associated with the use of the multi-screen video display terminals at Company XYZ, evaluate the potential risk factors contributing to WRMSDs using ergonomic risk analysis methods, collect and analyze the data and provide recommendations that correct the workstation ergonomically and present favorable management approaches. The methodology was carried out using picture analysis, a video recorder, a goniometer, an office ergonomic checklist, and RULA-REBA assessment tools. The video recorder was used to observe employees' postures, movements, repetitions and duration of the tasks at the workstation. A picture analysis was used to measure the deviations of the body parts from the neutral positions through the use of a goniometer. Those measured angles enabled selection of the correct score when performing the RULA and REBA assessment tools.

## Discussion

It appears that injuries and illnesses are present at Company XYZ due to the ergonomic related risk factors evaluated in the workplace. As indicated in Table 1, the employees who work in multi-screen video display terminals are exposed to some of the primary ergonomic risk factors (awkward posture, duration, force, repetition and temperature extremes) resulting in WRMSDs. Pain, discomfort, numbness and tingling are the symptoms of WRMSDs and may vary in severity from mild and periodic to severe, chronic and debilitating conditions (Guidance on the Prevention, n.d.). According to the RULA assessment results (Table 1), the final scores for all six employees are 6, 4, 7, 7, 5 and 4. A score of 4 requires further investigation and indicates a change may be needed, a score of 5 or 6 requires further investigation and signifies change soon, and a score of 7 requires an investigation and implementation of change. According to the REBA assessment results (Table 2), the final scores for all six employees are 4, 4, 4, 5, 8 and 2. A score of 2 represents

low risk and change may be needed, a score of 4 to 7 represents medium risk; it requires a further investigation and change soon, and a score of 8 to 10 represents high risk; it requires an investigation and implementation of change.

Since the REBA assessment tool evaluates the entire body, the final scores of REBA are lower than the RULA assessment tool. The RULA assessment tool assesses specifically the upper part of the body and the scores indicate that employees' upper body parts are more involved with the specific video display terminal tasks; therefore, upper body parts are more exposed to primary ergonomic risk factors. These results indicate that an investigation should be completed and changes should be implemented.

It appears that awkward posture of spine, arms, wrists and neck and the duration of the tasks may cause the pain and discomfort while employees are using the mouse, typing on the keyboard and sitting in the chair. The use of keyboard and mouse causes excessive ulnar deviation and flexion in the wrists and there is no use of pads to eliminate the contact of the lower arm with hard surfaces. The chairs and the desk used in the video display terminal are not adjustable, armrests of the chairs are quite wide for most employees and the monitors are not adjustable either. Adjustability is crucial at computer workstations. The lack of adjustability of office furniture and computer parts causes discomfort, pain and potential ergonomic-based injuries due to awkward postures.

**Conclusions**

Based on the data collected and results evaluated the following conclusions can be made:

- Based on the data analyzed, the written ergonomic program at Company XYZ needs to be updated and the ergonomic risk assessment method used at Company XYZ is not very effective at evaluating the work–related ergonomic risk factors.

- Interviews with the employees indicated that the symptoms of possible WRMSD may cause reduction the employee morale and a decrease in productivity. These are major problems for Company XYZ and effective control methods should be analyzed, selected and implemented immediately.
- Based on the observations during the data collection process, it is apparent that employee trainings on ergonomics do not focus on how to proactively prevent the WRMSDs, as well as how to recognize ergonomic hazards and how to report signs and symptoms.
- The RULA and REBA assessment results indicate that the employees are at high risk. Two of the scores are 7 which is the highest score requiring investigation and implementation of change immediately. The scores 5 and 6 require further investigation and change soon. And two scores of 4 require further investigation and change may be needed. These scores indicate that employees working at the video display terminal at Company XYZ are highly exposed to ergonomic-based risk factors.
- It was observed that awkward postures of the upper/lower arm, wrists, and neck most likely cause discomfort, pain and high RULA scores. The use of mouse and keyboard and incorrect positions of the screens are leading factors of awkward postures and wrist deviations.
- It is also concluded by the observations that employees are not aware of ergonomic-based risk factors, how to recognize the signs and symptoms of WRMSDs, and the importance of reporting of signs and symptoms.
- Utilizing the keyboard and mouse causes excessive ulnar deviation and wrist extension, which seems to be one of the main problems observed. The

combination of these two deviations in the wrist increases the amount of force exerted by one joint and leads to possible WRMSDs.

- Inappropriate position of the screens causes neck extension and flexion. This awkward posture results in strain in the eyes.
- It is also observed that employees abduct their upper arm while utilizing the mouse and keyboard, which increases the exertion of force and possibility of injuries.
- The contact with the hard surfaces of the lower arm is also one of the main contributing risk factors to possible injuries and WRMSDs.
- The bright sunlight behind the screens causes increased contrast and makes it hard to see the screen. This may lead to eye fatigue, eye strain and headache.
- The chair used at the VDT is too big for employees, has poor back support and does not have an adjustable seat pan or armrests, which results in inadequate lumbar support, back pain and fatigue. An inappropriate seat pan causes additional pressure on the buttocks or knee area, and extended use may block blood flow to the legs.
- The flooring at the VDT room is not suitable for the casters, so that makes moving the chair quite difficult and causes muscle strain and fatigue.

**Recommendations**

Based on the data collected and results evaluated, the researcher determined that it is necessary to implement controls in order to mitigate existing ergonomic-based risk factors at Company XYZ. The recommendations are:

- The first recommendation is updating the current ergonomic program, ensuring that management is committed to the program and the program identifies the

ergonomic-based risk factors, implements controls, evaluates the effectiveness of controls and monitors the program for continuous improvement.

- The second recommendation is training employees periodically on how to recognize the signs and symptoms of WRMSDs and how to recognize the importance of early reporting of signs and symptoms. This would help reduce the potential WRMSDs and injuries, by identifying the signs and symptoms.
- The third recommendation is encouraging all employees to have small breaks consisting of standing up, wandering around and stretching once at least every hour. This will reduce the force on the muscles and increase the blood flow.
- The fourth recommendation is utilizing adjustable furniture (monitor, chair, desk etc.) at the VDTs. This will allow employees to adjust furniture according to their body sizes and needs. This will result in reduced discomfort, pain and WRMSDs by utilizing the body parts in neutral positions and exerting less force.
- The adjustability of the chair is crucial. The chair should be changed with another one that has adjustability of the backrest, height, seat pan, and armrests. Adjustability will allow different sized employees to have the ability to adjust the chair according to their needs and minimize the exposure to awkward postures, forceful exertions and contact stress.
- Excessive abduction of the upper arms can be eliminated with an adjustable chair and armrests, which will reduce the amount of force exerted and possibility for injuries.
- The flooring at the workstation must allow the chair to move easily. The flooring and casters must be changed to ensure that the chair can be moved with less friction.

- The chair height should be adjusted to maintain the neutral body posture. This will allow the employee's elbow to be the same height as the keyboard. The keyboard should be in front of the user at a distance that allows the user's arms to stay close to the body and the lower arms to be parallel to the floor. The keyboard should be lowered or raised in order to promote neutral wrist posture and to reduce wrist extension. Also, alternative keyboard designs should be considered in order to reduce ulnar deviations of the wrist.
- A mouse and keyboard pad should be used in order to eliminate the contact stress with the hard surfaces while utilizing the mouse and keyboard. This will promote the neutral wrist posture and allow the blood to flow through the lower arm.
- Utilizing blinds on windows to eliminate the bright sunlight would help employees to see the screens clearly and minimize the eye strain, eye fatigue and headache.
- The monitors' mount should be changed so that they can be adjusted and should be adjusted to slightly below the employee's eye level.

Utilizing the keyboard and mouse was one of the most serious tasks that had the highest score. The wrist position score at step 3 of the RULA assessment tool was 4 for three employees and 3 for the other three employees. The researcher hypothetically redesigned the workstation in order to eliminate risk factors while utilizing the keyboard and mouse and performed the RULA assessment tool. It was assumed by the researcher that the chair was adjustable and that the height of the chair was adjusted in order to maintain neutral body posture. Elbows were at the same height as the keyboard and mouse, lower arms were parallel to the floor, the keyboard and mouse were set at a distance where elbows were close to the body, keyboard were adjusted so that the wrists were at neutral posture and there were

no flexion, extension or ulnar deviation. It was also assumed that the mouse and keyboard pads were used to eliminate contact with the hard surfaces.

Based on the redesigning of the task, the score at step 3 would be selected as 1. In conclusion, the task would be much safer with a theoretical reduction in the RULA score of wrist position based on the redesigning of the mouse and keyboard task.

**Area of Further Research**

The researcher recommends the following subjects that should be studied further to help minimize the risk factors found at VDT of Company XYZ:

- It could be useful to perform a similar analysis for all employees who work at video display terminals at Company XYZ. This would be beneficial for the organization to collect data from all employees who work at VDTs, implement controls and minimize the injuries and WRMSDs.
- Performing a cost benefit analysis that provides payback period information will be useful in order to determine the best control method.
- An area of further research would be in performing a similar study on other employees outside Company XYZ who work at VDTs, in order to observe whether they have similar risks and analyze the control methods that they have implemented.

## References

Adams, C. (n.d.). Ergo 101 - *What is ergonomics?* Retrieved from http://ergonomics.about.com/od/ergonomicbasics/a/ergo101.htm

Adams, C. (n.d.). *What is a cumulative trauma disorder?* Retrieved from http://ergonomics.about.com/od/repetitivestressinjuries/f/whatisctd.htm

American Optometric Association (2013). *Computer vision syndrome*. Retrieved from http://www.aoa.org/patients-and-public/caring-for-your-vision/protecting-your-vision/computer-vision-syndrome

Balance Systems (n.d.). *National & international statistics for carpal tunnel syndrome and repetitive strain injuries of the upper extremity.* Retrieved from http://www.repetitive-strain.com/national.html

Baron, S. L. (2013). *Nonfatal work-related injuries and illnesses* — United States, 2010. Retrieved from http://www.cdc.gov/mmwr/preview/mmwrhtml/su6203a6.htm

Bone and Joint Initiative (n.d.). *Musculoskeletal diseases: Leading cause of disability and health care cost.* Retrieved from http://www.boneandjointburden.org/highlights/FactsinBrief.pdf

Bureau of Labor Statistics (2013, November). *Nonfatal occupational injuries and illnesses requiring days away from work, 2012.* Retrieved from http://www.bls.gov/news.release/osh2.nr0.htm

Centers for Disease Control (2013). *Ergonomics and musculoskeletal disorders.* Retrieved from http://www.cdc.gov/niosh/topics/ergonomics/

Centers for Disease Control (n.d.). *Work-related musculoskeletal disorders prevention.* Retrieved from http://www.cdc.gov/workplacehealthpromotion/implementation/topics/disorders.html

Chengalur, S. N., Rodgers, S. H., & Bernard, T. E. (2004). *Ergonomic design for people at work* (2nd ed.; pp. 657-658). Hoboken, NJ: John Wiley & Sons, Inc.

Cornell University (n.d.). *Reba worksheet.* Retrieved from http://ergo.human.cornell.edu/ahReba.html

Cornell University (n.d.). *Rula worksheet.* Retrieved from http://ergo.human.cornell.edu/ahrula.html

Dictionary (n.d.). *Video display terminal.* Retrieved from http://dictionary.reference.com/browse/video display terminal

Ergosource (2013). *The history of ergonomics.* Retrieved from http://ergosource.com/articles-on-ergonomics/the-history-of-ergonomics/

Hajic, M. (n.d.). *Ergonomic glossary* - Risk factors. Retrieved from http://www.bellaonline.com/articles/art33472.asp

Health and Safety Authority (n.d.). *Guidance on the prevention and management of musculoskeletal disorders (MSDs) in the Workplace*. Retrieved from http://www.hseni.gov.uk/guide_on_prevention_and_management_of_musculoskeletal_disorders_msds_.pdf

Iowa State University (n.d.). *Repetition.* Retrieved from http://www.ehs.iastate.edu/occupational/ergonomics/repetition

Keeping workers safe from strains and pains. (2011, March). *Safety Now, 302*, 1-3.

Keller Online (n.d.). *Ergonomics.* Retrieved from https://www.kelleronline.com/Topics/TopicInfo.aspx?TopicKey=1066&DisplayType=3&Anchor=e1erg&Search=ergonomics&Exact=0

Keller Online (n.d.). *Carpal tunnel syndrome.* Retrieved from https://www.kelleronline.com/Topics/TopicInfo.aspx?TopicKey=1134&DisplayType=3&Anchor=e1cartun&Search=msd&Exact=0

Laulan, J., & Fouquet, B. (2012). Thoracic outlet syndrome: Definition, aetiological factors, diagnosis, management and occupational impact. Journal of Occupational Rehabilitation, doi: 10.1007/s10926-010-9278-9

Mayo Clinic (2011). *Bursitis.* Retrieved from http://www.mayoclinic.com/health/bursitis/DS00032

Michael, R. (2010, February 20). *Definitions in ergonomics*. Retrieved from http://www.ergoweb.com/news/detail.cfm?id=487

Peace Health (2013). *Tennis elbow.* Retrieved from http://www.peacehealth.org/xhtml/content/major/hw225372.html

Sanders, M. L. (1997). *Management of cumulative trauma disorders*. Newton, MA: Butterworth-Heinemann.

The University of Chicago (2010). *Ergonomics.* Retrieved from http://safety.uchicago.edu/tools/faqs/ergonomics.shtml

Think Quest (n.d.). *Computer vision syndrome.* Retrieved from http://library.thinkquest.org/C0123325/synd.ht

Wahlström, J. (2005). Ergonomics, musculoskeletal disorders and computer work. *Occupational Medicine, 55*, 168-176. doi:10.1093

Zwicky, K. (2010). *An ergonomic workstation analysis at company xyz.* (Unpublished master's thesis, University of Wisconsin-Stout).

## Appendix A: IRB Approval

STOUT
UNIVERSITY OF WISCONSIN

Research Services
152 Voc Rehab Building

University of Wisconsin-Stout
P.O. Box 790
Menomonie, WI 54751-0790

715/232-1126
715/232-1749 (fax)
http://www.uwstout.edu/rs/

April 4, 2014

Ahmet Tekin
Risk Control
UW-Stout

**RE: An Ergonomic Analysis of Employees working in a Multi-Screen Video Display Terminal**

Dear Ahmet:

In accordance with Federal Regulations, your project, "An Ergonomic Analysis of Employees working in a Multi-Screen Video Display Terminal," was reviewed on **April 3, 2014,** by a member of the Institutional Review Board and was approved under Expedited Review through **April 2, 2015.**

**If your project involves administration of a survey or interview, please copy and paste the following message to the top of your survey/interview form before dissemination:**

> **This research has been approved by the UW-Stout IRB as required by the Code of Federal Regulations Title 45 Part 46.**

If you are conducting an **online** survey/interview, please copy and paste the following message to the top of the form:
**"This research has been approved by the UW-Stout IRB as required by the Code of Federal regulations Title 45 Part 46."**

Responsibilities for Principal Investigators of IRB-approved research:

1. No subjects may be involved in any study procedure prior to the IRB approval date or after the expiration date. (Principal Investigators and Sponsors are responsible for initiating Continuing Review proceedings.)
2. All unanticipated or serious adverse events must be reported to the IRB.
3. All protocol modifications must be IRB approved prior to implementation, unless they are intended to reduce risk.
4. All protocol deviations must be reported to the IRB.
5. All recruitment materials and methods must be approved by the IRB prior to being used.
6. Federal regulations require IRB review of ongoing projects on an annual basis.

Thank you for your cooperation with the IRB and best wishes with your project.

Should you have any questions regarding this letter or need further assistance, please contact the IRB office at 715-232-1126 or email foxwells@uwstout.edu.

Sincerely,

[redacted]

Susan Foxwell
Research Administrator and Human Protections Administrator,
UW-Stout Institutional Review Board for the Protection of Human Subjects in Research (IRB)

## Appendix B: Human Subject Consent Form

**This research has been approved by the UW-Stout IRB as required by the Code of Federal Regulations Title 45 Part 46.**

**UW-Stout Signed Consent Form**
**For Research Involving Human Subjects**

**Consent to Participate In UW-Stout Approved Research**

**Title:** An Ergonomic Analysis of Employees Working at a Multi-Screen Video Display Terminal

**Investigator:**
Ahmet Tekin
University of Wisconsin-Stout
302 Jarvis Hall Science Wing
Menomonie, WI 54751
tekina0382@my.uwstout.edu
715 309 8463

**Research Sponsor:**
Bryan Beamer
University of Wisconsin-Stout
MS Risk Control Program
Department of Operations and Management
College of Management
beamerb@uwstout.edu
715 232 5178

**Description:**
The objective of this research is to identify factors for WRMSD (work-related musculoskeletal disorders) and complaints of employees who work in a control room at Company XYZ.
Employees who work within the control room at company XYZ recently reported complaints of muscle soreness in the spine as well as in the shoulders. These complaints are placing the organization at potential risk of incurring medical treatment, decreased product quality as well as legal-based losses. Every year over 700,000 employees experience work-related musculoskeletal disorders in the United States, which is more than one-third of all work-related injuries and illnesses. According to the U.S. Department of Health and Human Services, the estimated cost for treatment for musculoskeletal diseases and indirect lost wages was $950 billion a year for the years 2004 to 2006.
The methods that will be used to identify and analyze the workstation are video recorder, picture analysis, a goniometer, the rapid entire body assessment (REBA), the rapid upper limb assessment (RULA) and office ergonomic checklist. The researcher will take pictures and record a video to assess the deviations in the various body parts, repetitive motions and the duration of the tasks. There will be questions regarding to your work habits in the work area and how you use the computer elements such as keyboard, screen, mouse and other office materials such as document holder, telephone and chair. The assessment will be completed about in 10 minutes.

**Risks and Benefits:**
There will be no additional risks beyond doing daily routine tasks. You may feel discomfort because of being pictured and recorded, but the videos and pictures will only be used by the researcher, not be shared to anyone else and will be deleted when the research is complete. After the research is completed your workstation will be ergonomically redesigned so that possible injuries such as Carpal Tunnel Syndrome, pain and discomfort will be reduced.

**Confidentiality:**
Your name, face and any other information will not be included on any documents. We do not believe that you can be identified from any of this information.

**Right to Withdraw:**
Your participation in this study is entirely voluntary. You may choose not to participate without any adverse consequences to you. You have the right to stop participating at any time. 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. There will be no adverse consequences to your employment condition with the company if you choose to participate or not to participate in this study. The data gathered by the investigator will not be shared with anyone else.

**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.

**Investigator:**
Ahmet Tekin
University of Wisconsin-Stout
302 Jarvis Hall Science Wing
Menomonie, WI 54751
tekina0382@my.uwstout.edu
715 309 8463

**IRB Administrator**
Sue Foxwell, Research Services
152 Vocational Rehabilitation Bldg.
UW-Stout
Menomonie, WI 54751
715.232.2477
foxwells@uwstout.edu

**Advisor:**
Bryan Beamer
University of Wisconsin-Stout
MS Risk Control Program
Department of Operations and Management
College of Management
beamerb@uwstout.edu
715 232 5178

**Appendix C: RULA**

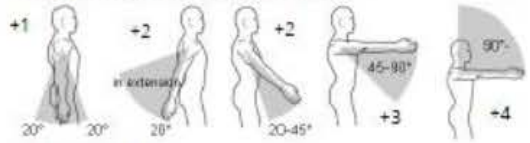
ERGONOMICS PLUS

# RULA Employee Assessment Worksheet

Task Name: Date:

## 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

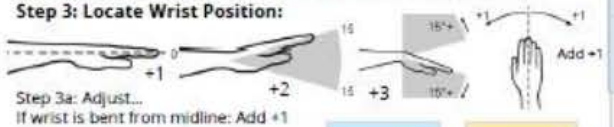
Upper Arm Score

**Step 2: Locate Lower Arm Position:**


Lower Arm Score

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

**Step 3: Locate Wrist Position:**




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

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

Wrist Twist Score

Wrist Score

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

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

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

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.**

Wrist & Arm Score

## Scores

Table A

| Upper Arm | Lower Arm | Wrist Score 1 Wrist Twist 1 | 1 2 | 2 1 | 2 2 | 3 1 | 3 2 | 4 1 | 4 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

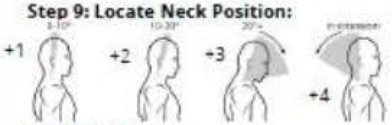
| Wrist / Arm Score | Neck, Trunk, Leg Score 1 | 2 | 3 | 4 | 5 | 6 | 7+ |
|---|---|---|---|---|---|---|---|
| 1 | 1 | 2 | 3 | 3 | 4 | 5 | 5 |
| 2 | 2 | 2 | 3 | 4 | 4 | 5 | 5 |
| 3 | 3 | 3 | 3 | 4 | 4 | 5 | 6 |
| 4 | 3 | 3 | 3 | 4 | 5 | 6 | 6 |
| 5 | 4 | 4 | 4 | 5 | 6 | 7 | 7 |
| 6 | 4 | 4 | 5 | 6 | 6 | 7 | 7 |
| 7 | 5 | 5 | 6 | 6 | 7 | 7 | 7 |
| 8+ | 5 | 5 | 6 | 7 | 7 | 7 | 7 |

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

RULA Score

## B. Neck, Trunk and Leg Analysis

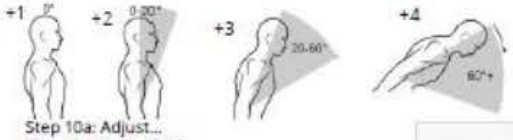
**Step 9: Locate Neck Position:**




Neck Score

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

**Step 10: Locate Trunk Position:**




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

Trunk Score

**Step 11: Legs:**
If legs and feet are supported: +1
If not: +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 | 2 | 2 | 2 | 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 | 8 | 8 | |
| 5 | 7 | 7 | 7 | 7 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | |
| 6 | 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

Posture B Score

+

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

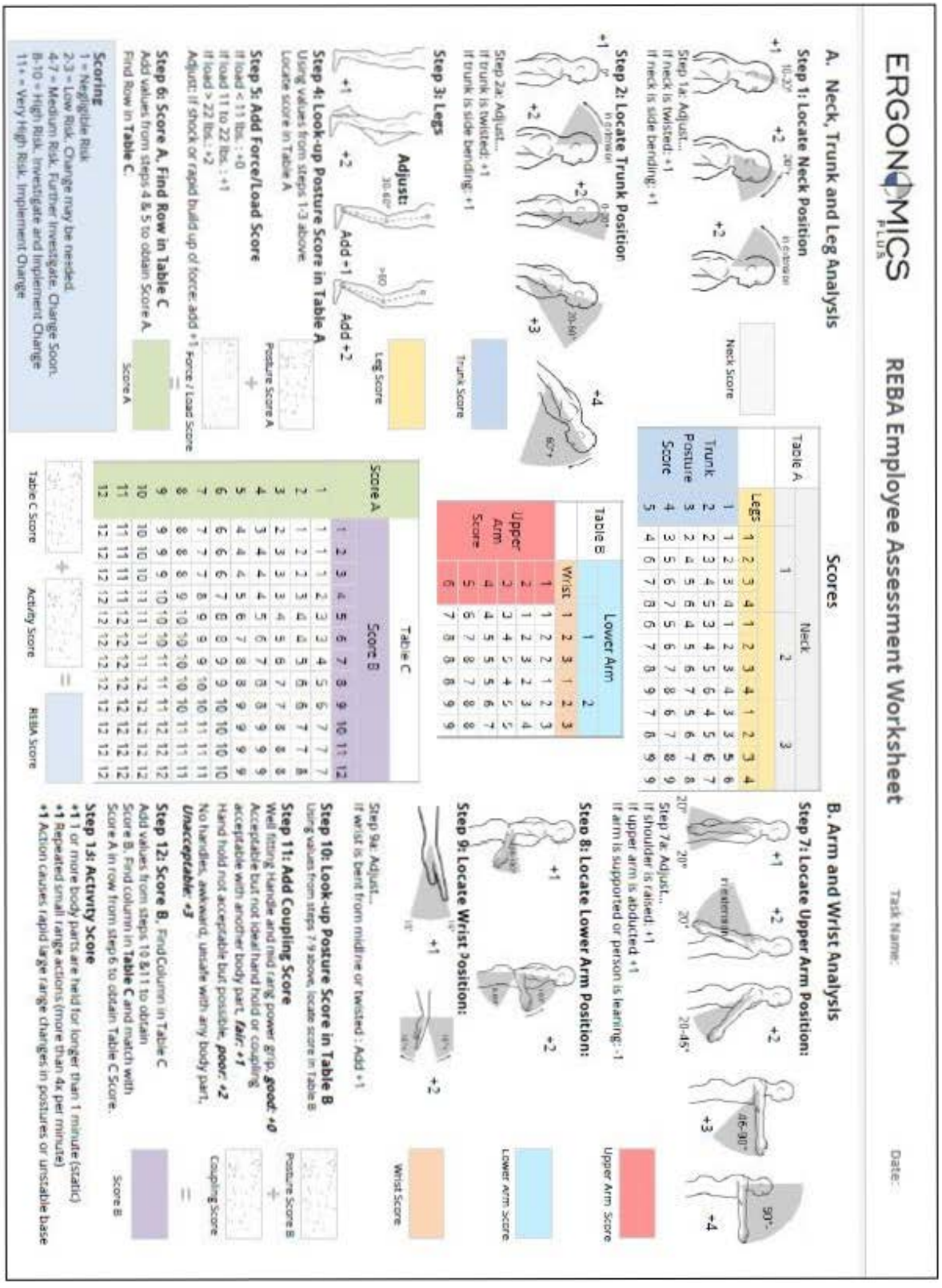
Force / Load Score

=

**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.**

Neck, Trunk, Leg Score

## Appendix D: REBA



# Appendix E: Office Ergonomics Checklist

## OFFICE ERGONOMICS CHECKLIST

Date _____

Any prior injury or significant discomfort within past 12 months

_____

Amount of time spent on the computer

_____

Rate Pain Level: 0 1 2 3 4 5 6 7 8 9 10 0 = No Pain; 10 = Extreme Pain

| Question | NA | Yes | No | Observations/ Comments | Recommended Options |
|---|---|---|---|---|---|
| **A. CHAIR &POSTURE:** | | | | | |
| 1. Does the chair support the back? | | | | The back of the chair should firmly support the lumbar region and the upper back. | (1) Adjust, fix, or replace chair (2) use addt. lumbar support |
| 2. Is the chair height properly adjusted for the person and the task? | | | | The hips should be slightly higher than the knees. | (1) Adjust, fix, or replace chair (2)have the work surface raised or lowered (3) use articulating keyboard arm |
| 3. Are the person's legs and feet properly positioned and supported? | | | | The legs should form appr. 90° angle, there should be a couple of inches between the back of the knee and the seat pan, feet should be flat on floor or footrest | (1) Adjust, fix, or replace chair (2) use footrest |
| 4. Are upper arms hanging relaxed by the sides? | | | | Don't keep arms propped on arm rests entire time | (1) sit closer to keyboard (2) readjust armrests |
| 5. If chair has adjustable armrests, are they correctly adjusted? | | | | Adjust height to where shoulders are completely relaxed and in a neutral position and adjust width so elbows aren't kept away from sides of body | (1) readjust armrests |
| 6. Does the person sit upright with the "natural S" curve in their spine not rounded over with a "C" curve? | | | | Keep spine pressed firmly against the back of chair while working. | (1) sit back in chair (2) sit closer to keyboard and desk |
| **B. WORK SURFACE:** | | | | | |
| 1. Can the person easily access their work surfaces? | | | | The rest of the evaluation is accomplished most easily by observing them work on their computer. | (1) reposition furniture and/or VDT equipment (2) remove desk drawers (3) remove armrests (4) get additional desk/pc table |
| 2. Are work surfaces of the proper size and height for the person to perform their tasks? | | | | For keyboarding, lower arms should be parallel to floor, for reading and writing desk surface should be a couple of inches higher | (1) raise or lower computer table (2) articulating keyboard arm (3) replace table |
| 3. Does the person work at their desk without propping their arms or wrists on any hard surface or sharp edges? | | | | Risk will be increased if significant time is spent reading and writing at the desk | (1) change behaviors (2) use padded or rounded edges (3) take frequent micro-breaks (4) sit closer to desk and keep back against chair |
| 4. Does the person have sufficient leg room? | | | | Keep legs relaxed and supported in front of body. | (1) remove clutter (2) reposition furniture and/or VDT (3) raise height of table with blocks (4) replace table or articulating keyboard arm |
| **C. KEYBOARD:** | | | | | |
| 1. Is the keyboard directly in front of the user? | | | | Keyboard should be lined up with person to reduce twisting and reaching. | (1) line up if desk space allows (2) use articulating keyboard arm (3) reposition furniture and/or VDT (4) replace table |
| 2. Is the keyboard in line with the monitor? | | | | Keyboard should be directly in line with monitor to reduce twisting of back and neck. | (1) line up if desk space allows (2) use articulating keyboard arm (3) reposition furniture and/or VDT (4) replace table |
| 3. Does the person maintain neutral wrist postures while keying? | | | | Wrists should be straight and floating over the keyboard, fingers should be curved in a natural position, don't flick wrists to right or left. The person should not prop their wrists on hard or sharp edges. | (1) use behavioral coaching and retraining on neutral positions (2) adjust height of keyboard so lower arms are parallel to ground (3) use ergonomic split keyboard (4) use wrist rest for support when not keying, but hands are still on keyboard (5) adjust keyboard to a flat or negative angle. |

| Question | NA | Yes | No | Observations/ Comments | Recommended Options |
|---|---|---|---|---|---|
| 4. Does the person use a minimal amount of force when keying? | | | | The louder the typing and the higher the fingers move, generally the more force created | (1) use behavioral coaching and retraining (2) use a keyboard with different key pressure resistance |
| 5. Is a palm rest used appropriately if needed? | | | | Use support of palm rest when not typing but resting your hands at the keyboard. Your wrists should never touch anything, only your palm. | (1) use behavioral coaching and retraining (2) gel palm rest to support palm area while not typing |
| **D. MOUSE:** | | | | | |
| 1. Is the mouse located to right or left of keyboard & at the same height? | | | | If a right handed person can't reach the mouse with excessively stretching their arm and shoulder, suggest mousing on left. Most people with short arms would benefit greatly from mousing on the left. | (1) Reposition keyboard & mouse (2) use articulating keyboard arm that supports both keyboard and mouse (3) replace pc table |
| 2. Is there enough room to comfortably move the mouse? | | | | Mouse should not be frequently picked up and relocated on the table when moving the cursor due to lack of room | (1) Reposition keyboard & mouse (2) use articulating keyboard arm that supports both keyboard and mouse (3) replace pc table (4) readjust tracking on the mouse |
| 3. Does the mouse fit the person's hand? | | | | Hand should be able to rest comfortably on the mouse in a neutral rounded position | (1) Replace mouse with different sized mouse |
| 4. Does the person move the mouse safely? | | | | Weight of hand should be completely supported by mouse and use the whole arm to move the mouse, not wrist. Do not prop wrist on the table while using mouse. | (1) use behavioral coaching and retraining on safe positions (2) recommend alternative shaped mouse that can be used more safely (3) learn how to safely mouse with left hand |
| 5. Does the person grip the mouse correctly and use it with a minimal amount of force? | | | | Whitened knuckles or flexed tendons generally indicate excessive force, hand should be relaxed and slightly curved | (1) use behavioral coaching and retraining (2) use a mouse pad |
| 6. If a wrist rest is present, does it interfere with neutral wrist postures? | | | | Does the wrist rest rub up against the person's wrist when they are moving the mouse correctly? | (1) remove wrist rest |
| **E. MONITOR:** | | | | | |
| 1. Is the monitor lined up directly in front of the user? | | | | Neck should not be angled up, down, left or right, but in a neutral position. | (1) reposition the monitor (2) use an articulating keyboard arm (3) replace desk with a wider/deeper one |
| 2. Is the monitor at the correct viewing distance, 16"-30"? | | | | This will depend on people's eye sight and size of the monitor. People generally feel most comfortable with the monitor at arms length. | (1) reposition the monitor (2) recommend periodic eye exams |
| 3. Is the screen height adjusted so the top line of characters is slightly below eye level? | | | | *Bifocal wearers are generally best suited by having the monitor as low as possible. People tend to gravitate to having their monitor too high. The top line of characters should be slightly below eye level. | (1) lower or raise the monitor with stackable monitor trays |
| 4. Is the screen free of glare? | | | | | (1) close blinds (2) reduce overhead lighting levels (3) reposition the location/tilt of the monitor (4) use a glare screen |
| 6. Does the person clean the screen? | | | | Use appropriate cleaning material | (1) clean screen at least monthly |
| **F. VISION:** | | | | | |
| 1. Is the lighting adequate? | | | | Higher levels of light are suggested for reading papers and lower levels for computer work | (1) adjust lighting by using task lighting to increase levels or reduce overhead lighting levels |
| 2. Does the person have appropriate visual correction? | | | | Computer glasses may be of benefit. | (1) have periodic eye exams |
| **G. DOCUMENT HOLDER:** | | | | | |
| 1. Are referenced documents correctly positioned and supported? | | | | Ideally document holders should be between the keyboard and the monitor so the neck is kept in line while working, if this is not possible, a | (1) use a document holder |

| Question | NA | Yes | No | Observations/ Comments | Recommended Options |
|---|---|---|---|---|---|
| | | | | document holder directly to the left or right of the screen at the same height will suffice | |
| **H. TELEPHONE:** | | | | | |
| 1. Is the telephone within easy reach? | | | | | (1) reposition phone |
| 2. If the phone is used extensively, does the person hold it correctly, or use a speaker phone or headset? | | | | Don't cradle phone with neck, if using the receiver hold with your hand | (1) use telephone headset (2) use speaker phone |
| **I. OTHER WORK & HABITS:** | | | | | |
| 1. Does the person reposition items, use good work practices, and/or use tools to avoid stretching or reaching to access or move items? | | | | All frequently used items should be within arms reach | (1) use behavioral coaching and retraining on safe positions (2) reposition items |
| 2. Does the person use a light grip on writing implements? | | | | Excessive grip is usually demonstrated by whitened knuckles and tight muscles/tendons, and awkward hand positions | (1) use behavioral coaching and retraining on safe positions (2) use pens with a wider softer base |
| 3. Does the person take frequent mini-breaks to stretch or rest? | | | | Take frequent micro-breaks to stretch your muscles or allow them to rest | (1) use behavioral coaching and positive reinforcement |
| 5. Do you vary your work routine? | | | | Alternate tasks as frequently as possible to minimize strain on individual body parts | (1) use behavioral coaching and positive reinforcement |

| |
|---|
| **RECOMMENDATIONS FOR PERSON:** |
| |
| |
| **EQUIPMENT RECOMMENDATIONS:** |
| |
| |
| **ADDITIONAL COMMENTS:** |
| |
| |
| |
| **REVIEWERS NAME:** |

## Appendix F: RULA Directions

Step 1 Locate Upper Arm Position:

Evaluate the upper arm position of the worker and determine the appropriate score according to the illustrations. Add one point to your score if shoulder is raised or upper arm is abducted, and subtract one point if arm is supported or person is leaning.

Step 2 Locate Lower Arm Position:

Evaluate the lower arm position of the worker and determine the appropriate score according to the illustrations. Add one point to your score if either arm is working across the midline or out to side of the body as shown in the illustration.

Step 3 Locate Wrist Position:

Evaluate the wrist position of the worker and determine the appropriate score according to the illustrations. Add one point to your score if the wrist is bent from midline.

Step 4 Wrist Twist:

Select score as 1 if the wrist is twisted in mid-range, select 2 if the wrist is at or near the end of range.

Step 5 Look up Posture Score in Table A:

Using the values from step 1 and step 2 find the row in Table A, using the values from step 3 and step 4 find the column in Table A and locate the score by intersecting row and column. Write that score in the Posture Score A box.

Step 6 Add Muscle Use Score:

Evaluate the posture, if the posture is mainly static (i.e. held longer than 10 minutes) or if the action occurs repeatedly 4 times per minute add muscle score as 1. Write that score in the Muscle Use Score box.

Step 7 Add Force/Load Score:

If the load is less than 4.4 lbs. and the repetition is intermittent select force /load score as 0, if the load is between 4.4 lbs. and 22 lbs. and the repetition is intermittent select force/load score as 1, if the load is between 4.4 lbs. and 22 lbs. and the repetition is static or repeated select force/load score as 2 and if the load is more than 22 lbs. or the repetition is repeated select force/load score as 3. Write that score in the Force/Load Score box.

Step 8 Find Row in Table C:

Add the values found from step 5 to step 7 and find the overall Wrist & Arm Score (i.e. add the Posture Score A, Muscle Use Score and Force/Load Score in the boxes). That score will be used to find the row in Table C.

Step 9 Locate Neck Position:

Evaluate the neck position and determine the appropriate score according to the illustrations. Add one point to your score if the neck is twisted or bending. Write the score in the Neck Score box.

Step 10 Locate Trunk Position:

Evaluate the trunk position and determine the appropriate score according to the illustrations. Add one point to your score if the trunk is twisted or side bending. Write the score in the Trunk Score box.

Step 11 Legs:

Select the score as 1 if the legs and feet are supported; if they are not supported select the score as 2. Write the score in the Leg Score box.

Step 12 Look-up Posture Score in Table B:

Use the Neck Score to locate the row in Table B and use the score trunk and legs score to locate the column. The intersection will give the Posture B score. Write that score in the Posture B Score box.

Step 13 Add Muscle Use Score:

Evaluate the posture, if the posture is mainly static (i.e. held longer than 10 minutes) or if the action occurs repeatedly 4 times per minute add muscle score as 1. Write that score in the Muscle Use Score box.

Step 14 Add Force/Load Score:

If the load is less than 4.4 lbs. and the repetition is intermittent select force /load score as 0, if the load is between 4.4 lbs. and 22 lbs. and the repetition is intermittent select force/load score as 1, if the load is between 4.4 lbs. and 22 lbs. and the repetition is static or repeated select force/load score as 2 and if the load is more than 22 lbs. or the repetition is repeated select force/load score as 3. Write that score in the Force/Load Score box.

Step 15 Find the Column in Table C:

Add the values found from step 12 to step 14 and find the overall neck, trunk and leg Score (i.e. add the Posture B Score, Muscle Use Score and Force/Load Score in the boxes). That score will be used to find the column in Table C.

Step 16 Determine Final RULA Score:

The values determined from step 8 (the row in Table C) and from step 15 (the column in Table C) will be used to determine the overall RULA score. The intersection of these values gives the final RULA score ranging from 1 to 7 in Table C.

## Appendix G: REBA Directions

Step 1 Locate the Neck Position:

Evaluate the neck position of the employee and determine the appropriate score according to the illustrations. Add one point to your score if the neck is twisted or side bending. Write the neck score in the box next to the illustrations.

Step 2 Locate Trunk Position:

Evaluate the trunk position and determine the appropriate score according to the illustrations. Add one point to your score if the trunk is twisted or side bending. Write the score in the Trunk Score box.

Step 3 Legs:

Evaluate the legs score according to the illustrations. Write the leg score in the leg score box.

Step 4 Look-up Posture Score in Table A:

Use the values from step 1-3 and locate the score in Table A. Write the score in the Posture Score A box.

Step 5 Add Force/Load Score:

If the load is less than 11 lbs. select force /load score as 0, if the load is between 11 lbs. and 22 lbs. select force/load score as 1, if the load is more than 22 lbs. select force/load score as 2. If shock or rapid build up of force exists add 1 point to your score. Write that score in the Force/Load Score box.

Step 6 Score A, Find Row in Table C:

Add the values found from step 4 and step 5 to obtain Score A (i.e. add the Posture Score A and Force/Load Score in the boxes). That score will be used to find the row in Table C.

Step 7 Locate Upper Arm Position:

Evaluate the upper arm position of the worker and determine the appropriate score according to the illustrations. Add one point to your score if shoulder is raised or upper arm is abducted, and subtract one point if arm is supported or person is leaning. Write the score in the upper arm score box.

Step 8 Locate Lower Arm Position:

Evaluate the lower arm position of the worker and determine the appropriate score according to the illustrations. Write the score in the lower arm score box.

Step 9 Locate Wrist Position:

Evaluate the wrist position of the worker and determine the appropriate score according to the illustrations. Write the score in the wrist score box.

Step 10 Look-up Posture Score in Table B:

Using the values from step 7-9 locate the score in Table B. Write that score in the Posture Score B box.

Step 11 Add Coupling Score:

Determine the coupling score as explained in the REBA worksheet. Write that score in the coupling score box.

Step 12 Score B:

Add values from step 10 and step 11 to obtain score B (i.e. add the Posture Score B and Coupling Score in the boxes). Find the column in Table C using this score and match with score A in row from step 6 to obtain Table C Score.

Step 13 Activity Score:

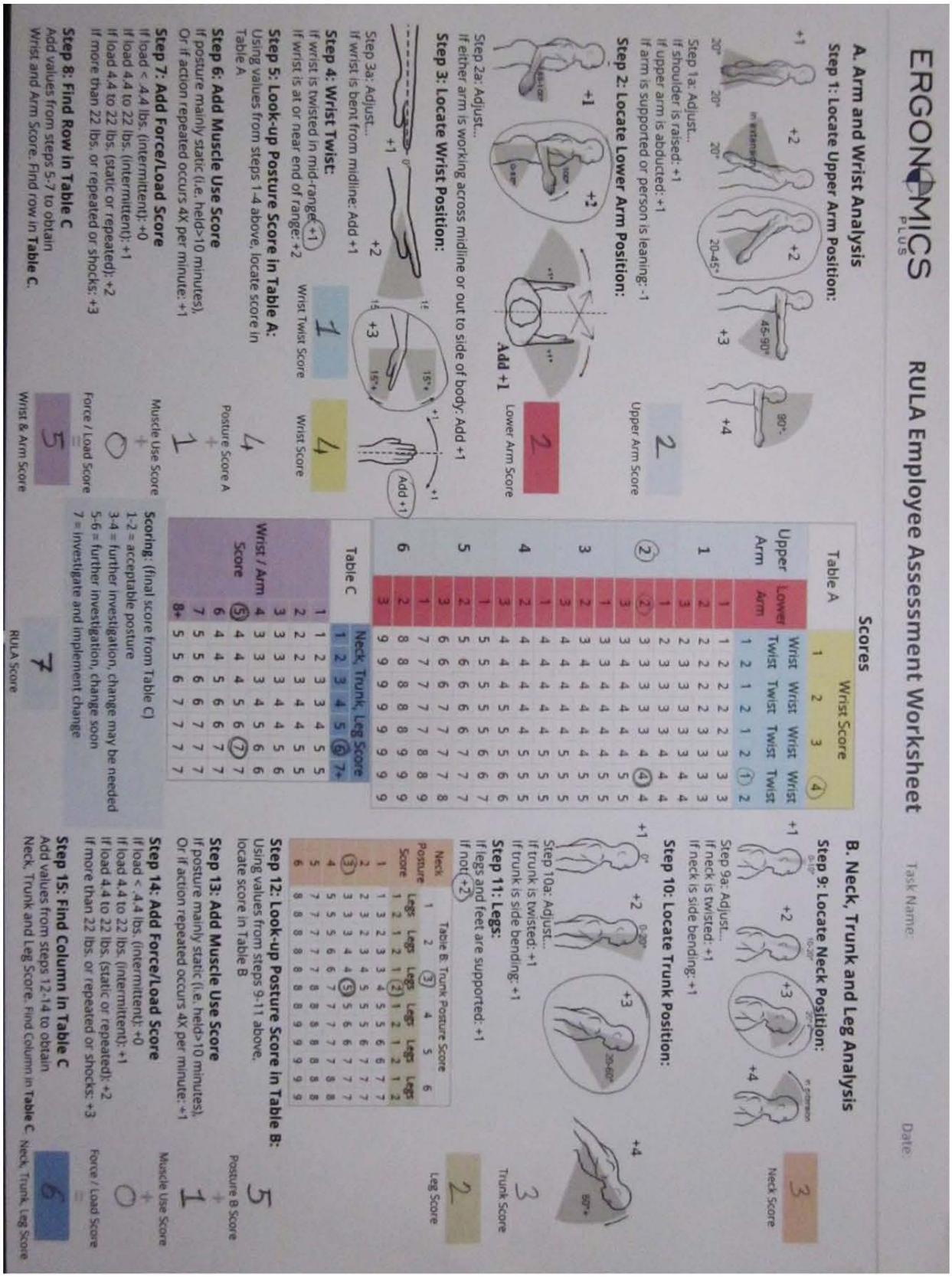
Add one point to Table C score if:

One or more body parts are held for longer than 1 minute (static)

Repeated small range actions (more than 4x per minute) or

Action causes rapid large range changes in postures or unstable base

# Appendix H: Completed RULA



ERGONOMICS PLUS

RULA Employee Assessment Worksheet

Task Name: Date:

**A. Arm and Wrist Analysis**

**Step 1: Locate Upper Arm Position:**

+1 +2 +2 +3 +4

20° 20° 20-45° 45-90° 90°+

Step 1a: Adjust...

If shoulder is raised: +1

If upper arm is abducted: +1

If arm is supported or person is leaning: -1

Upper Arm Score: 2

**Step 2: Locate Lower Arm Position:**

+1 +2 Add +1

Lower Arm Score: 2

Step 2a: Adjust...

If either arm is working across midline or out to side of body: Add +1

**Step 3: Locate Wrist Position:**

+1 +2 +3 Add +1

Step 3a: Adjust...

If wrist is bent from midline: Add +1

**Step 4: Wrist Twist:**

If wrist is twisted in mid-range: +1

If wrist is at or near end of range: +2

Wrist Twist Score: 1

Wrist Score: 4

**Step 5: Look-up Posture Score in Table A:**

Using values from steps 1-4 above, locate score in Table A

Posture Score A: 4

**Step 6: Add Muscle Use Score**

If posture mainly static (i.e. held>10 minutes),

Or if action repeated occurs 4X per minute: +1

Muscle Use Score: 1

**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

Force / Load Score: 0

**Step 8: Find Row in Table C**

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

Wrist & Arm Score: 5

**Scores**

Table A

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

Table C

| Wrist / Arm Score | Neck, Trunk, Leg 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 | 4 | 5 | 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)

1-2 = acceptable posture

3-4 = further investigation, change may be needed

5-6 = further investigation, change soon

7 = investigate and implement change

RULA Score: 7

**B. Neck, Trunk and Leg Analysis**

**Step 9: Locate Neck Position:**

+1 +2 +3 +4

Step 9a: Adjust...

If neck is twisted: +1

If neck is side bending: +1

Neck Score: 3

**Step 10: Locate Trunk Position:**

+1 +2 +3 +4

Step 10a: Adjust...

If trunk is twisted: +1

If trunk is side bending: +1

Trunk Score: 3

**Step 11: Legs:**

If legs and feet are supported: +1

If not: +2

Leg Score: 2

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 | 2 | 3 | 3 | 4 | 5 | 5 | 6 | 6 | 7 | 7 | 7 |
| 2 | 2 | 3 | 2 | 3 | 4 | 5 | 5 | 6 | 6 | 7 | 7 | 7 |
| 3 | 3 | 3 | 3 | 4 | 4 | 5 | 6 | 6 | 7 | 7 | 7 | 8 |
| 4 | 5 | 5 | 6 | 6 | 7 | 7 | 7 | 7 | 8 | 8 | 8 | 8 |
| 5 | 7 | 7 | 7 | 7 | 8 | 8 | 8 | 8 | 9 | 9 | 9 | 9 |
| 6 | 8 | 8 | 8 | 8 | 8 | 8 | 9 | 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

Posture B Score: 5

**Step 13: Add Muscle Use Score**

If posture mainly static (i.e. held>10 minutes),

Or if action repeated occurs 4X per minute: +1

Muscle Use Score: 1

**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

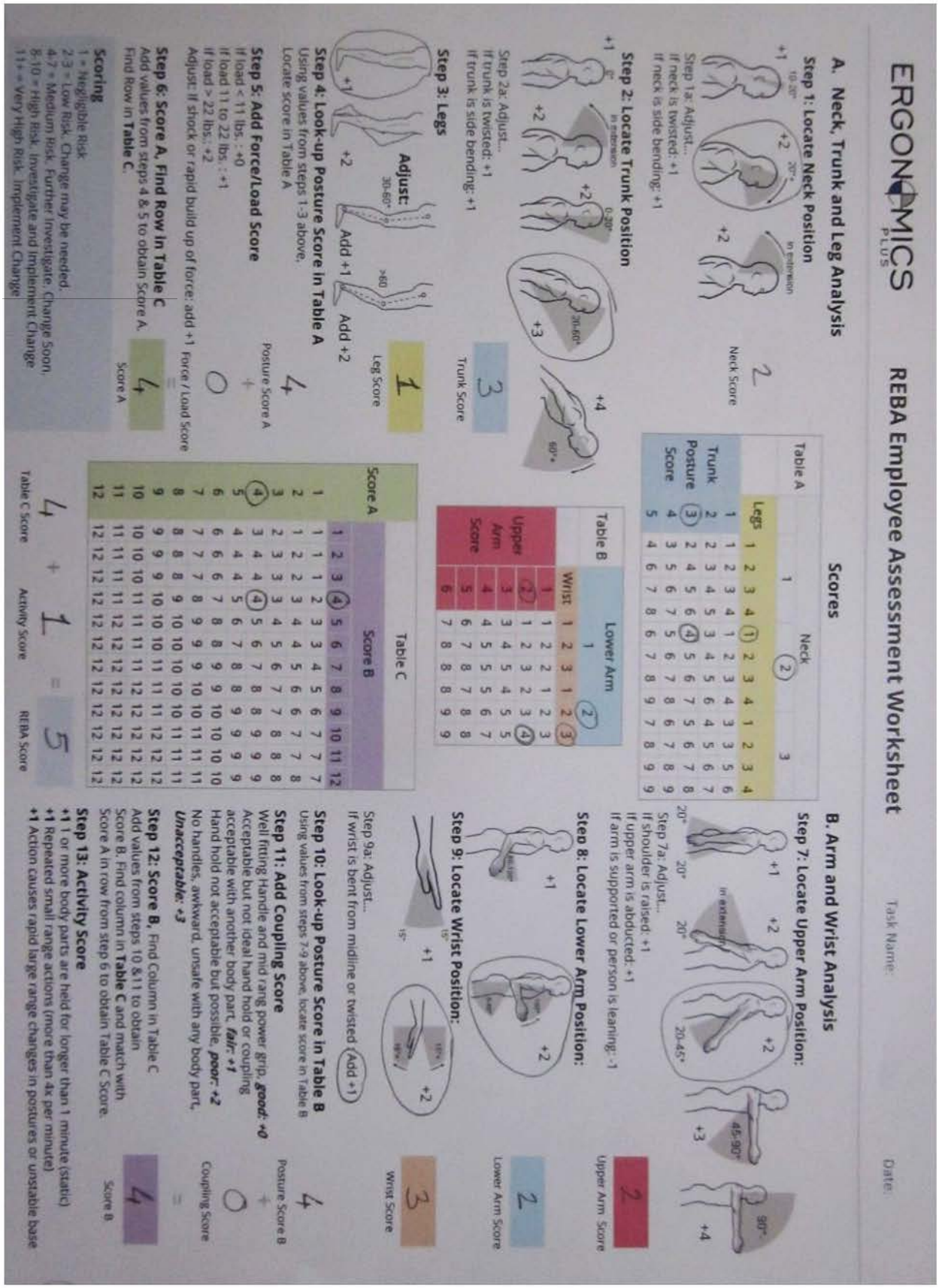
Force / Load Score: 0

**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**.

Neck, Trunk, Leg Score: 6

# Appendix I: Completed REBA



ERGONOMICS PLUS

REBA Employee Assessment Worksheet

Task Name:

Date:

**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: 3

**Step 3: Legs**

Adjust: +2

Add +1

Add +2

Leg Score: 1

Posture Score A: 4

**Step 4: Look-up Posture Score in Table A**

Using values from steps 1-3 above,
Locate score in Table 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: 0

**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: 4

**Scoring**

1 = Negligible Risk
2-3 = Low Risk. Change may be needed.
4-7 = Medium Risk. Further Investigate. Change Soon.
8-10 = High Risk. Investigate and Implement Change
11+ = Very High Risk. Implement Change

**Scores**

Table A

| Neck | Legs | 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|
| 1 | | 1 | 2 | 3 | 4 |
| 2 | | 1 | 2 | 3 | 4 |
| 3 | | 3 | 3 | 5 | 6 |

| Trunk Posture Score | Legs | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|---|
| 1 | | 1 | 2 | 3 | 4 | 5 |
| 2 | | 2 | 3 | 4 | 5 | 6 |
| 3 | | 2 | 4 | 5 | 6 | 7 |
| 4 | | 3 | 5 | 6 | 7 | 8 |
| 5 | | 4 | 6 | 7 | 8 | 9 |

Table B

| Upper Arm Score | Lower Arm | Wrist 1 | 2 | 3 |
|---|---|---|---|---|
| 1 | | 1 | 2 | 2 |
| 2 | | 1 | 2 | 3 |
| 3 | | 3 | 4 | 5 |
| 4 | | 4 | 5 | 5 |
| 5 | | 6 | 7 | 8 |
| 6 | | 7 | 8 | 8 |

Table C

| Score A | Score B 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1 | 1 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 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 | 11 | 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: 4 + Activity Score: 1 = REBA Score: 5

**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: 2

**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: 3

**Step 10: Look-up Posture Score in Table B**

Using values from steps 7-9 above, locate score in Table B

Posture Score B: 4

**Step 11: Add Coupling Score**

Well fitting Handle and mid range 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: 0

**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: 4

**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