AN ASSESSMENT OF EQUIPMENT SERVICE EMPLOYEES OF BACK INJURIES AT COMPANY XYZ

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Abstract

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Back injuries have become a major component in worker compensation costs within industry today. Company XYZ has felt this impact and recognize that the equipment service employees (ESEs) are at high risk of back injuries. The purpose of this study was to identify and analyze contributing factors for the occurrence of back injuries in equipment service employees (ESEs) at Company XYZ. Past records have indicated that ESEs are at high risk of back injuries. Within one year, over 300 back injuries were reported. For this study, the anatomy of the back and intervention approaches were researched. Some of these approaches that can be implemented into the workplace are the use of back belts, a physical fitness program, engineering controls and different types of lifting techniques.

To help identify and analyze the contributing factors, several data sources such as the loss tab analysis, worker compensation costs, and accident reports were evaluated as well as observing the daily tasks of the ESEs and customer service agents (CSAs). The results of the

evaluation from the loss tab analysis and accident reports were that the activity of lifting caused the majority of back injuries. For one year, worker compensation costs reported over $200, 000 for back injuries for the ESEs. The observations of the ESEs and CSAs were evaluated to find out additional factors that affected back injuries.

During the observations, several factors were recognized as contributing to back injuries during the unloading and loading of luggage from aircraft. Some of these indicators were poor use of lifting techniques and lifting luggage too heavy for one individual. Observations of the CSAs were made to analyze how ESEs were notified of the weight of the luggage. A "heavy bag" label was supposed to be placed on a piece of luggage that weighs between 45 to 100 pounds, however no accurate weight was placed on the tag or the luggage. Throughout this study, several factors were identified that contribute to the occurance of back injuries for the ESEs.

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Chapter 1

Statement of the Problem

Introduction

One of the most costly injuries in industry today is one that occurs in the back. In 1986, $11.1 billion was spent in worker compensation costs for back injuries (Zwerling, 1993). The direct and indirect costs for back injuries in 1990 were $27.9 billion (van Poppel, 1988). In 1992, the National Safety Council's *Accident Facts* reported that back injuries were responsible for 32% of all worker compensation costs (Constable, 1988). About 80% of adults will experience back pain sometime in their lives (Zwerling, 1993). With an injured back, the entire body can feel the effect.

The back is likely to be involved in almost every type of movement the body makes. Some of the movements are associated with various activities including exercising, bending, dancing, walking, and sleeping. There are 33 vertebrae bones and more than 100 joints to connect the bones to construct the back. All types and layers of muscles are found in the back. Some of the factors that can cause the back to become weak are lack of exercise, obesity, and poor posture. In the workplace, certain jobs involving physical labor can cause stress on the back muscles (American Medical Association, 1995). Over time, the back becomes degenerated or in other words, the muscles and joints become worn, stretched, and lose their elasticity (American Medical Association 1995; Constable and Dickey, 1988).

It appears that the airline industry possesses a high potential for placing employees at high risk of back injuries. As an equipment service employee (ESE) of the airline industry, the main requirement of this position is the ability to unload and load luggage. This job requires that the majority of the shift is spent lifting luggage on and off aircraft and carts. In an eight hour shift, a team of three to four people on the average will load and unload eight airplanes. Each airplane will typically hold the amount of luggage that can fit into 4 carts. The ESEs do a large amount of twisting and reaching to load and unload the luggage from the aircraft to the cart and vice versa. Within one year, Company XYZ had 194 accident reports involving the back. Based on past records, the ESEs at Company XYZ are at a high risk of injuring the muscles and joints of the back.

Purpose of the Study

The purpose of the study is to identify and analyze factors that contribute to the occurrence of back injuries at Company XYZ for the ESEs.

Objectives

The objectives of this study are as follows:

1) To analyze loss tab analysis, accident reports, and worker compensation costs.

2) To observe ESEs performing the tasks.

3) To identify and analyze management operations of weighing luggage.

Background and Significance

Company XYZ has requested to be anonymous within this study. This organization does recognize the high level of back injuries for ESEs within ground operations. Company XYZ has 1300 employees who are ESEs. For one year, a total of 354 back injuries were reported. Out of those 354 injuries, 194 cases involved the activity of lifting. Twisting and reaching were the second cause of back injuries at 59 cases. Company XYZ had workers' compensation costs of $237,731.75 attributed to back injuries for that same year. There were a total of 228 claims for back injuries with an average claim costing $1,042.68 (D. Heimdahl, personal communication, November 5, 1999). Company XYZ acknowledges the significance that the lifting and twisting/reaching techniques used by ESEs is causing physical damage to the body and high worker compensation costs.

Limitations

The limitations of this study are as follows:

1) No up to date demographic statistics for Company XYZ on ESEs.
2) No up to date job description for ESEs.
3) Limited contact with ESEs for surveys and questions due to potentially adverse relations with associated union personnel/representatives.

Definitions

Anterior- Toward the front surface.

Concave- Curved like the inner surface of a sphere.

Convex- Curved outward, exterior of a sphere.

Elasticity- Property of a material which allows the material to return to its original shape and size after being deformed.

Extension- To bend backward.

Fibrosus- Decrease ability of elasticity, contains more fibers within the tissue.

Flexion- To bend forward.

Oblique- Diagonal, not parallel.

Posterior- Toward the back.

Pubis- Bone of the groin.

(Definitions were provided by Chaffin, Andersson, and Martin, 1999; Biel, 1997; and Kapit and Elson, 1993)

Chapter 2

Review of Literature

Introduction

The structure of the back consists of muscles, joints, intervertebral discs, and bones. The spinal column has 33 vertebrae, with over 100 joints, and a variety of muscles that are connected to the bones (American Medical Association, 1995). The vertebrae form the column skeleton (Hay and Reid, 1982). To connect the column together, joints are formed between each vertebrae. Within the formation of the skeleton column between the majority of the vertebrae are gel-like round shaped discs called intervertebral discs. The muscles are connected to the vertebrae by bone projections called processes (Hay and Reid, 1982; American Medical Association, 1995). Without the muscles, joints, discs, and bones, the back could not allow the body to move or maintain an erect posture (American Medical Association, 1995). When a back injury does occur, that injury can limit the range of motion of the back. One activity that can cause back injuries is lifting. In fact, lifting has made such a high impact on back injuries that several intervention approaches have been used throughout industry to reduce the amount of back injuries in lifting occupations.

The Vertebrae

There are 33 vertebrae in the spinal column which are divided into the cervical, thoracic, lumbar, sacral, and coccygeal regions. The cervical region consists of seven vertebrae while the largest number can be found in the thoracic region at twelve vertebrae. Five vertebrae are located in the lumbar region, five are in the sacral section, and four are in the coccygeal section. The stacking of these 33 vertebrae form the column skeleton in a healthy back which contains four curves. The curves in the regions for the cervical and lumbar are convex forward while the thoracic and sacral regions have concave forward curves (Hay and Reid, 1982). Together the vertebrae forms the spinal column as presented in Figure 1. In each region, the vertebrae will have its own characteristics. In general, the vertebrae will have seven projections or processes, a vertebral foreman or an opening for the spinal cord, and two parts; posterior and anterior of the vertebrae (American Medical Association, 1995).

Figure 1 (Hay and Reid, 1982)

As indicated in Figure 2, the anterior or front section of each vertebrae is shaped like a drum. Between the vertebrae on the drum section are the location of the intervertebral discs. This drum area is where the spine handles the weight pressure. The opening for the spinal cord can be found in the posterior or rear part of the vertebrae. Beyond this point, the seven processes can be found on the sides and rear of the vertebrae (American Medical Association, 1995). Four out of the seven projections make the joint connection between each vertebrae. These four projections are called superior costal facets and inferior costal facets (Hay and Reid, 1982). This joint involves the two superior facets of one vertebrae and two inferior facets of another vertebrae. The superior facets of one vertebra are attached to the two inferior facets on the above vertebra. Because of this connection, it allows movement and bending of the upper body (American Medical Association, 1995). Figure 2 shows this connection between two vertebrae.

Figure 2 (American Medical Association, 1995)

The muscles in the back are attached to the spinous and transverse processes. The transverse processes are on either side of the vertebrae. The spinous process is pointing away from the spinal column. In fact, when a person runs their finger up and down the spine, they are feeling the spinous process (American Medical Association, 1995). Vertebrae not only provide support for the muscles and joints, but for the spinal nerves as well. Each vertebrae has two bars of bone called the pedicle of the vertebral arch which project backwards (Hay and Reid, 1982). The intervertebral foramen, a notch located below each pedicle, allows the spinal nerves to pass through the vertebrae. Figure 3 shows the sixth thoracic vertebra to demonstrate the location of the intervertebral foramen and the pedicle of the vertebral arch.

Figure 3 (Hay and Reid, 1982)

<u>Cervical Region</u>

Seven vertebrae are found in the cervical region (Hay and Reid, 1982). The cervical vertebrae support the movement and weight of the head and neck (Kapit and Elson, 1993). The first two vertebrae are called the atlas and axis, respectively (Hay and

Reid, 1982). As indicated in Figure 4, the atlas has no body and is shaped in a ring form. Also, there are no discs between the skull and the third vertebrae (Kapit and Elson, 1993). In fact, the weight of the head is transformed to the third vertebrae. The axis is connected to the atlas through joints. A joint is formed with a dens that is found on the axis and the anterior arch of the atlas. (Hay and Reid, 1982). Along with the two superior facets on the atlas, this joint serves as a pivot for the atlas and allows the head and neck to rotate in 90 degree movements (Kapit and Elson, 1993). Figure 4 provides a description of the atlas and axis. Figure 5 shows the joint connection between the atlas and axis. The third to the seventh vertebrae have small bodies, with a vertebral foreman shaped in a triangle (Hay and Reid, 1982). Figure 6 is an example of a cervical vertebra.

Figure 4 (Hay and Reid, 1982)

Figure 5 (Kapit and Elson, 1993)

Figure 6 (Hay and Reid, 1982)

Thoracic Region

The thoracic region has twelve vertebrae with slender spinous processes and small bodies. What is unique about the thoracic vertebrae is that each rib is attached to the two demifacets on the vertebral bodies of the adjacent vertebrae. In addition, there is a connection to a facet on the transverse process on the lower vertebrae (Kapit and Elson, 1993). Figure 7 shows a rib connected to two vertebrae. Movement is restricted within the thoracic region. Little flexion is allowed, but being the primary curve, lateral bending can occur with rotation (Hay and Reid, 1982).

Figure 7 (Kapit and Elson, 1993)

Figure 8 demonstrates the entire rib cage connected to the thoracic vertebrae.

Figure 8 (Kapit and Elson, 1993)

Lumbar Region

The five lumbar vertebrae have different characteristics in that they are the five largest vertebrae in the column (Kapit and Elson, 1993). Lumbar vertebrae have a large body shaped like a kidney and have short pedicle and long transverse processes. A triangular shape is formed by the vertebrae foreman and the spinous process is almost horizontal. No facets are found in this region, like in the thoracic region for the ribs (Hay and Reid, 1982). Figure 9 shows a lumbar vertebra, while figure 10 compares the vertebrae of the lumbar, cervical, and thoracic regions.

Figure 9 (Hay and Reid, 1982)

Figure 10 (Kapit and Elson, 1993)

The intervertebral discs within the lumbar region are wedge shaped, thus causing the lumbar region to have a characteristic of lordosis (Roberts and Falkenburg, 1992). Lordosis is the concave curvature of the lumbar spine that aids in keeping the center of gravity in line between the head and pelvis (Biel, 1997; Roberts and Falkenburg, 1992). The range of motion varies between individual vertebrae and increases downward in the lumbar region (Hay and Reid, 1982).

Sacrum and Coccyx Region

The sacrum and coccyx regions have bones that are either individual or fused together. The five sacrum vertebrae are fused together and there is no room or space for discs. A major joint in this region is called the sacroiliac joint that connects with the hip bone. The coccyx region has two to four very small vertebrae that may never be fully developed. Some can be individually or partially fused together. The first coccyx vertebrae is the only one that is mostly developed (Kapit and Elson, 1993). Figure 11 provides a description of the sacrum and coccyx regions.

Figure 11(Kapit and Elson, 1993)

Intervertebral Discs

Within the skeletal column there are soft, kidney shaped discs between the vertebrae called intervertebral discs. A disc consists of two parts; the nucleus and the annulus. These two parts produce the load bearing characteristics of the back (Chaffin, 1999). The annulus is an outer fibrosus that surrounds the nucleus (Hay and Reid, 1982). The nucleus which is called the nucleus pulposus is a gel-like mass. Figure 12 provides a description of the intervertebral disc. Without the nucleus pulposus, the vertebrae could not move. When the back is twisting and tilting, the nucleus pulposus shifts to alter the shape of the disc. Figure 13 demonstrates how the disc alters its shape.

Figure 12 (Kapit and Elson, 1993)

Figure 13 (Kapit and Elson, 1993)

Over time the disc loses water content and become more fibrous and with a loss of moisture and elasticity, thus causing it to shrink (Hay and Reid, 1982; Constable and Dickey, 1988). This shrinking process is called degeneration. Degeneration is an irreversible process that increases with age (Videman and Battie, 1999). Besides normal wear in the ankle, knee, and hip joints, this may be one of the reasons why older people lose their height.

Nerves

When each vertebra is connected and forms the skeleton column, the vertebral foramen or opening forms the spinal canal. The spinal canal is where the spinal cord runs through from the base of the brain to a few inches above the waist. At the end of the spinal cord, nerve fibers in strands are spread out. These strands of nerve fibers are called the "Horse's Tail". Off the spinal cord, nerve roots are located on the sides of the vertebrae. The purpose of these nerve roots is to send signals from the brain to the muscles and vice versa. For example, nerves in the cervical region send signals to the shoulder, wrist, and finger muscles. In the lumbar region, the nerves send signals to the hips and knees. Two sciatic nerves are formed between the lumbar and sacrum nerve fibers. Sciatic nerves are two nerves on either side of the body that run through the pelvis and down the legs (American Medical Association, 1995). Figure 14 provides a description of the nerve roots and sciatic nerves of the back.

Figure 14 (American Medical Association, 1995)

<u>Muscles</u>

Muscles of the back are designed by numerous bands of fibers that are dense and interwoven. The muscles form a complex system to a point where it is difficult to separate the four groups of muscles. These four groups are the erector spinae, transversospinalis, splenius, and suboccipital. The erector spinae group covers the vertebral column from the sacrum to the neck. Figure 15 shows the erector spinae muscle. A description of the erector spinae muscle group is like a poplar tree with three main branches. The three branches are spinalis, longissimus, and iliocostalis (Biel, 1997). Together, these muscles provide the ability for the back to flex and extend (Roberts and Falkenburg, 1992).

Figure 15 (American Medical Association, 1995)

Similar to the erector spinae, the transversospinalis muscle group also has three main branches. The multifidi, rotatores, and semispinalis are found along the vertebrae column. Transversospinalis refers to the muscle fibers that are extended to the transverse and spinous processes which can vary in length. The multifidi group is found in the lumbar region and are very thick. These muscles lie across the posterior surface of the sacrum. Smaller rotatores are underneath the multifidi and the semispinalis are of thoracic and cervical regions of the back (Biel, 1997).

Muscles in the upper back and neck regions include the splenius capitis and splenius cervicis. Unlike the previous muscle groups, these muscles run oblique to the vertebral column, not parallel with the spine. Both muscles are very deep and difficult to isolate. The eight suboccipital muscles support the atlas and axis. Rocking and tilting of the neck are possible because of these muscles (Biel, 1997). Figure 16 shows a description of these muscles. A very deep muscle that is found in the lower back but is considered an abdominal muscle is the quadratus lumborum. This muscle is located under the erector spinae and transversospinalis muscles. Another name for the quadratus lumborum is the " hiphiker" because of its ability to lift the hip (Biel, 1997).

Figure 16 (Kapit and Elson, 1993)

The muscles that provide the most support to the back are the four abdominal muscles (Constable and Dickey, 1988). These four muscles in the stomach region are rectus abdominis, external and internal obliques, and transverse abdominis. Rectus abdominis is a vertical muscle that stretches from the sternum to the pubis. The rectus flexes and resists extension of the trunk against gravity. Internal oblique are the middle layers of muscles located from the iliac crest upward to the three lower ribs. The external oblique muscles run downward from the last eight ribs to the iliac crest. Together the obliques provide the motion of lateral flexion and rotation of the back. The innermost layer is the transversus abdominis. This muscle assists in lateral flexion and rotation (Roberts and Falkenburg, 1992).

<u>Low Back Pain</u>

Normally, if a person feels a sharp pain in the lower back, it is more than likely the muscles and ligaments were overextended (American Medical Association, 1995). Low back pain is 97% of the time attributed to a sprained or strained muscle, joint, or ligament (Kiritzky and White, 1997). The reason why the pain occurs in this area is that the lumbar region is subject to heavy weight from the upper body. Also, the range of motions such as twisting and lifting are performed primarily by the lumbar region (American Medical Association, 1995).

There are several risk factors that come into play with low back pain. Some personal risk factors are age, gender, physical fitness, and lumbar mobility. Heavy physical work, prolonged sitting and standing, and twisting are a few factors involved on the job that can increase the likelihood of back pain (Garg, 1992). One job factor that stands out is lifting (Snook, 1978). Snook reported that 70% of workers involved in material handling tasks such as lifting were affected by back pain.

Other causes of back pain could be a facet joint displacement or a prolapsed disc. Facet joint displacement is when a person moves in a twisting motion in which the vertebrae slips and falls out of place. This action can pinch a nerve and thus increase the pain. A prolapsed disc is when the nucleus enters the annulus region of the disc causing the disc to bulge. In turn, the disc adds pressure to the nerve roots and thus causes the pain (American Medical Association, 1995).

Lifting

Several activities in a material handling environment that can cause injury to the back are carrying, twisting, pulling, and pushing. The one action that stands out the most is lifting (Kroemer, 1980). Lifting of objects can add a tremendous amount of pressure on the vertebrae and muscles of the back and abdomen. When lifting the object, the motion of bending affects the erector spinae muscle. On return to the upright position while lifting the object, the abdominal muscles tighten to give additional support to the erector spinae muscle (Alexander, 1992). Adding a carrying or twisting motion with lifting an object can increase an individual's chances of injury due to the additional strain on the muscles.

Intervention Approaches

Lifting Techniques

To help reduce back injuries, several lifting techniques have been used throughout the material handling industry. The "back lift" is a technique that should be rarely used. A back lift is when a person bends the back and keeps the legs straight. This technique adds tremendous strain to the lower back and should be avoided. The opposite of this technique is the "leg lift". A leg lift consists of bending the knees while keeping the back straight, then lifting the object by using the muscles of the legs. The leg lift has been promoted throughout industry, but not fully practiced by employees (Kroemer, 1980). Another technique that is offered by the National Institute of Occupational Safety and Health (NIOSH) concentrates on minimizing the weight of the object that is being lifted.

In 1981, NIOSH came out with a lifting guide for manual lifting involving four factors. These factors are the distance travel of the object, horizontal and vertical measurements of the object being lifted, and the number of lifts performed in one minute. (Chaffin, 1999). Thirteen years later, NIOSH revised the guide into an equation with the final product as the recommended weight limit (RWL). RWL is a weight limit on the object that is being lifted for one person to help reduce injury to the lower back. This revised equation evaluates two-handed manual lifting tasks in a variety of occupations. A lifting task essentially the manual grasping of an object with two hands to move it vertically without mechanical assistance. The NIOSH revised equation is as follows:

RWL= LC x HM x VM x DM x AM x FM x CM

The RWL is attained by taking into account certain variables that are measured throughout the lifting task. Following is a brief description of the variables which are included in the NIOSH equation:

Load Constant-(LC)- a standard number within the equation set at 23 kilograms or 51 pounds.

Horizontal Multiplier- (HM)- the hand distance away from the body measured from the midpoint between the ankles.

Vertical Multiplier- (VM)- the vertical measurement of the hands to the floor.

Distance Multiplier- (DM)- the distance travel vertically between the origin and destination of the lift.

Asymmetric Multiplier-(AM)- angle measurement on how far the object is in from the person’s body at the origin and destination of the lift.

Frequency Multiplier-(FM)- measurement determined by how many lifts in a minute and the vertical measurement between the hands to the floor is less than or greater than 75 centimeters (See Appendix 1).

Coupling Multiplier-(CM)- measurement on how the object is held with the hands. Measurement is ranked as good, fair, and poor. Description is offered under each measurement (see Appendix 2). Once a measurement has been chosen, the vertical value that is less than or greater than 75 centimeters helps determine a numerical value for the CM (U.S. Department of Health and Human Services, 1994).

When all the measurements have been determined, a mathematical equation is used to determine the final RWL. The measurements can be taken in metric or U.S. customary systems. The metric system consists of measurements of weight and angles in kilograms and centimeters, respectively while the U.S. customary system deals with measurement in pounds and inches (U.S. Department of Health and Human Services, 1994). The following table provides the equation in metric and U.S. customary systems.

	Metric (kilograms (kg) and centimeters (cm))	U.S. customary (pounds (lbs) and inches (in))
LC	23 kg	51 lbs
HM	(25/H)	(10/H)
VM	(1-(.003)[V-75]))	(1-(.0075)[V-30])
DM	(.82 + (4.5/D))	(.82 + 1.8/D)
AM	(1-(.0032A))	(1-(.0032A))
FM	Appendix 1	Appendix 1

CM	Appendix 2	Appendix 2

The NIOSH lifting equation also provides a lifting index. The lifting index determines the stress involved in manual lifting jobs. The equation for the lifting index or LI is:

$$LI = \frac{\text{Load Weight}}{\text{RWL}}$$

Load weight is the actual weight of the object that is being lifted. RWL is the number calculated out in the lifting equation. If the LI is below 1.0 the job is referred as possessing a minimal amount of stress. If the value is 1.0, the task is considered fairly stressful. At value of above 3.0, engineering or administrative controls, should be put into effect to bring the stress level back down to an acceptable level. (U.S. Department of Health and Human Services, 1994).

The NIOSH lifting equation is valuable to manual lifting tasks to help recognize hazards involved in some occupations. This equation is limited and excludes jobs that involve multiple activities in performing a lifting task. However, the NIOSH lifting equation does have limitations in where it cannot be applied to all lifting occupations. These limitations involve lifting/lowering objects,

- with one hand
- over 8 hours
- while seated or in a kneeling position

- in restricted work space
- while carrying, pushing, or pulling
- with the use of wheelbarrows or shovels
- at high speed motion (30 inches per second)
- with unreasonable foot/floor coupling
- in an unfavorable environment such as rain or snow (U.S. Department of Health and Human Services, 1994).

Back Belts

One of the most common intervention techniques used in industry today to help reduce back pain are lumbar supports. A lumbar support or back belt in general consists of soft elastic materials with metal or plastic inserts. The support is shaped like a belt and goes around the abdomen and lower back. Several studies have been conducted to see if back belts do help reduce back injuries (Dillingham, 1998). However, the studies have not produced a consensus on the use of back belts. According to the Agency for Health Care Policy and Research, a back belt should be used if it is a means of reducing the work time lost for injured employees who are required to do frequent lifting. Conversely, the National Institute for Occupational Safety and Health recommended uninjured workers not to use lumbar supports (van Poppel, 1998).

A study was performed on cargo employees to determine the effectiveness of education and back belts in the workplace. There were four groups involved in this study. Group one received training of lifting techniques and back belts. Groups two and three only received education and back belts, respectively. Group 4 had no intervention.

Before the study, subjects were asked to fill out questionnaires about demographics, medical history, work perception, and status of health. The study lasted six months. Every month, the subjects filled out questionnaires about sick leave, any occurrence of back pain, and compliance issue of wearing the lumbar support. The results of the study showed that there were no difference between the groups who wore the lumbar supports and the groups who had received the training. But what was interesting about this study was the compliance issue. According to the monthly questionnaires filled out by the subjects who were given the lumber supports to wear, only 43% of those subjects wore the supports throughout the eight month study. Some of the comments the employees had about the lumbar supports were restriction on movement, too warm, and also being uncomfortable during seated activities (van Poppel, 1998).

Another lumbar support based study was conducted by evaluating airline baggage handlers with the use of a weighlifting belt and training class. Four groups were involved at different airport stations at Dallas-Fort Worth, Los Angeles, Raleigh-Durham, and Nashville. As in the previous study, one group received a belt only, group two attended the training class, group three had both the training and the belt and the control group was labeled group four. The subjects were 572 males and 70 females between the ages of 19 to 67 years. The employees tasks were to manually transfer luggage, mail, and supplies to another location. The belt that subjects received was 150 millimeters tall at the back center of the belt and 20 millimeters deep at its thickest point. The belt was adjustable and not attached to the trousers. The groups that received training watched a video and participated in practicing pivoting and lifting techniques. The video consisted of spine anatomy, warm-up exercises, job specific body mechanics, and after injury care. Employees within the training classes performed stretching exercises and were reminded that stretching before and after a flight would reduce the risk of sprain or strained ligaments and muscles. Subjects in groups one and three were simply instructed on how to tighten the belt during work and to loosen the belt when not performing the activities. Information received regarding the subjects' on age, gender, weight belt size, and the height of pelvis to rib cage of the subjects were also collected. Also, two questions were asked concerning back injuries. These questions were "Have you suffered back pain?" and "Have you ever suffered from a specific back injury?" A questionnaire was given to all the subjects who were assigned a belt. The study lasted eight months (Reddell, Congleton, Huchingson, and Montgomery, 1992).

The results of the airline baggage handler study indicated that neither training nor the belt made a difference in reducing injury. Of the 272 subjects that received the belt, only 114 continued to wear the belt for the eight month period. There were 28 lumbar injuries that had occurred during this study. Five of the injuries happened to personnel who were wearing the belts and previously did not have back injuries. As in the previous study, complaints were recorded. One of the more frequent comments was the belt would not stay in place. The belt would rise up and pinch or jab the ribs. Another major complaint was on how hot the subjects got when wearing the belt. Some subjects had rashes on their stomachs due to the amount of sweat that had build up. Also, two people noticed ice forming on the belt because their sweat had frozen (Reddell, Congleton, Huchingson, and Montgomery, 1992).Thus the outcome of this study showed that back belts did not assist in the reduction of back injuries.

Physical Fitness

Another intervention technique used to help reduce the occurrence of back injuries is physical fitness. Physical fitness is defined as the ability to attain optimal efficiency of the blood vessels, muscles, heart, and lungs. Optimal efficiency is a level in which a person reaches an enthusiastic and pleasurable participation in daily activities. Physical fitness has five basic components. Two of the components are muscular strength and endurance. These two topics often get mistaken for each other. Strength is the muscle's capability to exert a force against a resistance (Getchell, 1976). An example of muscle strength is trying to move a wall (Klug and Lettunich, 1992). Endurance is the ability of the muscle to exert force over a period of time (Getchell, 1976). Muscular endurance enables the muscle to last longer in a static contraction, for example, someone doing situps or pushups (Klug and Lettunich, 1992).

Cardiorespiratory endurance and body composition are two other factors involved in physical fitness. Cardiorespiratory endurance is considered the most essential element to physical fitness. This factor increases the efficiency of the heart, blood vessels, and lungs to deliver oxygen and nutrients to the tissues (Getchell, 1976). Aerobic exercise such as running increases the cardiorespiratory endurance (Klug and Lettunich, 1992). Body composition is the overall factor that involves the level of body fat. When exercising to improve muscle strength and endurance as well as cardiorespiratory endurance, the body will change its shape. Muscles will become leaner and/or bigger and provide more energy for the body. With increased muscle mass, body fat decreases (Klug and Lettunich, 1992; Getchell, 1976).

The last component is flexibility. Flexibility is the ability of movement by the joints. The range of motion would include movements such as twisting, bending, and stretching (Getchell, 1976). Limited flexibility can be one of the reasons for low back pain. Flexibility of the joints does decrease with age and the development of a lifestyle which includes no or little activity (Klug and Lettunich, 1992). Sore muscles can be experienced when physical exertion is applied to short muscles with limited flexibility as well as when required more output exceeds muscle capability (Getchell, 1976). However, good maintenance to the joints, such as regular activity, can provide resistance to muscle injury (Klug and Lettunich, 1992; Getchell, 1976). A regular activity can be a stretching program that involves static stretching methods. Static stretching involves a slow movement reaching for a body part and holding that position for 10 to 30 seconds. With increased flexibility, the time and repetitions of the stretching exercises can increase up to 3 to 5 times at the same time length for each turn (Klug and Lettunich, 1992).

Engineering Controls

With the high amount of back injuries today, many companies are implementing engineering controls within their organization. Engineering controls are devices that are used to help eliminate the hazards from the job. Some devices that can assist lifting or eliminate manual handling practices are lift tables, tilted conveyors, and work station cranes. Two devices that eliminate manual handling of objects are the manipulators and vacuum lifters. Manipulators are rigid arm-based systems that can be attached to the ceiling, wall, or mounted to the ground on top of a pedestal. An operator can control the manipulator to perform lifting , rotating, turning, tilting, and reaching tasks. Two types of manipulators are hydraulic and pneumatic. Hydraulic manipulators can reach up to nine feet, have a five foot vertical lift, and handle products weighing up to 1500 pounds. Pneumatic manipulators can lift up to 1000 pounds with an eight foot vertical lift and have the ability to reach up to ten feet (Holzhauer, 1998).

Vacuum lifters help the worker eliminate the repetitive motion situations. A vacuum lifter is made out of two parts: the vacuum grab and hoist or balancer. The vacuum grab, which is connected to the hoist or balancer, attaches itself to the product while the hoist or balancer performs the actual lifting of the object. Another vacuum lifter is a retracting tube lifter. Retracting tube lifters are like a vacuum cleaner hose where a vacuum is turned on and by placing your hand over the opening, the suction will pull your hand into the opening. This type of vacuum lifter can handle a variety of loads without any adjustments. Vacuum lifters can be suspended from the ceiling or attached to a building column and with a long, flexible vacuum hose can lift and position the product within a given range (Schwind, 1994).

Summary

The back is a very complex structure that involves muscles, bones, joints, and nerves. With all of these components, it provides movements for the entire body. When these components become injured, not only does the back suffer but other factors suffer as well. Low back pain can cause lost work days and decrease in production. Industry, especially material handling, has recognized the effect of low back pain. Several approaches have been used to help reduce back injuries such as back belts, the NIOSH lifting equation, physical fitness, and engineering controls.

One company has recognized the effect of low back pain within the workplace. Company XYZ has a material handling operation that have employees experiencing low back pain.   Due to this recognition, a study will be conducted to demonstrate what factors may be contributing to low back pain in employees at Company XYZ.

Chapter 3

Methodology

Introduction

Back injuries have become a major component in worker compensation costs throughout industry today. At Company XYZ, back injuries for the equipment service employees (ESEs) have become a big concern. This study is to research and identify issues of back injuries, especially low back pain. The structure of the back and intervention approaches to help reduce back injuries has been looked at through research of literature. The purpose of the study is to identify and analyze factors that contribute to the occurrence of back injuries at Company XYZ for the ESEs.

Methodology

The methodology of this study is as follows:

1) To analyze loss tab analysis, accident reports, and workers' compensation costs from Company XYZ on back injuries only. The information from the loss tab analysis, accident reports, and worker compensation costs for one year (September 30, 1998-October 1, 1999) can be used within this study by permission received from the Safety Manager. Data collected from these tools are factors that may contribute to back injury,

cost per back injury case for Company XYZ, and the activities performed while the injury had occurred. These tools will concentrate on one location and only the ESEs.

2) To observe ESEs performing daily tasks of loading and unloading luggage and mail from aircraft. Observation will take place at one location and data collected will be through observation by noting the activities the employees are performing while loading and unloading an aircraft. The location will remain confidential due to Company XYZ requesting this information to retain anonymity.

3) To identify pieces of luggage that have or have not been labeled as a heavy package during operation. As a customer service agent(CSA), one of the job duties is to determine if a piece of luggage is over 45 pounds. If one piece of luggage is between 45 to 100 pounds, the CSA will place a bright orange label on the luggage (see Appendix 3). This label is to notify ESEs of a heavy package. Without this knowledge, the ESEs may be lifting luggage too heavy for that individual which in turn can cause injury. Data collected through observation by noting how a CSA determines an accurate weight of one piece of luggage.

Summary

The study will identify and analyze contributing factors to back injuries with ESEs at Company XYZ. The results will be discussed in Chapter 4.

Chapter 4

The Study

Introduction

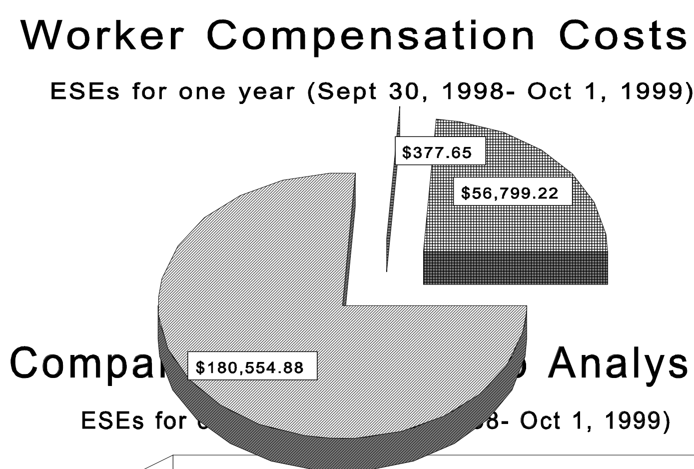
Company XYZ recognizes that equipment service employees (ESEs) are at high risk of back injuries. The purpose of this study is to identify factors that contribute to back injuries. Loss tab analysis, workers' compensation costs, and accidents reports were analyzed to identify activities that the ESEs were performing when the injury had occurred. The observer watched the ESEs perform their daily tasks and locations that the customer service agents (CSAs) identify heavy luggage. The evaluations of the loss tab analysis and accident reports indicated that lifting was the number one cause of back injuries reported at Company XYZ. During the observations, the ESEs were performing several activities such as lifting, twisting, and carrying that can increase the chances of injury. The CSAs were also watched to see if individual pieces of luggage were being weighed. The results of the CSA observation determined that accurate luggage weight were not being taken nor were ESEs notified of the weight of heavy piece of luggage. With the loss tab analysis, accident reports, and observation, it is concluded that certain factors do contribute to back injuries in ESEs at Company XYZ.

The Results from the Reports

To help identify contributing factors for back injuries at Company XYZ, several tools were analyzed. For a given year at one location, reports concerning worker compensation costs, and employee accidents, were evaluated through a loss tab analysis for causes of back injury. The loss tab analysis provides a description of the injury/illness and the body part that was injured. The body part section of the loss tab analysis does not give a specific region. For example, if an employee injured the back, the word "back" would be typed in the body part section instead of lower back or upper back. Under the description of injury /illness, the terminology used to describe injuries of the back was overextension. Unfortunately a definition for overextension was not provided on the loss tab analysis. Also, several activities that an employee was performing when the injury occurred are given in the description section of the analysis. Chart 1 provides the top five causes of back injuries for the ESEs. According to Chart 1, lifting is the number one cause of back injury with 194 cases reported, out of a total number of 354 cases. A variety of other causes such as slip and fall, falls at same elevation, and repetitive motion accounted for 30 cases of back injuries.

Chart 1- Company XYZ Loss Tab Analysis

In order to assess the financial impact of back related injuries, worker compensation costs were evaluated for the same year as the loss tab analysis. From the time period of September 30, 1998 through October 1, 1999, there were a total of 228 cases where employees had received worker compensation. From these 228 cases, 144 were classified as lower back- related injuries. Chart 2 shows that Company XYZ paid over $180,000 in one year for lower back injuries from the total cost of $237, 731.75 for all ESEs back injuries at one location.



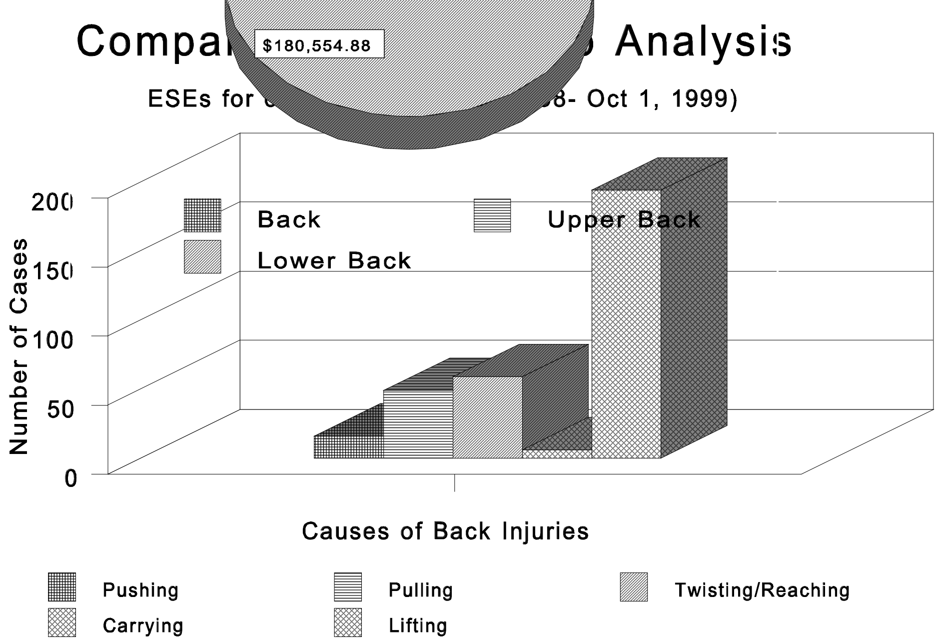


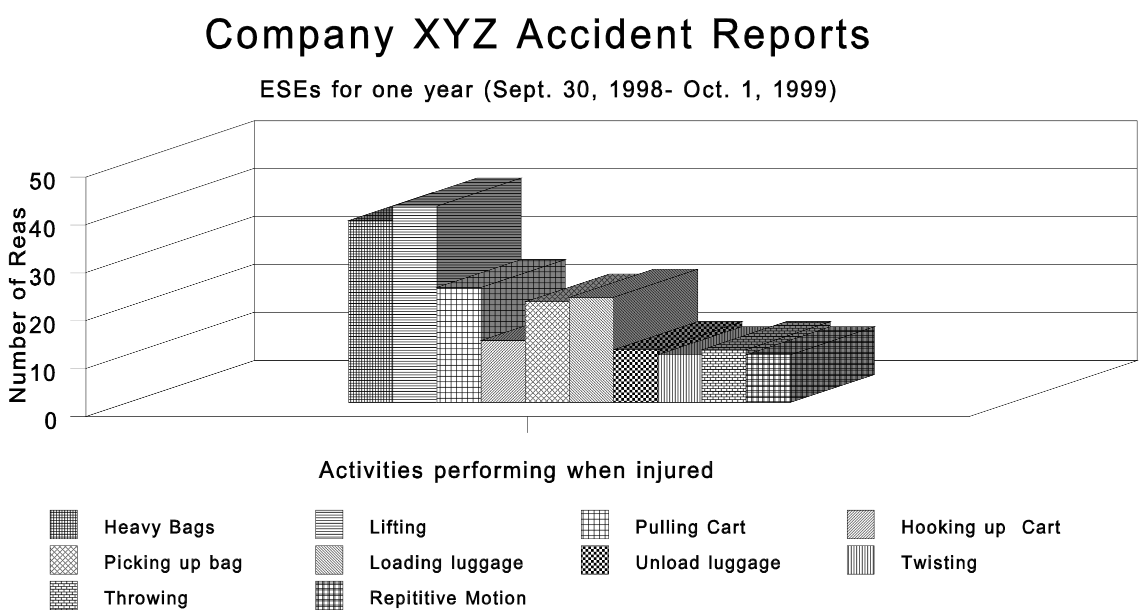
Chart 2- Worker Compensation Costs

Accident reports were provided for the same year as the worker compensation costs and loss tab analysis. The accident reports provided a one sentence description of what happened when the respective back injury occurred. Chart 3 provides ten activities that ESEs were performing when the injury developed. One activity of interest listed on this chart indicates that 38 injuries involved lifting and /or picking up a heavy bag. It should be noted that Chart 3 does not show whether or not a combination of these activities contributed to injury. In contrast, many reports stated two activities such as bending down and picking up a piece of luggage or lifting a bag and slipping and falling, were the cause of the injury.

Chart 3- Accident Reports

Results from ESEs and CSAs Observations

The ESE observations took place during the morning period at one location. The



unloading and loading of luggage, mail boxes, and bags by the ESEs were observed for two domestic flights and one international flight. A basic process for luggage handling activities performed by the ESEs were noted. A variety of three techniques for unloading a flight are as follows:

- Pick up bag off the conveyor belt, place bag on the ground for further pick up (or)

-Pick up bag off the conveyor belt, place bag into cart by twisting the body and throwing bag into cart (or)

-Pick up bag off the conveyor belt, place bag into cart by walking over to the cart.

For loading a flight, two different techniques were used:

-Pick bag up out of the cart, walk over to the conveyor belt (or)

-Pick bag up out of the cart, twist the body while holding the luggage and place bag on conveyor belt

Observations for the domestic flight of loading the luggage onto the aircraft noted high amounts of twisting of the lower back to place luggage onto the belt. Also, awkward packages such as golfbags were handled by the ESE with a one hand grip and consequently did not use both hands to carry the bag. With the use of a one hand grip, the employee looked off balance as a result placing the weight of the specific piece of luggage on one side of the body. When ESEs needed to lift luggage, the use of the leg lift method was not being used. According to the Safety Manual for Company XYZ, it is highly recommended to use the leg lift method to avoid injury. But observation indicated that ESEs were bending more at the waist and keeping the legs straight instead of using the leg lift method of keeping the back straight and bending at the knees.

The second domestic flight observed was quite different from the previous observation. This domestic flight was an arrival and up to four ESEs were involved with unloading several mail boxes that had a rope tied around each individual box. These employees would pick up two boxes, one in each hand by the rope, and walk over and place the box in the cart. None of these employees seem to have any problems handling the boxes. The employees showed no awkward postures or visible difficulties when lifting these boxes off the conveyor belt.

The last flight observed was an international flight. This flight arrived and departed within an hour and a half. Two conveyor belts were in position for this flight. One conveyor belt was blocked from the observers' view due to a cleaning truck parking next to the aircraft to allow the cleaners to take care of the plane. The other conveyor belt, which had three ESEs working on it, was in clear view. Five connected carts were placed next to this conveyor belt with three ESEs working on this belt. These employees would pick up two pieces of luggage in each hand at one time, walk over to the carts, and look on a chart to decide where to put the luggage. After deciding what cart the luggage belonged to, the employees would lean to one side and throw the luggage into the cart with one hand. When a heavy piece of luggage came down the belt, an ESE would pick up the luggage with one hand, place the other arm and hand out to the side for balance, walk over to the cart, and throw the luggage into the cart. One cart became so full that ESEs needed to lift the luggage over their heads and shove the luggage into the cart. There were also pieces of luggage or mail that needed to go to different locations. These packages were placed on the ground for later pick up. The ESEs associated with this unloading operation only took 11 minutes to empty the plane.

While waiting for the same aircraft to depart, different ESEs came by to pick up the luggage and bags on the ground to be brought over to separate destinations. One ESE drove over in a tug with a cart to pick up three bags of mail. The ESE bent over, picked up the three bags at once, walked a few steps, and dropped one of the bags. This individual continued to place the other two bags into the cart, and then went back and picked up the third bag by bending at the waist. This employee threw the bag into the cart and drove off. Lifting all three bags at once created a heavy and awkward lift, increasing the chances of injury.

Once the international flight was ready for departure, ESEs set up the conveyor belts to load the aircraft. The full carts being loaded onto the aircraft were placed at a distance far enough for the ESEs to take 3 to 4 steps to reach the conveyor belt. An ESE would pick up one or two pieces of luggage, depending on the weight of the luggage or if the luggage had if a strap or handle was available, walk over to the conveyor belt, and placed the luggage on the belt. ESEs had a high amount of reaching within the cart to get the pieces of luggage out of the cart. There was a limited amount of twisting because the ESEs had to covera fair amount of distance to the conveyor from the cart. This entire procedure of loading the plane took less than 15 minutes.

The observations for the CSAs on weighing the luggage took place on the same day as the ESE observations. One of the job duties for the CSAs is to determine if a piece of luggage weighs between 45 to 100 pounds. If a piece of luggage weighs between those figures, the CSAs must place a “heavy bag” label on the luggage. If it weighs over 100 pounds, the luggage must be separated into two packages. The weight scale is located between two computer stations. This setup enables two CSAs to work at separate computer stations and share one weight scale.

During the check-in process, a customer will often have two or more bags that are placed on the scale. If the scale does not read over 90 pounds for two pieces of luggage, the employee assumes that neither package is over 45 pounds and either package does not receive a “heavy bag” label. Often the CSA assumes the weight of the luggage based on the size and shape of the package and does not accurately weigh it.

An accurate weight of a customer’s packages is not taken for several reasons. One factor is that customers often place more than one piece of luggage on the weight scale. Another reason why accurate weights are not taken is the fact that CSAs feel it will take too much time and slow the process down when checking customers in for flights. Although accurate weights are usually not taken, it would not mater anyway due to the fact that only generic heavy bag labels are used that indicate the package is between 45- 100 pounds.

Summary

The results of the study indicated several factors were involved in causing back injury. The most predominant factor is lifting as indicated by the loss tab analysis and accident reports. But, the ESEs do perform certain tasks that can increase their risk to back injury such as lifting luggage with one hand or bending down to pick up a heavy piece of luggage without bending the knees. The CSAs also increases the risks to the ESEs by not giving accurate information concerning the weights of heavy luggage. Without an accurate weight on the luggage, an ESE could possibility be lifting a package too heavy for that individual. Conclusions regarding the collected data, as well as recommendations on improving certain factors to possible reduction of back injuries will be discussed in Chapter 5.

Chapter 5

Summary, Conclusions, and Recommendations

Summary

The purpose of this study was to identify and analyze contributing factors for the occurrence of back injuries in equipment service employees (ESEs) at Company XYZ. Past records have indicated that ESEs are at high risk of back injuries. Within one year, over 300 back injuries were reported. For this study, the anatomy of the back and intervention approaches were researched. Some of these approaches that can be implemented into the workplace are the use of back belts, a physical fitness program, engineering controls and different types of lifting techniques.

To help identify and analyze the contributing factors, several data sources such as the loss tab analysis, worker compensation costs, and accident reports were evaluated as well as observing the daily tasks of the ESEs and customer service agents (CSAs). The results of the evaluation from the loss tab analysis and accident reports indicated that the activity of lifting caused the majority of back injuries. For one year, worker compensation costs reported over $200, 000 for back injuries for the ESEs. The observations of the ESEs and CSAs were evaluated to find out additional factors that affected back injuries.

During the observations, several factors were recognized as contributing to back injuries during the unloading and loading of luggage from aircraft. Some of these indicators were poor use of lifting techniques and lifting luggage too heavy for one individual. Observations of the CSAs were made to analyze how ESEs were notified of the weight of the luggage. A “heavy bag” label was supposed to be placed on a piece of luggage that weighs between 45 to 100 pounds, however no accurate weight was placed on the tag or the luggage. Throughout this study, several factors were identified that contribute to the occurance of back injuries for the ESEs.

Conclusions

After completing this study, several contributing factors were identified.

1. After performing the loss tab analysis as well as analyzing worker compensation costs and accident reports, lifting was identified the number one cause of back injuries for the ESEs. One hundred ninety-four cases were reported in one year to involve listing lifting as the cause of the injury. That same year, the cost of workers' compensation for ESEs for injuries to the back was at $237, 731.75. Lower back injuries accounted for $180,554.88 out of the $237, 731.75. The accident reports for the same year as the loss tab analysis came up with the same conclusion that lifting was the major cause of back injuries. A review of the accident reports indicated a prevalence of the use of "heavy bag" as a contributing factor to the injury.

2. Observations were conducted on the ESEs during one morning. The daily job duties of the ESEs were noted and the researcher concluded that poor lifting techniques were used. Many of the ESEs would grab too many bags at once or lift a package that was too heavy for one individual. The lifting techniques used throughout the morning was a style in which the employee kept the legs straight and the back bent over. Within the Safety Manual for the ESEs it is highly recommended that the employee perform a leg lift technique instead of the style being practiced during this observation.

3. Observations were conducted on the CSAs during one morning to analyze how pieces of luggage were being weighed. Very rarely did an employee take an accurate weight.

Even if accurate weight readings were taken, the “heavy bag” labels do not provide an area to indicate the weight. The labels are a generic way of identifying that a bag is between 45 to 100 pounds.

Recommendations

One of the primary recommendations of this study is to improve the operation of checking in luggage at the ticket counter. Having the CSA taking an accurate weight and providing that information to the ESE will be very beneficial for the luggage handlers. This knowledge of how much a particular piece of luggage can let the ESE know if they are able to lift this package without assistance. If the CSAs feel that taking accurate weight is too much time, incorporate a computer software program to identify the weight of the luggage to show on the destination label. ESEs need to read the destination label to determine where the luggage is going to so by adding the weight to this label in bold print may be easily recognized.

Another benefit of taking accurate weights would be to increase revenue. If one piece of luggage weighs over 75 pounds, CSAs should be charging the customer additional fees. Without taking an accurate weight, customers are not being charged and thus the company could possibility be losing money.

The system of “heavy bag” labels needs improvement. One label represents a range of 45 to 100 pounds per package. This 55- pound range is quite large. A suggestion to reduce this broad range is to implement a color coded label system. For instance, an orange label represents 45-55 pounds per package, then the next color identifies luggage to have a weight between 55-65 pounds, and so forth.

Another recommendation for possible reduction of back injuries is to promote a stretching program for the ESEs. This stretching program would consist of performing different back stretches before and after loading and unloading an aircraft. Stretching the muscles of the back may lengthen the muscles and provide resistance to injury.

The implementation of a manipulator device to eliminate the reaching and lifting activities the ESEs perform daily is also recommended. The ESE can operate the manipulator to perform the reaching into the cart, lifting the luggage, and placing the package onto the conveyor and vice versa when unloading the plane. This device may greatly reduce back injuries for the ESEs.

A future project for Company XYZ would be to investigate the development of luggage carts that are equipped with conveyor- type bottoms. The conveyor belt would bring the luggage out of the cart to avoid employees from reaching into the cart. This process of adding a conveyor bottom system within the carts may reduce the injuries caused by reaching.

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Appendix 1

Frequency Multiplier Table (FM)

Frequency	Work Duration

Lifts/Mins	<or= 8hrs V < 75	V >or= 75	< or = 2 Hrs V < 75	V > or = 75	< or = 1Hr V> 75	V> or = 75
0.2	0.85	0.85	0.95	0.95	1	1
0.5	0.81	0.81	0.92	0.92	0.97	0.97
1	0.75	0.75	0.88	0.88	0.94	0.94
2	0.65	0.65	0.84	0.84	0.91	0.91
3	0.55	0.55	0.79	0.79	0.88	0.88
4	0.45	0.45	0.72	0.72	0.84	0.84
5	0.35	0.35	0.6	0.6	0.8	0.8
6	0.27	0.27	0.5	0.5	0.75	0.75
7	0.22	0.22	0.42	0.42	0.7	0.7
8	0.18	0.18	0.35	0.35	0.6	0.6
9	0	0.15	0.3	0.3	0.52	0.52
10	0	0.13	0.26	0.26	0.45	0.45
11	0	0	0	0.23	0.41	0.41
12	0	0	0	0.21	0.37	0.37
13	0	0	0	0	0	0.34
14	0	0	0	0	0	0.31
15	0	0	0	0	0	0.28
>15	0	0	0	0	0	0

Values of V are in centimeters

Appendix 2

Hand to Container Coupling Classification

Good

1) For containers of optimal design, such as some boxes, crates, etc., a "Good" hand- to-objec
2) t coupling would be defined as handles or hand-hold cut-outs of optimal design (see notes 1 to 3 below)

2) For loose parts or irregular objects, which are not usually containerized, such as castings, stock, supply materials, etc., a "Good" hand-to-object coupling would be defined as a comfortable grip in which the hand can be easily wrapped around the object

Fair

1) For containers of optimal design, a "Fair" hand -to-object coupling would be defined as handles or hand -hold cut-outs of less than optimal design (see notes 1 to 4 below).

2) For containers of optimal design with no handles or hand-hold cuts-outs or for loose parts or irregular objects, a "Fair" hand-to-object coupling is defined as a grip in which the hand can be flexed about 90 degrees (see note 4 below).

Poor

1) Containers of less than optimal design with no handles or hand-hold cut-outs or loose Parts or irregular objects that are bulky or hard to handle (see note 5 below)

1. An optimal handle design has 1.9 to 3.8 centimeters (.75-1.5 inches) diameter, ≥ 11.5 centimeters (4.5 inches) length, 5 centimeters (2 inches) clearance, cylindrical shape, and a smooth, non-slip surface.

2. An optimal hand-hold cut-out has ≥ 3.8 centimeters (3 inches) height, 11.5 centimeters (4.5 inches) length, semi-oval shape, ≥ 5 centimeters (2 inches) clearance, smooth non-slip surface, and ≥ 1.1 centimeters (0.43 inches) container thickness.

3. An optimal container design has ≤ 40 centimeters (16 inches) frontal length, ≤ 30 centimeters (12 inches) height, and a smooth non-slip surface.

4. A worker should be capable of clamping the fingers at nearly 90 degrees under the container, such as required when lifting a cardboard box from the floor.

5. A less than optimal container has a frontal length ≥ 40 centimeters (16 inches), height ≥ 30 centimeters (12 inches), rough or slippery surface, sharp edges, asymmetric center of mass, unstable contents, or require gloves.

Couplings	V < 75 cm (30 in)	V > or = 75 cm (30 in)
	CMs	
Good	1	1
Fair	0.95	1
Poor	0.9	0.9

Appendix 3

Heavy Bag Label

HEAVY **Get Help To Lift**	**HEAVY** **Get Help To Lift**	**HEAVY** **Get Help To Lift**

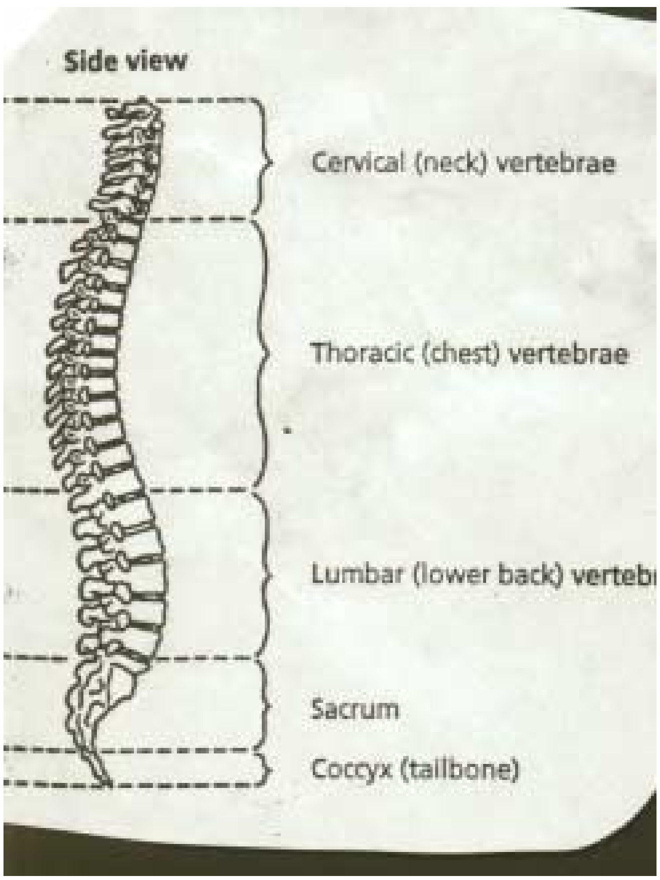

Figure 1 (Hay and Reid, 1982)

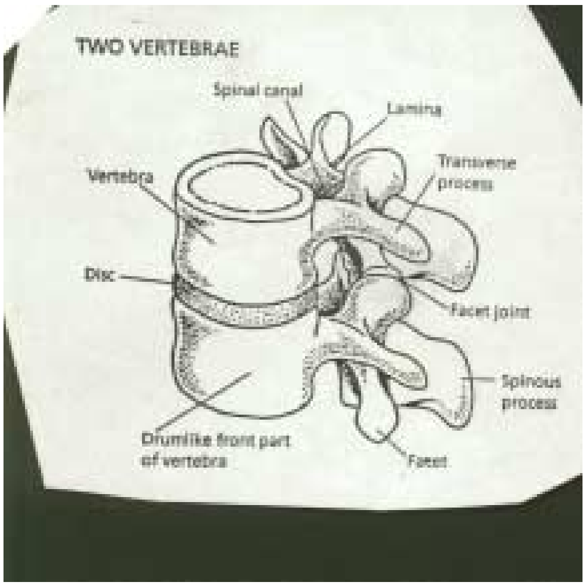

Figure 2 (American Medical Association, 1995)

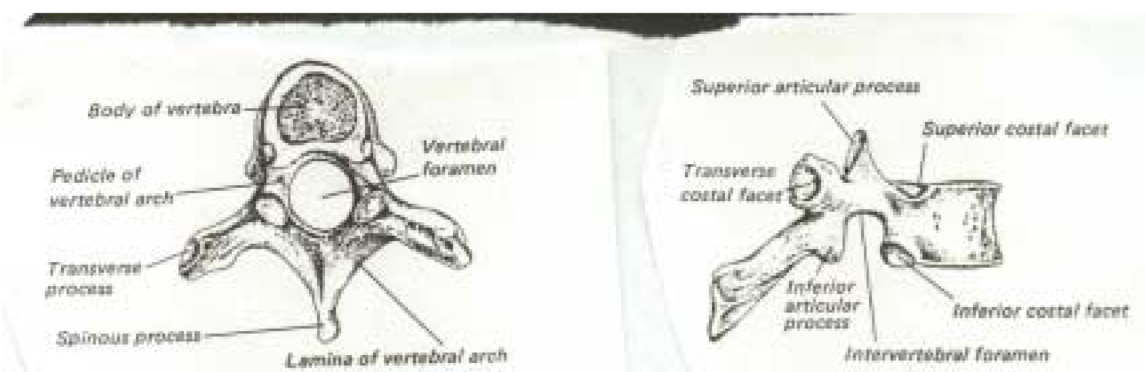

Figure 3(Hay and Reid, 1982)

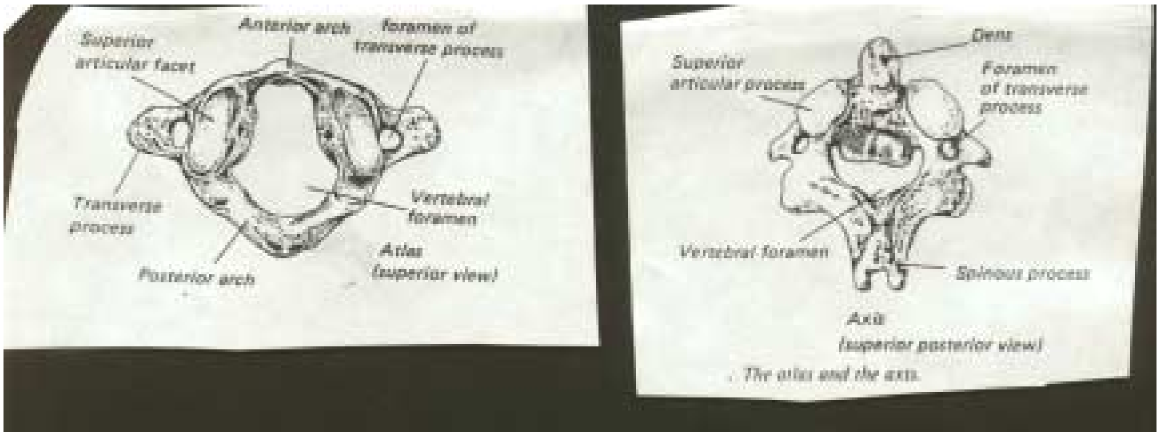

Figure 4 (Hay and Reid, 1982)

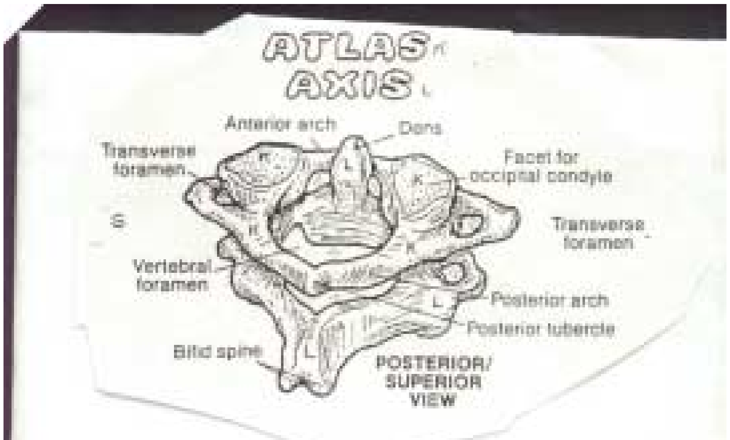

Figure 5 (Kapit and Elson, 1993)

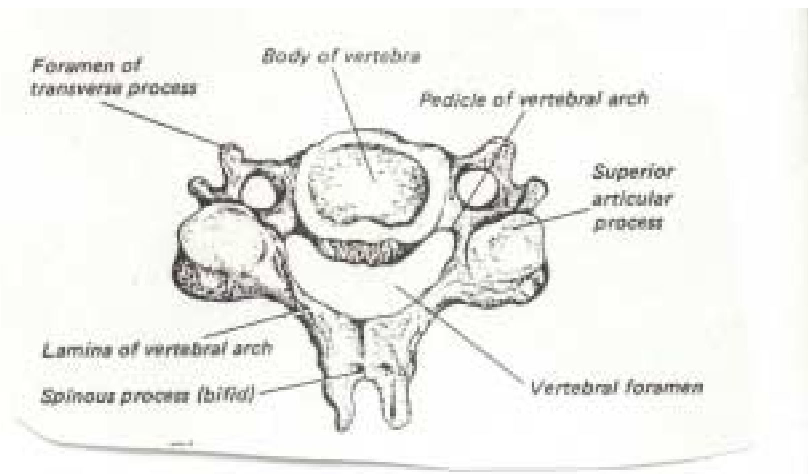

Figure 6 (Hay and Reid, 1982)

Figure 7 (Kapit and Elson, 1993)

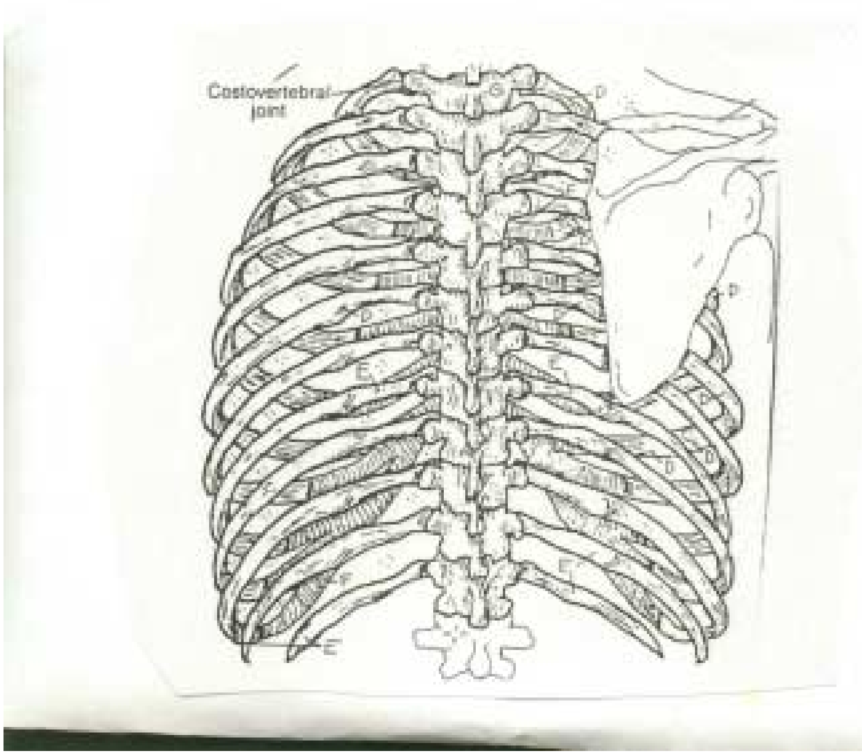

Figure 8 (Kapit and Elson, 1993)

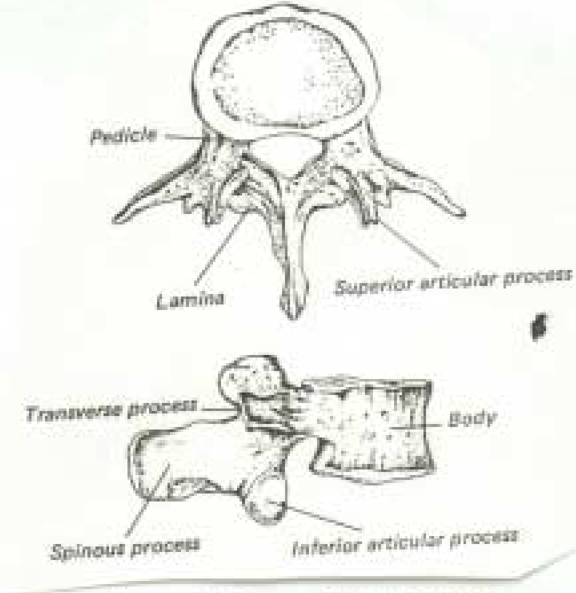

Figure 9 (Hay and Reid, 1982)

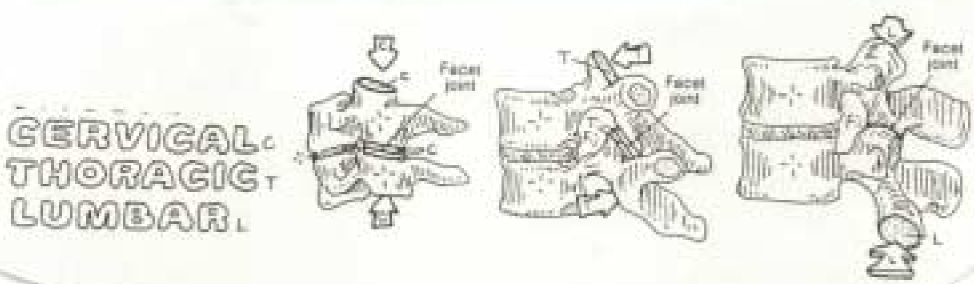

Figure 10 (Kapit and Elson, 1993)

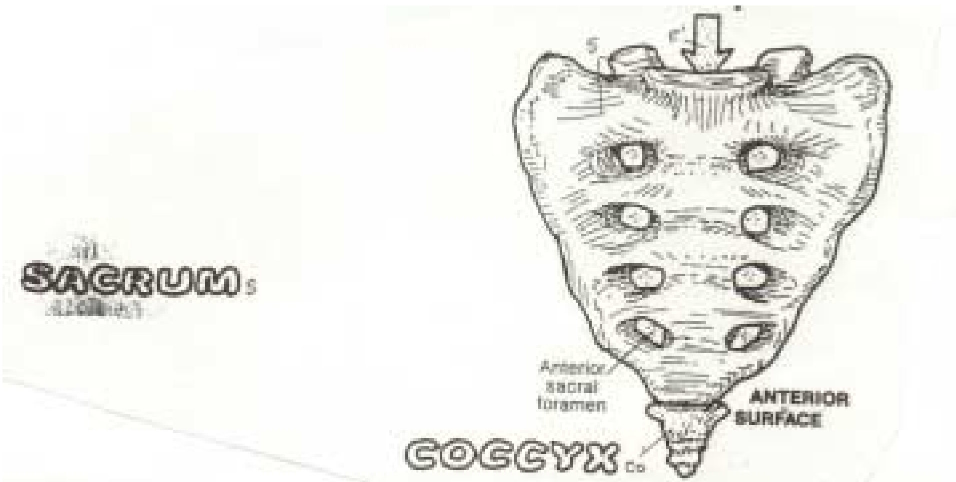

Figure 11 (Kapit and Elson, 1993)

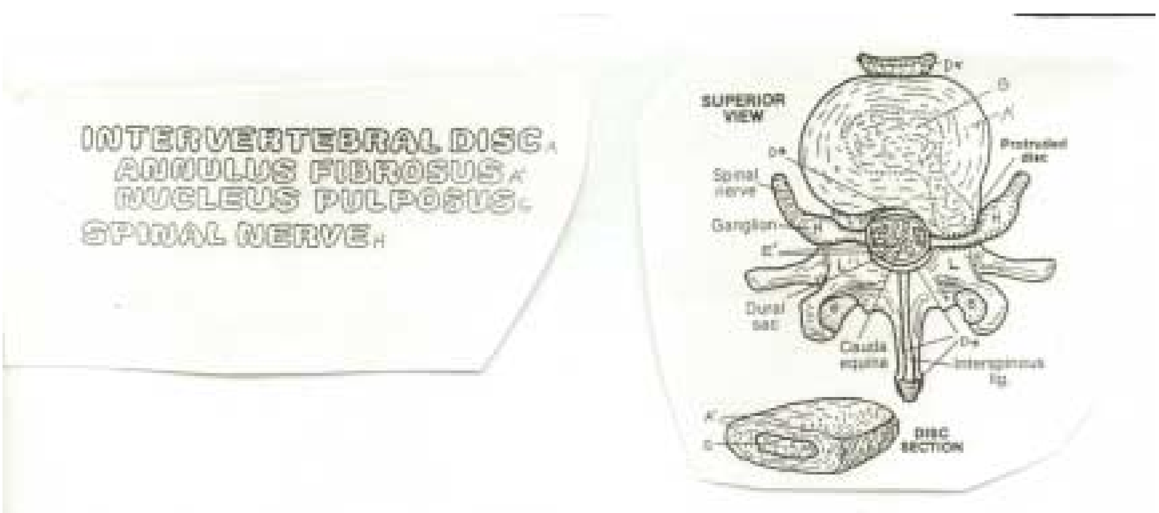

Figure 12 (Kapit and Elson, 1993)

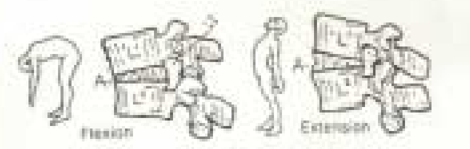

Figure 13 (Kapit and Elson, 1993)

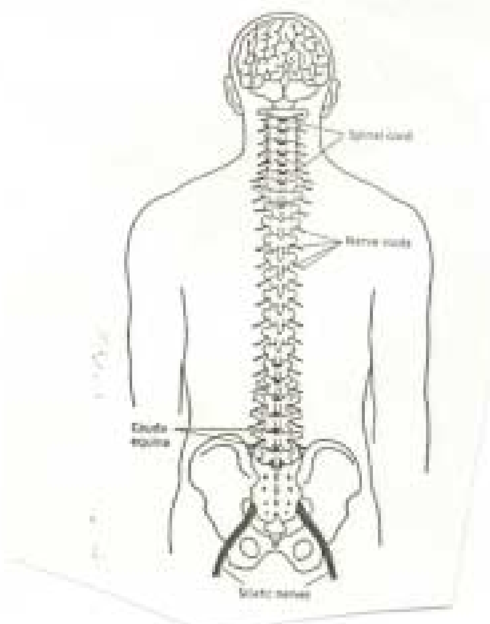

Figure 14 (American Medical Association, 1995)

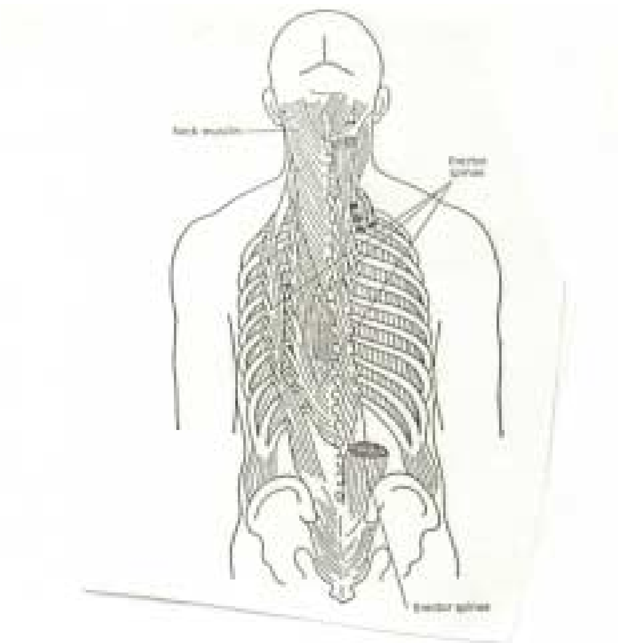

Figure 15 (American Medical Association, 1995

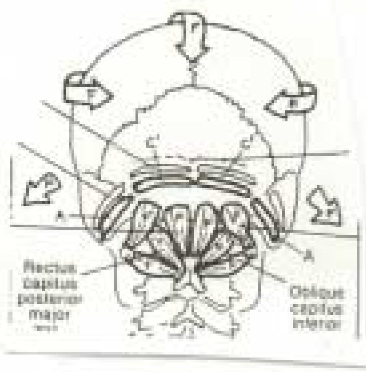

Figure 16 (Kapit and Elson, 1993)