An ergonomic assessment of the airline baggage handler

Stephen P. Salomon
New Jersey Institute of Technology

ABSTRACT

AN ERGONOMIC ASSESSMENT
OF THE AIRLINE BAGGAGE HANDLER

by

Stephen P. Salomon

A material or baggage handler is responsible for loading and unloading baggage and materials from inbound/outbound aircraft flights and transferring the materials to and from the baggage holding and sorting areas and back to the passengers or output source. Baggage handlers work in all types of inclement weather, all over the airport, and in-and-around the aircraft. The baggage handler's job entails repeated lifting pulling, pushing, squatting, twisting, kneeling, and stretching of the arms and back, which makes the baggage handler's job one of the more challenging material handling jobs to ergonomically assess and make corrections for. The aim of the present study is to evaluate the current literature available pertaining to baggage handlers and ergonomics, as well as examine all aspects of the baggage handlers' job in an effort to develop ergonomic solutions.

This thesis is based on the literature review of a core set of articles that thoroughly cover the major aspects of the baggage handlers' job, work environment, and ergonomic afflictions pertinent to the baggage handlers using ergonomic evaluation techniques. It was shown that typical solutions to ergonomic problems of baggage handlers, such as wearing back support belts, are not conclusively effective in reducing the back injury rate amongst airline baggage handlers. The redesign of workstations and aircraft holds, although thought to be the most effective idea due to success where

already applied, was not the most practical or readily available solution financially. The future of ergonomic advancements in the field of airline material handling will rely on future research. Such a research will need to develop a benefit analysis to quantify the dollars spent on back-related injuries against the cost of remodeling aircrafts and workstations.

AN ERGONOMIC ASSESSMENT OF THE AIRLINE BAGGAGE HANDLER

by

Stephen P. Salomon

A Thesis
Submitted to the Faculty of
New Jersey Institute of Technology
In Partial Fulfillment of the Requirements for the Degree of
Master of Science in Occupational Safety and Health Engineering

Department of Industrial Engineering

May 2004

Blank Page

APPROVAL PAGE

AN ERGONOMIC ASSESSMENT OF THE AIRLINE BAGGAGE HANDLER

by

Stephen P. Salomon

Dr. One-Jang Jeng, Thesis Advisor — Date
Research Associate Professor,
Department of Industrial and Manufacturing Engineering, NJIT

Dr. Arijit Sengupta, Committee Member — Date
Associate Professor, Department of Engineering Technology, NJIT

Dr. Norman Van Houten, Committee Member — Date
Director of Health and Environmental Safety, NJIT

BIOGRAPHICAL SKETCH

Author: Stephen P. Salomon

Degree: Master of Science

Date: August 2004

Undergraduate and Graduate Education:

- Master of Science in Occupational Safety and Health Engineering
  New Jersey Institute of Technology, Newark, NJ, 2004

- Bachelor of Science in Engineering Sciences, Biomedical Engineering
  New Jersey Institute of Technology, Newark, NJ, 2002

Major: Occupational Safety and Health Engineering

To my grandmother, Amelie Romain

To my mother, Annemarie Irving

ACKNOWLEDGMENT

I would like to express my sincere gratitude to Dr. One J. Jeng, the professor and research advisor who has inspired me to imagine, learn, and create by providing me with constant supervision and guidance, many suggestions, new ideas, encouragement, and support toward the completion of this work and in life.

My gratitude is extended to Dr. Arijit Sengupta, for all of his time and effort, and Dr. Norman Van Houten, for serving as members of my thesis committee to guide, comment on, and suggest my future work.

It is a high pleasure to express my gratitude to my family, my mom, dad, all my bothers, my friends, and especially Geraldine Gomez, whose support and patience I really appreciated. Lastly, I would like to thank Mrs. Clarisa Gonzalez, and Jason Barrett for their dedication and guidance through this process.

TABLE OF CONTENTS

TABLE OF CONTENTS
(Continued)

Chapter **Page**

TABLE OF CONTENTS
(Continued)

CHAPTER 1

INTRODUCTION

1.1 Baggage Handling

Baggage handling is a very physically demanding task. Like other professions that require intense physical labor, baggage handlers are required to lift and handle heavy bags and materials. Unlike some of the other material handling jobs baggage handlers have to work in rotating workstations (i.e. baggage room, cargo hold, baggage sorting area with conveyor belts) and in various types of weather.

In addition to customer baggage, airline material handlers must deal with freight and postal materials as well. Baggage, freight and parcels come in all different sizes making it difficult to develop fully or semi automated systems that can handle the diverse workloads of the airline baggage handlers. It is this diversity in work environment as well as in the materials handled that makes the airline material handler's job unique.

The Baggage handler's job can also be extremely repetitive with recurring lifting, pulling, and reaching for bags, and materials. Handlers load and unload aircrafts, transports materials to and from aircraft to collection and storage areas, and work in confined quarters loading and unloading materials.

1.2 Background Information

1.2.1 Objective

The author was interested in studying the baggage handlers' job because a large part of the job requires heavy to moderate physical labor. Having seen baggage handlers at work, and having a good idea of what types of materials primarily handled, the author had a good understanding of what the baggage-handling job entailed. Other jobs that primarily focus on material handling and lifting deal in handling uniform type weights (i.e. boxes versus some types of baggage which can hold materials in loose structured shapes). Unlike other jobs that have a primary focus on material handling, the materials that the baggage handlers deal with are not typically uniform. The baggage handler deals mostly in commercial baggage and postal freight (mail bags). Commercial baggage is baggage of passengers that will be flying on the aircraft.

Handling passenger baggage is one of the things that make the baggage handler's job very different from other material handling type jobs. One major reason for this is because passenger baggage design is highly variable from one bag design/style to the other. Baggage comes in all different shapes, sizes and dimensions making it challenging for the handler to be able to get accustom to a general baggage type. Baggage handlers have to lift and handle odd size bags with centers of mass asymmetrical to the baggage, making it difficult to handle heavier bags, with awkward centers of mass, which lead to uneven weight distributions. Heavier bags with asymmetrical mass centers of distribution are more difficult to gage, thus making it more difficult to lift and manage the bags. This makes it difficult to develop a consistent lifting rhythm and technique adding to the difficulty of the job. Add in the time factor where in many cases during the morning and afternoon shifts baggage handlers have to make a timeline to keep flights going out on time, or in the case where flights have been delayed they must worked even faster to compensate for the lost time. For the baggage handlers this makes their job more difficult and thus more hazardous than the other manual lifting jobs.

1.2.2 Author's Preparation

Many times when passing through the airport one might see a baggage handler working and not think much outside of how fast, and how careful they are getting bags in and out the cargo bins of the plane. From the passenger perspective, outside of watching the baggage handlers load up the baggage cart on the sides of the aircraft, you do not see the full scope of the loading and unloading process. There is a team of baggage handlers inside and outside the cargo bins of the narrow-bodied aircrafts, who are working to unload it.

Establishing contact with a safety director of a major airline company made it possible to go to the airport as a non-costumer to be able to watch baggage handlers work in and outside the aircraft and the baggage make up room.

1.3 Exploring the Problems

1.3.1 Overview of Risks Associated with Manual Handling Tasks

The nature of the injuries arising from Manual Handling tasks are based primarily on the repetition of the tasks associated with the labor. Moreover, when lifting is involved the hazards can range from repetitive stress disorder to muscle injury. These injuries often occur to baggage handlers because:

- Handlers must adopt harmful postures in order to handle loads (Thomas et al., 1995);
- Handlers are expected to lift loads which are too heavy (Dell, 1997);
- Some baggage/luggage/objects are not designed for ease of handling (Dell, 1998);
- Some workplaces are poorly designed (baggage rooms, conveyors, cargo holds),

- Work systems are poorly designed, e.g. frequency and pace of handing tasks increase the risks (e.g. conveyor belt speeds, rates of upload and download of materials) (VI, et al. 1998)).

1.3.2 Working in Inclement Weather

A Baggage Handler's work is a strenuous job. There are many ergonomic hazards that baggage handlers have to deal with regularly as a part of their job. Baggage handlers work all year long in and outside the airport, across all seasons, and in all types of weather. The work area of a baggage handler rotates from the interior baggage room, baggage makeup room (inbound baggage area), to the aircraft, which awaits outdoors in the elements of nature.

Whether rain, snow, sleet, or hail, baggage handlers must tend to their duties of uploading and downloading aircrafts whenever flights are in-service. Baggage handlers are provided personal protective equipment (PPEs) to brave the rotating elements. Gloves, a heavy-lined parka and raincoat are company issued to the baggage handler to deal with excessive cold, wind, and precipitation while processing baggage. The process of transferring passenger bags and material handling is primarily a manual process. The baggage handler must do a good part of this process manually. When there is a shortage of handlers, other workers must make up for this shortage by working on flights longer and foregoing a break.

1.3.3 Working in Confined Quarters

One of the more difficult parts of performing the tasks of a baggage handler is working within small and or confined quarters. Confined spaces are very small workspaces or areas that employees have to carry out their duties in. Another important characteristic of a confined space is that the entry/access point is limited, in other words there is only one way in and out of the work area. The baggage handler must handle materials in areas that standing may not even be possible. Under conditions such as these, it is very difficult for these handlers to exercise a full range of motion thereby making it difficult to perform lifting tasks with proper postures.

Working inside narrow body aircrafts posses a high level of difficulty and risk for baggage handlers due to its short or cramped cargo area, which baggage handlers, in most cases where this process is not mechanized, must load manually. Loading and unloading narrow body aircraft requires baggage handlers to kneel inside the cargo bin for the purpose of storing bags along the back end and sides of the cargo bin. Baggage handlers are positioned at the front access point of the bin, and along the backside of it. The rest of the handlers are outside the aircraft feeding baggage along the baggage conveyor belt to the handlers inside the aircraft. The baggage sorting area can also be a workplace that carries a high risk of injury and confinement of posture due to the layout of the conveyor belts. If conveyor belts are placed too close or far together, on the horizontal or vertical planes, this can cause worker to bend over at angles that could pose a danger to the lumbar spine when lifting heavy loads (Thomas et al., 1995).

1.3.4 Repeated Reaching/Pulling/Lifting and its Effects

Historically, baggage handlers would have to move baggage and materials almost exclusively by hand. Hours of manpower would be needed to process the material handling for the flights. Workers would be broken up into groups, loading and unloading the aircrafts and transferring baggage and materials. During the course of a shift, baggage handlers would, repeatedly lift, push, reach, carry, and move several bags and materials during the handling process. Repetitive motion of the body's joints and limbs can cause stress and strain on body parts (Table 1.1). With technology some of this burden has been reduced with automated and semi-automated mechanisms.

The symbolism used in the table provided by National Institute of Occupational Safety and Health (NIOSH) and the Center for Disease Control (CDC) is explained by the plus (+), minus (-), and zero (O) nomenclature as explained below (Bernard, et al. 1997).

1.3.4.1 Strong Evidence of Work-Relatedness (+++). A causal relationship is shown to be very likely between intense or long duration exposure to the specific risk factor(s) and musculoskeletal disorder (MSD), when the epidemiologic criteria of causality are used. A positive relationship has been observed between exposure to the specific risk factor and MSD in studies in which chance, bias, and confounding factors could be ruled out with reasonable confidence in at least several studies.

1.3.4.2 Evidence of Work-Relatedness (++). Some convincing epidemiologic evidence shows a causal relationship when the epidemiologic criteria of causality for intense or long duration exposure to the specific risk factor(s) and MSD are used. A positive relationship has been observed between exposure to the specific risk factor and MSD in studies in which chance, bias, and confounding factors are not the likely explanation.

1.3.4.3 Insufficient Evidence of Work-Relatedness (+/0). The available studies are of insufficient number, quality, consistency, or statistical power to permit a conclusion regarding the presence or absence of a causal association. Some studies suggest a relationship to specific risk factors but chance, bias, or confounding may explain the association.

1.3.4.4 Evidence of No Effect of Work Factors (-). Adequate studies consistently show that the specific workplace risk factor(s) is not related to development of MSD (Bernard, 1997).

It follows that a positive relationship can be made with lifting baggage, for an extended amount of time, and prevailing back pain experienced after lifting. The baggage handler's job involves heavy and repetitive lifting, which can affect the posture, which in turn can result in MSD to the neck, shoulders and back.

Table 1.1 Evidence for Causal Relationship Between Physical Work Factors and MSDs

Body part *Risk factor*	**Strong evidence (+++)**	**Evidence (++)**	**Insufficient evidence (+/0)**	**Evidence of no effect (-)**
Neck and Neck/shoulder				
Repetition	...	++	...	...
Force	...	++	...	...
Posture	+++	...	...	...
Vibration	...	...	+/0	...
Shoulder				
Posture	...	++	...	...
Force	...	...	+/0	...
Repetition	...	++	...	...
Vibration	...	...	+/0	...
Elbow				
Repetition	...	...	+/0	...
Force	...	++	...	...
Posture	...	...	+/0	...
Combination	+++	...	...	...
Hand/wrist				
Carpal tunnel syndrome				
Repetition	...	++	...	...
Force	...	++	...	...
Posture	...	...	+/0	...
Vibration	...	++	...	...
Combination	+++	...	...	...
Tendinitis				
Repetition	...	++	...	...
Force	...	++	...	...
Posture	...	++	...	...
Combination	+++	...	...	...
Hand-arm vibration syndrome				
Vibration	+++	...	...	...
Back *Lifting/forceful movement*	+++	...	...	...
Awkward posture	...	++	...	...
Heavy physical work	...	++	...	...
Whole body vibration	+++	...	...	...
Static work posture	...	...	+/0	...

http://www.cdc.gov/niosh/ergosci1.html

CHAPTER 2

MOST COMMONLY INJURED BODY PARTS AND THEIR ANATOMY

2.1 Commonly Injured Body Segments

The most commonly injured and/or strained body parts due to manual material handling activity are the back, neck, shoulders, and the knees. These body parts are heavily used in the bending, reaching, pulling, twisting, squatting, and lifting necessary to perform many material-handling tasks. The following sections describe the anatomical detail and injury mechanisms of these body parts.

2.2 The Back

The most commonly injured body part suffered by people in the workforce is injury to the lower back. Back injury makes up 20% of all injuries that happen in the workplace, which makes up approximately 20 to 50 billion dollars in lost productivity and worker's compensation (Dell, 1997). Baggage handlers suffer from a high rate of back injury due to the heavy and repetitive lifting required by their job. The lower part of the back is more susceptible to back injury. The lower back or lumbar area is most heavily stressed because of the structure and the muscular arrangement of the lower back muscles. Figure 2.1 illustrates the major muscle groups in the back. When the forces are too large for the back muscles to support, the soft tissue and tendons in the back get injured.

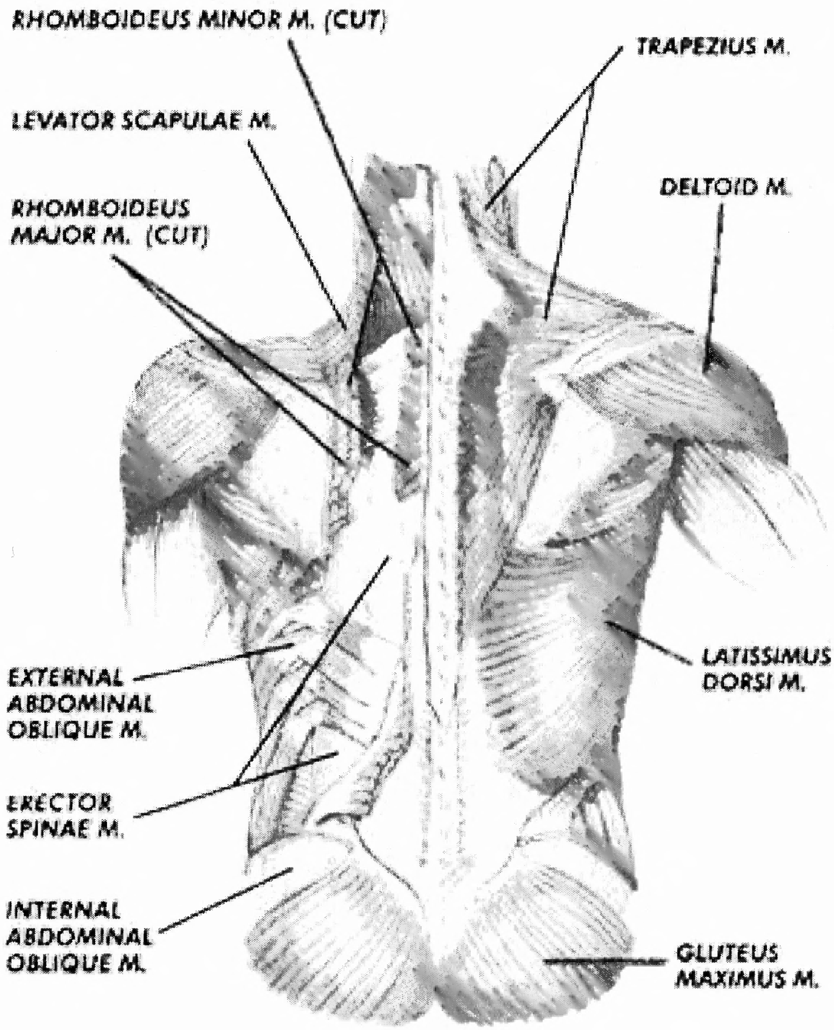

Figure 2.1 Principle muscle groups of the lower and upper back.

The "lower back" is most commonly described as the area from the thorax to the pelvis on the dorsal (back) aspect of the body. The important anatomic structures include lumbar vertebrae, facet joints, lower back muscles and ligaments, vertebral discs, spinal chord and nerves (Figure 2.2).

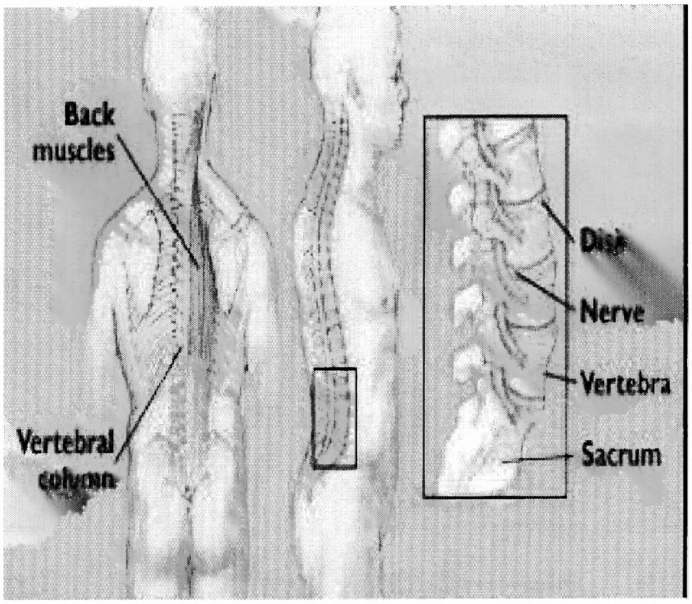

Figure 2.2 Anatomy of the lumbar bone structure.

The spine is made up of 33 vertebrae. Vertebrae are bony segments stacked on top of each other connecting the upper spine to the pelvis arranged in five sections. The cervical, thoracic, lumbar, sacral, and coccygeal make up those five sections. The lumbar segment contains five vertebrae, named sections L1 through L5, respectively. This is the origination site of most back pain. Ligaments, cartilage, and muscle work together to maintain the vertebrae in proper position. This system provides enormous strength and flexibility, helping to support body weight and maintain an upright position and balance. Also, this section of the back absorbs a large part of the lifting force that the body and back encounters during material handling.

Each vertebra consists of a thick cylindrical hollow-core bone from which three bony pieces protrude out. The bony structures join with those of the adjacent vertebrae at a point called a facet joint. When a section of the vertebrae is thrown out of alignment, the facet can press on nerve tissue causing pain and discomfort. Normally when the vertebrae are aligned, their centers form a canal, which the spinal cord and nerves pass through connecting the cord to the body's network of nerves.

Ligaments and muscles help form the connection of the vertebrae. This system provides strength and stability while also allowing a range of flexibility. Strains (muscle) or sprains (ligaments) of these structures within the system are a common source of low back pain.

The lower back contains six vertebral discs that protect the lumbar vertebrae, while also serving as cushioning shock absorbers and stabilizers. The vertebral disk is made up of the nucleus pulposis, a soft jelly-like center, and the fibrous annularis, a tough fibrous outer portion of surrounding the nucleus. As the discs become worn form movement and activity, i.e. material handling such as baggage handling, discs may degenerate under stress or as a result of the normal aging process. Vertebral fractures or pressure from protruding disks at the point where nerves pass through spinal openings can impinge or pinch the nerves, causing damage and pain. Figure 2.3 provides a schematic illustration of the spinal nerve pinching by herniated disk.

The spinal cord passes through the vertebrae canal allowing for transmission of electrical signals from the brain to the skeletal muscles of the body. Spinal nerves flow through the spinal foramen between each set of vertebral bodies. If the spinal cord, nerves or vertebral housing is damaged from some type of trauma, or overuse through excess material handling, compression and or impingement of the spinal nerves may potentially result causing pain, numbness, or loss of function of the body parts, which it innervates.

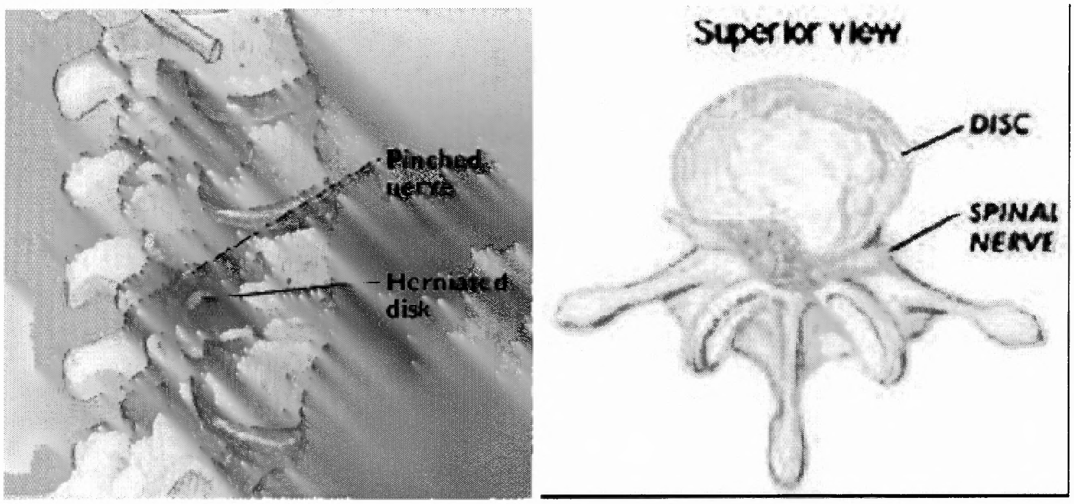

Figure 2.3 Herniated disk and pinched spinal nerve.

2.2.1 Common Causes of Low Back Pain

The lower back contains a team of muscles and ligaments allowing strength and stability for walking, lifting, standing, bending, etc. A strain is injury to the muscle. When it comes to the back, a sprain is typically an injury to the lower back musculature, which is often caused when a muscle is overworked, overstretched, or used in a poorly conditioned state. As a result pain most commonly occurs during activity. This condition is usually worsened with back flexion and prolonged standing, as the pain from sprain might not immediately occur. As a natural response to the injury and subsequent discomfort from back sprain, the affected area's muscles spasm or stiffen as the body attempts to immobilize the painful area to prevent it from further damage.

A sprain is an injury to the ligaments. These injuries commonly occur when a sudden or forceful movement damages a ligament. Once damaged or injured the ligament may become stiff or weak. Injury may have resulted from overuse due to excessive or repetitious motion generally associated with material handling. Lumbosacral sprains and strains are the most common causes of lower back pain, of which obesity, poor conditioning, and improper biomechanics and lifting are the most frequent causes of lumbar injury. Although injury to the lower back cannot be completely eliminated, it can be slowed by regular exercise, and proper lifting techniques.

Degenerative disk disease occurs when changes associated with breakdown occur in the disks. Between each vertebral body, vertebral disks are housed. These vertebral discs act as shock absorbers, cushioning the lumbar area from loads encountered through activity and daily work. The vertebral disk is made up of the nucleus pulposis, a soft jelly-like center, and the fibrous annularis, a tough outer shell surrounding the nucleus. Through the normal process of aging, the nucleus begins to harden which that weakens the disc potentially causing material from the disk to push out or rupture. The bulging of disks is common and often times painless. However, the bulging of a disk, referred to as a herniated disk, becomes painful when excessive bulging or fragments of the disc protrude and place pressure on nearby nerves (Figure 2.3).

2.3 The Neck

Neck and shoulder injuries are common to material handlers. The neck muscles can become stiff and tight from repetitive motion and excessive use. As a result, pain can develop causing the body to inhibit the flexibility of the neck area and surrounding muscles. The side and back muscles of the neck are most susceptible to stiffening if overused during a particular task, and over long durations. Tasks most associated with this problem are viewing a computer monitor leading to muscle fatigue due to static contraction of the neck muscles in the attempt to hold the head in place for long periods of time, or from viewing products over a long period of time on an assembly or production line, i.e. constant rotation of the neck and repetitive muscle contraction (looking back and forth), leading to neck and shoulder muscle strain and stiffness.

In a survey done by baggage handlers and safety professionals the neck and shoulders were ranked as a body part highly susceptible to injury and discomfort (Dell, 1997). The task that baggage handlers perform that can be most associated with neck pain is working on the conveyor belt loading and unloading baggage. As bags flow on the conveyor belt the baggage handler must constantly rotate his/her neck and torso from the conveyor belt to the storage area/carrousel, selectively picking up bags.

A network of neck muscles (Figure 2.4), primarily the Sterno-Cleido-Mastoideus and the Trapezium muscles, allows head to maintain an upright posture as well as rotate and flex in all directions. The trapezium muscle is usually the one most affected when the subject has a soar a stiff neck due to some type of activity.

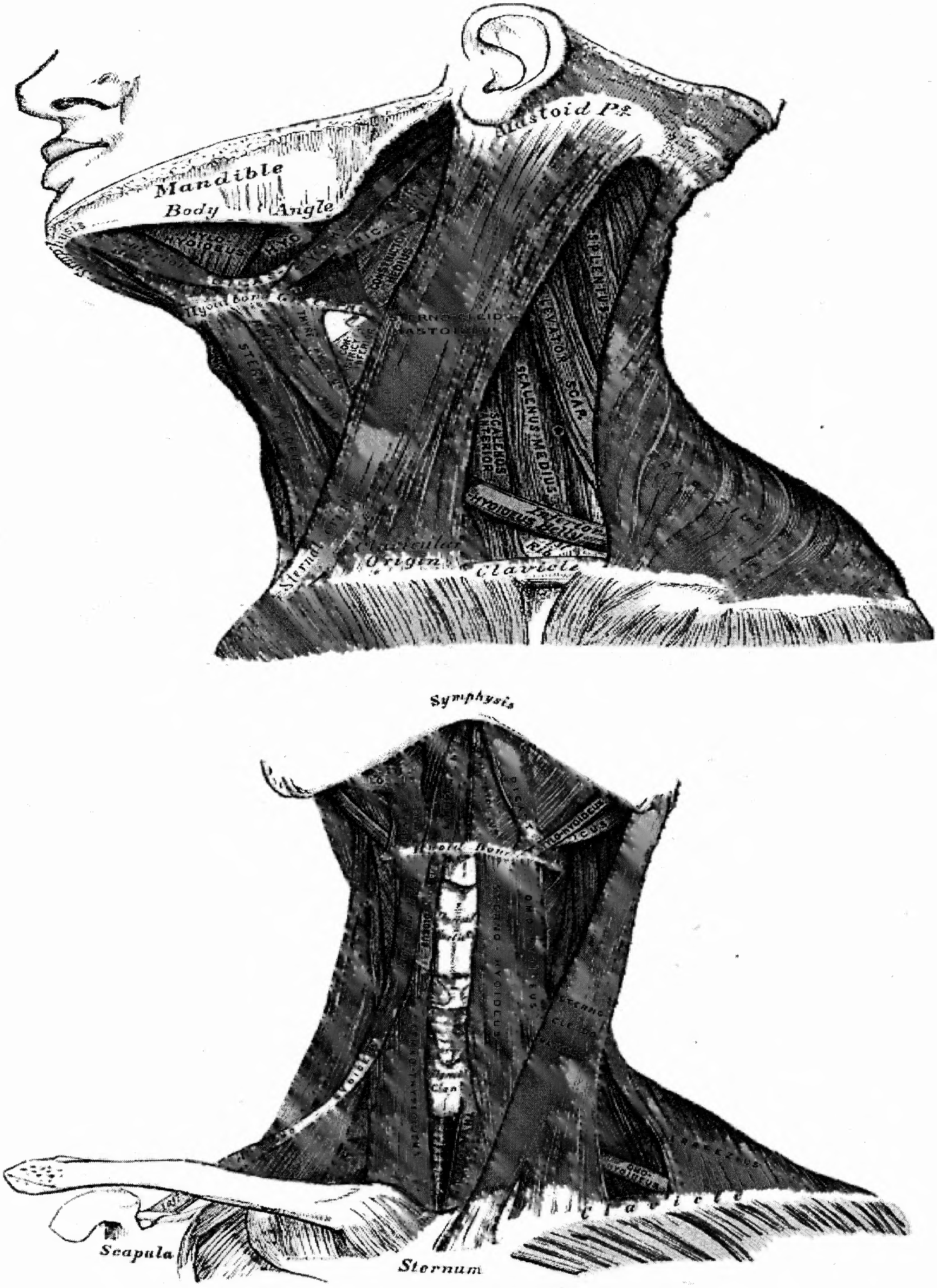

Figure 2.4 Musculature of the Lateral and Anterior Neck.

2.4 Shoulders

Common injuries of the shoulders due to excessive use are when the shoulder subluxates, or dislocation, which is when the ball joint of the shoulder partially or completely, comes out of the socket. Another injury most common to the shoulder is shoulder instability, which happens as a result of damage to the shoulder's ligaments. Ligaments can become damaged from any type of traumatic injury such as a violent hit to the shoulder or a jolt caused from trying to lift something excessively heavy. Ligaments can also become stretched from excessive or repeated strenuous use.

The shoulders, arms, and back are used a lot for repetitive lifting and material handling. The baggage handler often uses his shoulders to lift, pull, and reach for baggage and materials while loading and uploading aircraft. Studies on baggage handlers revealed that baggage handlers who work with two-tier baggage conveyor belts system are more susceptible to shoulder injury. The reason why is because the chances for shoulder injury or ligament aggravation increases as the height of the shelf or top tie conveyor belt increases. If the handler has to raise the weight/bag above his shoulder level this could cause ligament and shoulder injury.

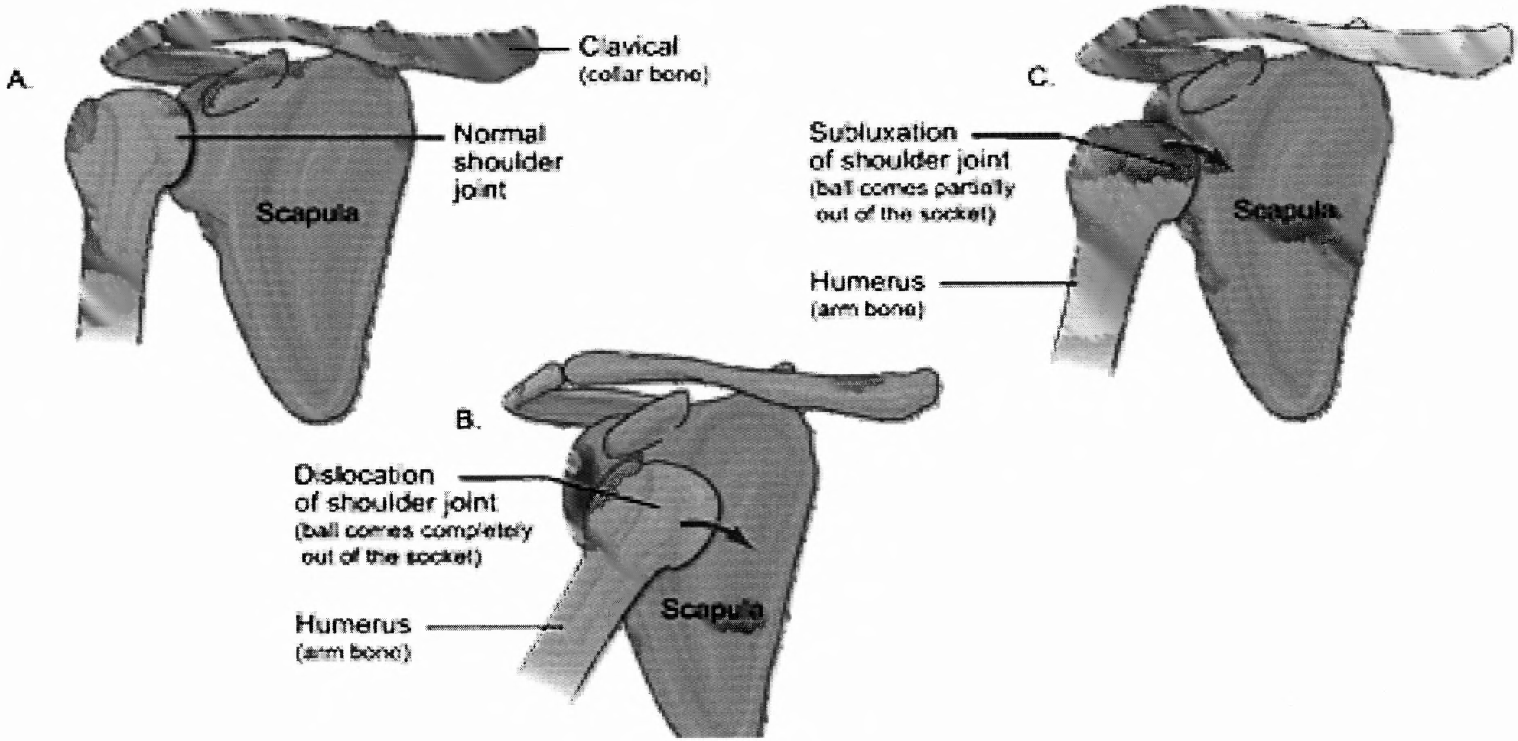

Figure 2.5 Anatomy of the Shoulder Bones. Examples of) Normal (A), Subluxation (B) and Dislocation (C) shoulder injuries.

2.5 The Knees

Baggage handlers spend a lot of time working in cramped or confined spaces. Whether working in cramped baggage rooms with baggage conveyor belts positioned very close to the other, or in the cargo hold of a narrow body aircraft, the baggage handler must adapt and compromise their posture to carry out their lifting tasks. From an ergonomic standpoint, the most compromising position that many baggage handlers must work through is working on their knees inside the narrow body of an aircraft, which was noticed by the author during his walkthroughs of the ramp area and inspection of the workplace and workers. Working on the knees for extended periods of time can cause discomfort to the body as well as the knees, which overtime may lead to musculoskeletal problems. Some of these problems associated with overuse and excessive kneeling, squatting and lifting are injury to the knee meniscus, and injury to the patella or kneecap, which may lead to arthritis, dislocation and inflammation of the tendon.

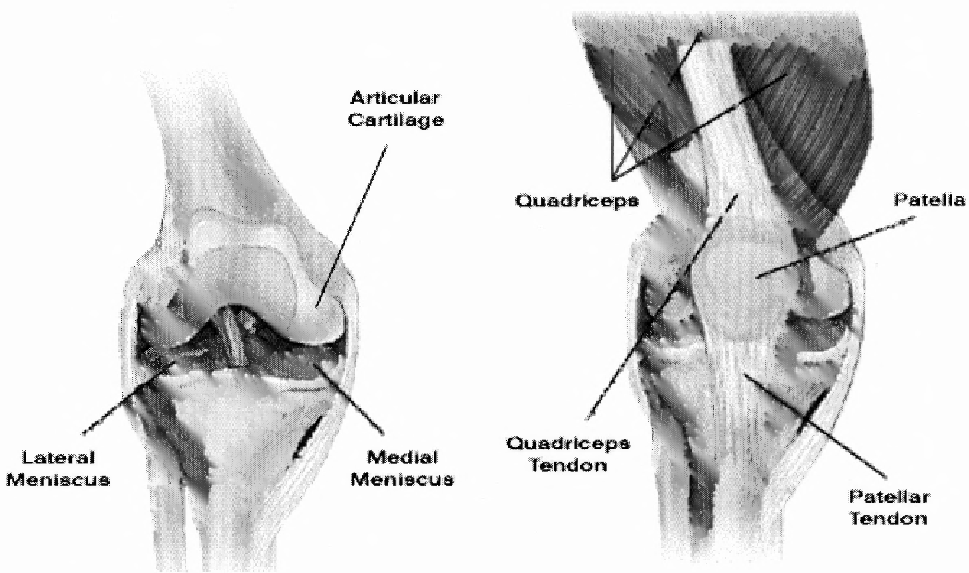

Figure 2.6 Anatomy of the knee.

CHAPTER 3

LITERATURE REVIEWS

3.1 Summation of Core Articles

A literature search for ergonomic research and scientific reviews on baggage handlers was performed. To the author's surprise, there were not many journal articles available that focused on baggage handlers and the ergonomic aspects of this work group. Literature review revealed that most articles referred back to a few articles written by Geoff Dell (Dell, 1997, 1998a, 1998b) in the late 90's. Dell wrote two main articles, which served as the basis for the many subsequent articles on baggage handlers, and ergonomics, all of which referenced Dell. These two articles are "*The Causes and Prevention of Baggage Handler Back Injuries*: *A Survey of Airline Safety Professionals Airline Baggage Handler Back Injuries Vol1;* and *"Airline Baggage Handler Back Injuries: A Survey of Baggage Handlers Opinion on Causes and Prevention Vol2."* Other articles that focused on the baggage conveyor systems were, "*Postural strain and discomfort during loading and unloading flights: an Ergonomic Intervention study, and Baggage handling postures and the design of conveyors"* by Thomas et al. (1995). I also reviewed investigations pertaining to baggage handlers and the use of back supports belts of which were: "*An evaluation of a weightlifting belt and back injury prevention training class for airline baggage handlers"* by Reddell *et al.* (1992)*, and "Effects of industrial back supports on physiological demand, lifting style and perceived exertion"* by Jorgensen et al. (1987). Furthermore, a few more articles that were non-specific to baggage handlers that focused on back belts, lifting postures and applied lifting forces in various body positions, with and without the knowledge of the center of mass, were reviewed.

3.2 Review of Dell's Survey of Safety Professionals

Dell (1997) states that "the most common type of injury suffered by people at work are back injuries". Labor-intensive jobs that involve material handling and repetitive lifting are high in cases of muscle and joint pains. The Baggage handling job is intense with repetitious lifting, pulling, pushing, bending, and stretching of the body and its various parts. Over time this could be extremely taxing on the body causing various breakdowns and deterioration of muscles, bones, and joints. Out of these highlighted body segments the back is a body region especially susceptible to injuries caused by lifting. 20% of all injuries and illnesses in the workplace of the US were back injuries, costing companies over 20 billion dollars (NIOSH, 1994). Moreover, back injury expenses of baggage handlers totaled an average of twenty one million dollars per annum collectively for 15 airlines and a ground handling company in 1992 through 1994 (Dell, 1997).

Historically, one of the first groups to track the rate of back injuries to baggage handlers was the International Air Transport Executive of the National Safety Council of America (ARTEX). ARTEX highlighted a case where 340 baggage handlers across 10 different airlines were involved in some type of injury related to material and baggage handling. This study attributed 85% of those injuries to the baggage handlers were caused by working the narrow-bodied flights (Dell, 1997). Since the 80's there has been an effort to focus on back injury and material handling (Dell, 1997). In one of the earlier studies, conducted by ARTEX (ARTEX, 1981) of 10 airline companies, found that 340 baggage handlers incurred back injuries in 1977. Eighty five percent of those injuries loading and unloading of narrow-bodied aircraft. In more recent study by Dell (Dell, 1997) of safety professionals found that the loading and unloading of narrow body aircraft was the top cause of back injuries to baggage handlers.

3.2.1 Methodology Used to Render Surveys

Dell created two surveys which summaries the opinions of safety professionals and baggage handlers from 15 different airlines and two ground handling companies on the subject of back injury. The surveys are broken up into two volumes, one which focuses on the safety professionals and their reasoning on the causes and prevention of baggage handler back injuries, and the other, which does so from the baggage handlers' perspective.

The first study featured a survey, which polled Safety Professionals from 15 airlines and ground handling company. The focus of this survey was to identify the cost of back injury to the baggage handler and to identify the rates at which baggage handler back injury happens. Engineering controls such as re-design of some airport terminal facilities, baggage handling systems and compartment, and aircraft layout were discussed.

The survey questions were divided into two parts. Part A focused on quantifying the back injury problem from a cost and magnitude perspective. Part B focused on the causes of baggage handler back injury and the preventative measures employed by the airlines in the attempt to circumvent it. The safety professionals were asked:

- The number of baggage handlers employed per annum
- The average number of hours worked per week per baggage handlers
- The number of lost time back injuries per annum

- The annual cost of those injuries
- Whether baggage handlers in their organization were required to lift baggage and cargo exceeding 32kg (70lb) weight? 32Kg is a pre-existing notional industry limit on passenger baggage weight.
- What back injury control measures had been applied in their companies? In particular, information was sought on use of back support belts, back care training, use of ground equipment, use of narrow body aircraft in-plane baggage stacking systems and details of any attempts at building redesign to reduce the instance of baggage handler manual handling injuries.
- What measure did they believe would be necessary in future to reduce the instance of back injuries to baggage handlers?

In the attempt to lower the subjectiveness of the magnitude of the back injury problems in the questionnaire Dell had instructed the safety professionals to list their responses pertaining to the years, 1992 to 1994.

3.2.2 Results of Safety Professional's Survey

The average hours worked per person per week remained consistent from 1992 to 1994 with 38.3 hours. The number of baggage handlers that worked in the same time period fluctuated however from 19,430 in 1992 to 30,257 in 1993 and back down to 29099 in 1994. The cost of back injury for the aforementioned airlines rose from 1992 to 1993 from $17,639,857 to $23,697,170 and declined to 21,710,953 in 1994 as their workforce decline.

Table 3.1 The Frequency and Cost of Back Injury Among Airline Baggage Handlers

Year	1992	1993	1994
Number of baggage handlers	19430	30257	29099
Average hours worked/person/week	38.0	38.4	38.4
Number of lost time back injuries	1570	2408	2405
Annual cost ($US)	$17,639,857	23,697,170	21,710,953
Lost time injury frequency (per 10^6 hours worked)	42.5	41.5	43.5
Average cost per back injury ($US)	$11,236	$9841	$9027

Source: Dell, 1997

Table 3.2 Perceptions of Safety Professionals about Workplaces Most Likely to Cause Injury

	n=16
Baggage check-in	1
Baggage make-up room	2
Inside narrow body aircraft bulk hold	10
Inside wide body aircraft bulk hold	0
Outside aircraft on the tarmac	3

Source: Dell 1997 n=16 safety professionals.

When the safety professionals were surveyed about which manual handling locations were the most likely to cause injury, the overwhelming majority identified that to be the inside of a narrow body aircraft bulk hold; a 10 out of 16 votes from the safety professionals surveyed. The place thought to be the least likely was the inside of a wide body aircraft bulk hold, which none, of the 16 respondents selected as their choice. The next most likely workplace to cause injury was outside aircraft on the tarmac, which registered three responses.

Table 3.3 Baggage Handling Task Most Likely to Cause Injury

	n=80
Lifting baggage on or off scales at check-in	2
Loading baggage onto trailers in the baggage make-up room	8
Loading containers in the baggage room	6
Unloading baggage trailers in the baggage room	3
Unloading containers in the baggage room	1
Pushing and pulling loaded baggage trailers, containers and pallet dollies	7
Transferring baggage from a trailer to mobile belt positioned at the aircraft	2
Transferring baggage from a trailer directly into an aircraft through the cargo door	11
Pushing baggage from the doorway into the baggage compartment of narrow body aircraft	1
Stacking baggage inside the baggage compartment of narrow body aircraft	14
Pushing and pulling containers and pallets inside wide body aircraft	9
Stacking baggage in the bulk hold of wide body aircraft	6

Source: Dell 1997 n=80 Baggage Handlers

When the safety professionals were polled about the manual handling tasks most likely to cause injury, the majority response was stacking baggage inside the baggage compartment of a narrow body aircraft with 14 responses. This is somewhat consistent with the responses given above, which baggage handling locations were the most likely to cause injury, as it relates to working conditions of a narrow body aircraft. The second baggage-handling task mostly likely to cause injury was the transferring of baggage from a trailer directly into an aircraft through the cargo door, which received 11 responses. Pushing and pulling containers and pallets inside wide body aircraft, along with loading baggage onto trailers in the baggage make-up room were the third and fourth most selected areas, with nine and eight responses, respectively.

It is interesting to note that in Dell's interview of the 16 safety professionals from 16 different airlines that when asked if their company imposes a weight limit on bags that baggage handlers can lift, only 1 out of the 16 stated that there was a limit of 70 lbs (32kg). The rest, 15 out of 16, stated that baggage handlers were required to lift bags that exceeded 70lbs (32kg). However, 10 of the 16 felt that an enforcement of a limitation of bags to be handled/lifted by baggage handlers was necessary.

3.2.3 Author's Views and Comments on Dell's Survey of Safety Professionals

Dell's survey of airline safety professional was the first study, which provided extensive data on the baggage handlers back injury problems, and to successfully coordinating information amongst several companies in the airline industry. The surveys also provided comprehensive data on problems that existed with specific work areas, and types of aircrafts, while providing redesign options and engineering controls, as possible solutions. Dell's work has served as the basis for latter study and research done in this field of study.

Although Dell's survey of airline safety professional covered mostly engineering control and redesign issues of work areas and facilities layout, he lacked focus on the aspects of administrative control on back problems. Questions such as *do you as a supervisor support and endorse stretching and lifting training and techniques for your baggage handlers,* were absent from the questionnaire list. Another follow up question to the prior would be, *if yes, does your airline enforce this training through supervisor and floor manager supervision?* This would have been an important question since the airline safety professionals are directly responsible for the safety of the baggage handler. Dell's survey did pose the question of back care training and how effective this training was towards reducing the incident rate of back injury, which 80% of the baggage handlers thought that it would (Dell, 1998a and 1998b). However this was the only question that focused on this type of administrative control.

Another concern with this survey was that Dell included the check-in or ticket agent personnel in the baggage handlers group. Dell included this group of workers because they do in fact handle baggage. However, since their contact with customer baggage is becoming more and more limited, the author feels if it would be best to exclude them from the baggage handler group in any future survey.

In the authors experiences at the Newark International Airport it was expressed several times, baggage handlers and airline personnel that Newark Airport's Ticket or Check-in agents were not to lift customer baggage due to ergonomic concerns, mainly back-related issues. The ticket agent would explain to the customer that he/she would have to be responsible for placing their baggage on the weighing scale themselves. Once the bag(s) is on the weight scale the Check-in agent would have someone help them place the baggage on the baggage conveyor belt for the baggage handlers to process later.

The author realizes that although this may be the case for some airline check-in employees this may not be the general case or model for the rest of airline companies' nation and worldwide. For the check-in agents that must deal with bags, if the customer cannot lift the bag themselves the check-in agent(s) assists. Once the bag is on the scale the check-in agent moves the baggage about a meter's length across to the baggage conveyor belt. This point withstanding, even in the cases where check-in or ticket agents must deal with customer baggage their contact with baggage is limited compared to that of the baggage handler. The check-in agent, although exposed to their own level of risk to musculoskeletal disease, the author purposes that they may have a level of risk that maybe considerably less than the baggage handler. Moreover, another important thing to consider is that the majority of check-in or ticket agents are women-although this too is slowing changing along the landscape of the industry-who traditional are not considered to be part of the heavy lifting and labor group. This being the case, check-in handlers are not given the same attention to detail as far as lifting, stretching and warming up techniques are considered. In some cases no training is given to check-in/ticket workers at all (Rosskam, 2004).

A study conducted specifically on airport check-in workers revealed that the rates of musculoskeletal disease are different for check-in workers. The study factored in the fact that worker at manual and semi-automated check-in stations are subjected to prolonged sitting, standing and forced and awkward hand moments associated with computing work (Rosskam, 2004). This is why the author feels that separate studies should be performed on check-in/ticket agents, as their risk factors and rates are different from the baggage handler.

Another interesting point to make is that in Dells inquiry of the baggage handler's work areas most likely to cause back injury, Dell included the storage areas of the wide body aircraft. Currently speaking most wide body aircraft have fully automated systems, which do the loading of the cans, or storage bins meant for use in the wide body aircraft. This being the case, most baggage handlers do not have to manually load these wide body aircrafts. In the authors experience at the international airport it was expressed by the baggage handlers and managing staffs that nowadays baggage handlers almost never have to load wide body aircraft manually. If the baggage loading mechanism becomes malfunctioned for a wide body aircraft then another aircraft is rotated into use. In Dell's survey of the safety professional it was asked if the wide body should be considered as an injury prone work area, which nowadays seems like a question not worth asking for airlines that do not allow baggage handlers to manually load wide bodies in the event that the baggage loading mechanism malfunctions. Moreover, it is the opinion of the author that questions addressing-how often do the automated systems breakdown for wide body aircraft, along with what is the percentage of airline companies that require baggage handlers to manually load (push/pull baggage storage cans) inside of the wide body aircraft in case of a malfunction-should be asked. If indeed that this practice is not performed anymore then it would be a question that should be left out for a future study.

3.3 Dell's Survey of the Baggage Handler

Dell's second survey used 156 baggage handlers from ten airlines companies, and two ground handling companies. This survey focused on the concern of what baggage handlers perceive to be the high back injury risk tasks, what parts of the baggage handling system and equipment are considered to present significant manual handling problems, and what solutions may be appropriate.

Dell surveyed 156 baggage handlers at random from the work force of a diverse range of airlines with a standard set of structured interview questions. The airlines involved were: Aerolineas Argentinas-Argentina, Austral Airlines-Argentina, Delta Airlines-Germany, Delta Airlines-USA, Lufthansa-Germany, Northwest Airlines-USA, Midwest Express-USA, Qantas Airways-Australia, Scandinavian Airline System-Scandinavia, Service Master-USA, and CLT Aviation-USA.

3.3.1 The Standard Set of Interview Questions

The baggage handlers survey contained the following questions.

- How long had the participant worked as a baggage handler, what was their age and gender?

- Had they personally experienced a back injury?
- How often did they experience back pain?
- Whether baggage handlers in their organization were required to lift baggage and cargo exceeding 32 kg (70lbs) weight? (32 kg is a pre-existing national industry limit on passenger baggage weight).
- From a list of five baggage handler workplaces, which were considered most and least likely to cause back injuries?
- From a list of twelve manual handling tasks routinely carried out by baggage handlers, which did they consider to be the five most likely to cause baggage handler back injuries.
- What back injury control measures had been applied in their companies? In particular, information was sought on use of back support belts training, use of equipment, use of narrow body aircraft in-plane baggage stacking systems and details of any attempts at building re-design to reduce the instances of baggage handler manual handling injuries.
- What measure did they believe would be necessary in future to reduce the instance of back injuries to baggage handlers?

3.3.2 Results from the Baggage Handlers' Survey

Table 3.4 Baggage Handlers' Opinion: Workplace Likely To Cause Most Back Injuries

Inside narrow body aircraft baggage compartments	110
Baggage check-in	13
Outside aircraft on the tarmac	11
Baggage sorting room	9
Inside wide body aircraft bulk hold	9
No response	4

Source: Dell 1997 n=156

In the evaluation of the *workplaces most likely to cause back injury,* (Table 3.4) 110 baggage handlers out of 156 (70%), responded that working inside a narrow-bodied aircraft was the most likely cause of back injury. Twenty seven percent of the baggage handlers surveyed, out of the remaining 30% responded that baggage check-in, outside aircraft on the tarmac, the baggage sorting room, and the inside wide body aircraft bulk relatively held the same amount of risk factor for causing back injury.

Table 3.5 Baggage Handlers' Opinions: Manual Handling Tasks Likely To Cause Back Injuries

TASK	LIKELY	UNLIKELY	N/R
Pushing bags from doorway into body compartment	136	18	2
Stacking bags inside narrow body baggage compartment	135	16	5
Transferring bags from trailer directly into aircraft	131	21	4
Pushing &pulling loaded trailers	129	25	2
Pushing containers inside wide body aircraft (safety u/s)	118	27	11
Stacking baggage inside wide body aircraft bulk holds	113	30	13
Loading bags onto trailers in the baggage room	107	47	2
Loading containers in baggage room	104	42	10
Transferring bags from trailer to mobile belt	103	49	4
Unloading containers in the baggage room	101	44	11
Unloading trailers in the baggage room	93	61	2
Lifting baggage on &off conveyors	69	83	4

Source: Dell 1997

In the category of *manual handling task,* (Table 3.5) baggage handlers felt that pushing bags from the doorway into the body compartment of an aircraft (136) and stacking bags inside narrow body baggage compartment (135) were the tasks most likely to cause back injury. One hundred thirty one baggage handlers thought that transferring bags from trailer directly into aircraft was the next most likely task to cause injury, with pushing and pulling loaded trailers not far behind with 129 votes. Pushing containers inside wide body aircraft and stacking baggage inside wide body aircraft bulk holds followed with 118 and 113, respectively. It should be noted wide body aircraft have automated systems, which raise and load the cans (huge containers filed with baggage) mechanically into the huge storage bin areas. However, when part of this automated process malfunctions, if left with no other options, baggage handlers must manipulate and maneuver the cans manually inside the bin of the aircraft. Conversely, baggage handlers thought that lifting baggage on and off conveyors was the least hazardous of the manual handling tasks with on 69 out of 156 felt that this is hazardous.

Table 3.6 Baggage Handlers' Opinions: Personal Injury Experience

Question	YES	NO	N/R	n
Have you personally experienced a back injury while handling Baggage?	72	84	0	156
Has the Back injury reduced your ability to handle baggage?	40	32	0	72
Has the injury recurred since the first occasion?	43	29	0	72

Source: Dell 1997

In regards to the personal injury experience question, less than half (46%) of the baggage handlers, Seventy-two votes, experienced a back injury while handling luggage (Table 3.6). However, out of the seventy-two responses, forty (56%) claimed that the back injury reduced their ability to handle baggage, and forty-three (60%) claimed that the injury has recurred since the first occasion.

Table 3.7 Baggage Handlers' Opinions: Engineering/Re-Design Solutions

Solutions	Yes	No	N/R
Develop in-plane baggage and cargo stacking systems	122	27	7
Redesign baggage handling systems to reduce injury risk	111	41	4
Provide mechanical assistance devices for lifting baggage	93	49	14
Introduce robotics to eliminate manual handling	89	60	6
Resign aircraft baggage compartments	78	69	9

Source: Dell 1997 n=156

When baggage handlers were surveyed for opinions concerning prevention and solutions, they answered as follows (Table 3.7). With regards to the question of develop in-plane baggage and cargo stacking systems, that answer gathered the highest response with 122 baggage handlers out of 156 (78%) responding yes. The question of redesigning baggage-handling systems to reduce injury risk also ranked high amongst the baggage handlers with 111 (71%) positive responses. Providing mechanical assistance devices for lifting baggage drew 93 positive responses, more than half (60%) of the baggage handlers poled and 89 respondents (57%) felt that the introduction of robotics to eliminate manual handling would be effective. It is interesting to note that the baggage handlers were almost in the middle (53%) on whether or not effective aircraft design would cut done on back-related injuries.

For the procedural and administrative solutions section, the baggage handlers overwhelming felt that putting "heavy" tags on heávy baggage to warn staff, 40 positive responses (90%), would be a very good procedural and administrative control (Table 3.8). Inducing better baggage handler training was also a very highly selected choice of an effective administrative control. Better maintenance of equipment, the introduction of better baggage and cargo acceptance procedures, better roster of staff to meet work demands, and educating the public concerning injury risks to baggage handlers all scored relatively high with the scores of 121 (78%), 122 (77%), 119 (76%), and 118 (75%), respectively.

Table 3.8 Baggage Handlers' Opinions: Procedural and Administrative Solutions

Solutions	Yes	No	N/R
Put "heavy" tags on heavy baggage to warn staff	140	3	13
Introduce better baggage handler training	138	14	4
Better maintenance of equipment	121	27	8
Introduce better baggage &cargo acceptance procedures	120	23	13
Better roster of staff to meet work demands	119	31	6
Educate the public concerning injury risks to baggage handlers	118	26	112
Should a lower baggage weight be enforced	114	28	14
Slow the baggage handling process down	104	48	4
Make passengers re-pack heavy baggage to reduce weight	101	42	13
Introduce back support belts	100	47	9
Introduce warm-up exercise	98	52	6
Improve quality of supervisor	67	81	7

Source: Dell 1997

Table 3.9 Baggage Handlers' Opinions: Back Support Belts

Questions	Yes	No	N/R
Have you personally worn a back support belt to help prevent back injuries	63	90	2
Have you experienced a back injury while wearing a back support belt?	10	123	23
Do back support belts improve a wearer's ability to do baggage-handling tasks?	93	52	11
Back support belts help prevent lost time back injuries	94	52	10
Back support belts should be worn for all lifting tasks	86	60	10
Back support belts make lifting technique training unnecessary	13	133	10
If you wear a back support belt at work, you must wear it when lifting at home	66	78	10

Source: Dell 1997

The section that refers to back belt supports was interesting (Table 3.9). Ninety baggage handlers answered no to the question—have you worn a back support belt to prevent injuries, which is a little more than half at 58%. More interesting still was that only ten baggage handlers, about 6%, experienced back injury while wearing a support belt. This answer is misleading simply because it does not give a clear percentage of how many baggage handlers used support belts in the first place. More than half of the baggage handlers surveyed felt that back support belts improve a wearer's ability to do baggage handling tasks (93), helps prevent lost time back injuries (94), and that back support belts should be worn for all lifting tasks (86). However, despite this an overwhelming number of baggage handlers 133 (78%) felt that back support belts does not make lifting technique training unnecessary (133, 85%).

Table 3.10 Baggage Handler Opinions: Training

Questions	**Yes**	**No**	**N/R**
Training must include techniques for lifting in restricted posture/confided spaces?	145	9	2
Back care training will help you prevent lost time back injury?	129	25	2
Back care training improves baggage handler ability to conduct handling task?	123	30	1
Warm up exercises should form part of baggage handlers' daily routine	105	48	2
Lifting technique (back straight/knees bent) training benefits baggage handlers	104	48	11

Source: Dell 1997

In response to the training questions an overwhelming number of baggage handlers, 145 (93%), felt that training must include techniques for lifting the restricted posture and confided space. A large number of baggage handlers also felt that back care training will help to prevent lost time due to back injury, as well as back care training improves the baggage handler's ability to conduct handling task with 129 (83%), and 123 (79%) positive responses, respectively. The baggage handlers seem to be in favor of training, and felt that it was helpful towards reducing back injury incidents. One hundred five (67%) felt that warm up exercises should form part of a baggage handlers routine, while 104 (66%) felt that training classes focused on lifting techniques were necessary. Though 93% of the baggage handlers surveyed felt that training must included techniques for lifting in restricted posters and confide spaces, only 66% thought that lifting techniques (back straight/knee bent) training benefits baggage handlers.

Another angle to explore would be the design layout or work area of the baggage handlers. As Dell (1997) established in his work, the redesigning of the aircraft cargo hold area is vital towards remedying the back injury problem for baggage handlers, however the incentive for manufacturers of these aircraft; Boeing, McDonnell Douglas, Avro, Airbus Industrie and Fokker, to change the existing designs is not there till more research is done to quantify the problem.

3.3.3 Author's Views and Comments on Dell's Survey of the Baggage Handlers

Dell's survey of the baggage handler was one of the first to probe the baggage handlers for their feedback, suggestions and or recommendations on issues that strongly affect their working communities. Dell successfully quantified the opinions and voice of the baggage handler, gathering necessary feedback that has provided the research community with the means to access the views and perceptions of the baggage handlers on the topic of the causes and preventions of baggage handler back injuries. This feedback has identified key issues such as the main areas that baggage handler's view as high risk tasks that my lead towards injury, and the need for improved training techniques on lifting and back care.

Dell's survey of the baggage handler was relatively similar to the survey of the safety professionals, with one major deviation in the line of questions. The baggage handlers' survey focused more on administrative controls, with questions about back care, lifting techniques, and warming up exercises, as well as engineering controls. Collecting information on back care and lifting training primarily from the baggage handlers' point of view gives only part of the story, as reinforcement of these administrative controls are not controlled by baggage handlers.

The author's opinion, as stated in the earlier section, is the same in reference to Dell's definition of baggage handlers and ticket/check-in agents. The concern with the wide body cargo area question is still valid for anyone wanting to conduct a survey of baggage handlers in the future. Ticket agents should be evaluated separately and the question about loading the wide body aircraft should be reworded or omitted since many airlines do not presently expect the baggage handler to manual load wide bodies or push/pull cans into these aircraft.

Lastly, there was a strong focus in the survey that questioned whether or not a back belt should be used by the baggage handler, followed by more questions about the perceived notions of benefit from the use of back supports. The scientific and academic support for the use of the back belt is inconclusive. In addition to this, the National Institute of Occupational Safety and Health (NIOSH) do not support the use of back belts for the lack of scientific support that exist. This being the case, it was the opinion of the author that this question should not be posed to baggage handlers because it may lead to the assumptions that the use of the back belt could be a viable option in eliminating or reducing the incidents of back injury.

3.4 Review of Study on Conveyor Belt Design

The use of a conveyor belt is quite routine for baggage handlers at work. The design and layout of the belt can affect the posture, and work rhythm of baggage handlers. In the literature review there were two main articles that focused on design of conveyors: (1) *Baggage Handling Postures and the Design of Conveyors* (Thomas et al., 1995) and, (2) *Ergonomic Improvements to a Baggage Conveyor System at a Large Airline Company* (Vi et al., 1998). The first article highlights a study that took place at the Schiphol Airport in Holland of a baggage conveyor belt system. The conveyor belt was used by baggage handlers to sort and transfer bags from one point to another. While baggage is on the conveyor, baggage handlers often have to pick bags up and transfer them to mobile baggage carts. It is during this transfer that baggage handlers are forced to frequently twist and flex their torso, and neck due to the layout of the baggage conveyor belt. The rotating and twisting of the lower back in conjunction with lifting put baggage handlers in awkward postures that form serious risk factors for the development of back pain (Keyserling and Armstrong, 1990). It follows that certain property that can be attributed to the baggage conveyor belt system that can have an effect on the development of lower back pain.

Thomas et al., (1995), conducted a survey of the baggage handlers' preferences on the conveyors used in Schiphol Airport was obtained. Based on the baggage handlers' preferences, the height, angle and velocity of the conveyor were selected, which were thought to have an impact on the handlers' workload. These parameters were changed according to baggage handlers' preferences. A mock-up trail was conducted to simulate the work conditions of the conveyor. Some baggage handlers expressed that they would frequently hurt their knees against the front side of the conveyors prompting the need to investigate and possible adjust the height underneath the conveyor in the mock-up trails as well. The authors only included the ergonomic design changes that would not compromise the quality of the baggage handling.

One hundred and seven baggage handlers and ground crew workers from the Royal Dutch Airlines (KLM) and Aero Ground services (AG) participated in the mock-up trails. Baggage handlers with a minimum work experience of six month were included as the participants of the study.

The standard conveyor speed was 0.48m/s. Two more speeds of 0.35 m/s and 0.6 m/s were chosen and sampled for trails. The height-angle combinations for the trail were calculated with respect to the horizontal plane (see Table 3.11). Six height angle combinations were calculated. Each of the three conveyor belt velocities were combined and calculated with the six height angles producing 18 testing conditions, which in-turn was tested on six subjects. One condition was completed by only five subjects.

The dependent variables as defined by this trail were the postures of the subjects, the way the handler experienced the baggage handling task, and the quality of baggage handling. A computer program, task recording and analysis on computer (TRAC), was used to record the multi moment observation of the arm angles and the trunk. Observations of the posture of the subject performing the task of baggage handling on the mock-up conveyor were recorded at 10-second intervals. The portable computer (Psion Organizer XP) was used to record the angles of the arms and trunk.

Table 3.11 Height-Angle for Mock-up Conveyor

Height (cm)	**Angle (degrees)**
40	30
55	20
55	30
75	10
75	20
100	0

Table 3.12 The Trunk and Arm Angle Categories That Were Defined for the Observation

Trunk Angles (degrees)	**Arm Angles (degrees)**	
Flexion	**Flexion + Rotation**	
0-15	0-15	2 arms <60
15-45	15-45	1 arm <60
45-75	45-75	2 arms >60
>75	>75	

To address the problem "what is the right amount of space under the conveyor belt", light sensors were fitted underneath the mock-up conveyor to register any interruptions (broken light path) caused by the leg or foot that crossed too far under the plane of the conveyor causing a collision. The area that the light beam covered was 20 cm deep and 50 cm high.

After the trails, the baggage handlers were asked to fill out a questionnaire evaluating what combinations of variables they found most suitable, and what ergonomic aspects they found to be most unfavorable/favorable. The baggage handlers were instructed to rank the variables from a scale of 1 to 10, one being poor, and 10 being most optimal or excellent.

From a quality of work standpoint, observations were made to check if the changes in height, speed, and angle of the mock conveyor affected the rate of baggage sorting errors, and the number of bags falling off the conveyor belt.

All of the baggage handlers that participated in this experiment were given standard instruction about the purpose of the study. To negate the learning effects each baggage handler was allowed to go through the experiment only once under conditions that resembled that of a peak load situation which occurs several times during a normal work day. The mock conveyor was set up with 63 bags that consisted of five different destination labels which were presented at a fixed pace and order. While sorting the bags for this trail the baggage handlers were not given any restrictions on the loading and sorting techniques to be used for the observations.

An analysis of variance (ANOVA) table was created for the dependent variables to evaluate the influence of the velocity, height, and angle, along with a Ryan Einot Gabriel Welch multiple range test to determine the direction of influence. A Student t-test was also performed to determine if there was a significant difference between the participants from the Royal Dutch Airlines and Aero Ground services. The survey information collected from the handlers was also compiled and then averaged.

3.4.1 Results

In the statistical analysis of the data produced by the trials, it was observed that the higher the height was set on the mock-up conveyor belt the lesser the amount of flexion was imposed on the torso. The same held true for the rotation of the torso as well. The observed values for all flexion and rotation of the trunk gathered around 40, 55, 75, and 100 cm, of which 100 cm caused the least amount of flexion and rotation in the trunk.

The best speed for the mock-up conveyor was 0.35 m/s, which produced the lowest value for the trunk flexion; whereas 0.60 m/s produced the highest value of trunk flexion between 45 to 75 degrees. The explanation for this was that if the speed was too fast, the baggage handlers could not read the label destination of the bag until it had passed them making it so that the handler would have to turn his body to retrieve the baggage.

For trunk ration the speed of 0.60 m/s produced the highest values for all three ranges of rotation; rotations 0-15, 15-45, and 45-75 degrees, respectively. Overall, however, the changes in velocity were found not to affect the body postures all that significantly.

It can be concluded that the higher conveyor height allows the baggage handler to work more upright, which from an ergonomic standpoint is more ideal circumstance. The upright the body posture the less the magnitude of the moment produced by the weight of the trunk (Chaffin and Anderson, 1984).

During the baggage handling trials, all subjects interrupted one or more of the light sensors with their leg and feet indicating that a certain volume of open space, 20 cm deep and 50 cm high, would be a minimal requirement necessary to avoid knee collision with the conveyor. Moreover, this open space would allow the baggage handler to stand closer so that they could place their toes underneath the conveyor to adjust their balance and weight support.

The effect of the height of the conveyor on the arm elevation of baggage handlers resulted in one significant effect ($p<0.05$) in the category of one arm greater than 60 degrees. It was observed that this was due to the nature of suitcase design, which, for the most part provides one handle for the retriever for handhold.

Another important observation was that the lifting stress experienced on the shoulders and lower back region was minimized as the baggage handler stood closer to the load to be lifted (Chaffin and Anderson 1984).

Table 3.13 The average rating between 1 (poor) and 10 (excellent) given by baggage handlers

Height (cm)	Score
40	6.2
55	7.6
75	7.4
100	6.9
Angle (degrees)	
0	6.2
10	7.2
20	7.7
30	7.8
Velocity (m/s)	
0.35	7.6
0.45	6.9
0.60	4.8

The heights, angles, and velocities that scored most favorably amongst baggage handlers were the heights of 55 to 75 cm, the conveyor angles of 20 and 30 degrees, and the velocities of 0.35 and 0.48 m/s as shown in Table 3.13.

The quality of baggage handling (sorting errors) was not significantly affected ($p > 0.05$) by the changes in heights of the mock-up conveyor. The changes in speed, however, did show a significant effect in the number of sorting errors that occurred with baggage with the velocity of 0.60 m/s yielding the highest amount of errors ($p < 0.05$). The results also showed that the quality of baggage handling was most affected by the angle of 30 degrees, which produced the greatest increase ($p < 0.05$) in the number of dropped bags from the conveyor.

3.4.2 Author's Views and Comments on the Posture and Conveyor Belt Design

This study on baggage handlers' postures and conveyor belt design was very impressive. Having multiple criteria for the various heights, speeds and angles that a baggage conveyor belt could perform were practical. This is the only experimental study that used experienced baggage handlers to obtain objective data relevant to conveyor design. Furthermore, this study strongly supported the necessity of keeping free space underneath the baggage conveyor belt for balance and support of feet.

One limitation of this study was that it only used a population pool of male workers. Since many women work in the capacity of baggage handling at the various airports throughout the world, this study excludes a relatively significant population.

A survey about the condition and type of baggage conveyor belt system used by baggage handlers was given in the beginning of the study and a follow up survey was given to the handlers to identify any learning curves. The author feels that this is an appropriate thing to do, because it is important to understand how the workers think about elements of their jobs before the intervention was implemented.

3.5 Review of Another Study on Conveyor Belt Design at Air Canada

This study was focused on the applications of ergonomic principles for workplace design for baggage handlers. It was an ergonomic intervention study done on a baggage conveyor system that was used at Air Canada's Pearson International Airport. This airport was highlighted and profiled because, as is the case with most airports, the majority of the musculoskeletal cases being reported involved injury to the lower back and lumbar area. Moreover, it was reported in a cost analysis done by Air Canada of the Pearson Airport in 1991 that the average cost per injury was $5,636. The average number of lost days per back injury was 36. The Occupational Health Clinics of Ontario Workers Inc was solicited to come in to assess this situation.

A three-staged approach was used in this study to show how the recommendation of ergonomic workstation design could possibly help with these problems. The three-stage process was, identifying the problems and possible solutions, conducting a pilot study on workstation changes made, and performing an outcome assessment.

3.5.1 Identifying Problems and Possible Solutions

The purpose of their evaluation was to identify hazards, which attribute to any injuries. Once the hazards were identified, recommendations were provided to reduce the risk of injury.

A survey was developed based on workplace injury history. The questionnaire was based on the "Nordic" system (Kourinka et al., 1987), which analyzed the loads placed on various joints on the body while performing baggage handling. The results of the survey showed that three areas provided the highest problem for baggage handlers and the highest concerns for the evaluators. Table 3.14 provides the summary of responses by the baggage handlers regarding pain in lower back, knee, neck and shoulder in the previous 12 months.

The analysis of the baggage handlers' task on various conveyor belts concluded that the handlers' job has a high volume of repetition, heavy weight lifting, improper height of conveyor belts, along with confided spaces in-between conveyor belts, posed a high risk for injury.

Table 3.14 Population Response

% of Respondent Population with Lower Back Pain	
Experience over last 12 months	79%
Experience over last 7 days	40%
Affected ability to work normal within last 12 months	52%
% of Respondent Population with Knee Pain	
Experience over last 12 months	49%
Experience over last 7 days	20%
Affected ability to work normal within last 12 months	21%
% of Respondent Population with Neck	
Experience over last 12 months	45%
Experience over last 7 days	20%
Affected ability to work normal within last 12 months	24%
% of Respondent Population with Right Shoulder Pain	
Experience over last 12 months	39%
Experience over last 7 days	23%
Affected ability to work normal within last 12 months	19%

Source: Kourinka et al., 1987

3.5.2 The Pilot Test

After the survey and task analysis were evaluated, the Pearson Airport's two conveyer systems were modified for pilot test. The new pilot conveyer was changed from a two-tier system to one tier. The former two-tier system had a height of 132 cm for its top level and 36 cm for its bottom relative to the floor. The pilot conveyor had a height of 83 cm from the floor.

The purpose of introducing the pilot study was to determine if the new system would help bring down the incidence rate of back injury by decreasing the musculoskeletal load on the handlers. Another purpose was to see if the pilot design suggested met the ergonomic changes obtained from the feedback of the workers' surveys. To accomplish this, three volunteer baggage handlers participated in a controlled experiment. The handlers had to lift a 15kg bag; six lifts per minute, from three different conveyor belt heights on to a dolly. Two of the three heights consisted of the old conveyor belt dimensions, and the third height was developed from the survey and ergonomic guidelines.

During the experiment, the test subjects were instructed to lift for 15-minute intervals. During the task performance, the baggage handlers were filmed as well as fitted with ECG sensors to monitor and record their heart rates. The handlers were administered a pain and discomfort rating scale in which they indicated their discomfort levels by using a 10 cm visual analog scale (VAS) with verbal descriptions. The pilot study showed that all four measured dependent variables, heart rate, perceived exertion, discomfort, and disc compression were significantly lower for the test conveyor with 83 cm height. Although the sample size was limited this investigation clearly indicated that the ergonomic recommendation for workspace design was superior to the existing design.

3.5.3 Limitations of the Study

This study took a very simple but practical ergonomic approach towards examining the baggage handling conveyor system and its effects on posture. Unlike the prior study by Thomas et al., (1995) on conveyor belts mentioned above in this work, the baggage handler's survey and ergonomic evaluation and assessment of the baggage conveyor belts took place at the beginning of this study, which seemed to be more efficient. Having the subjects of the experiment complete a survey at the beginning of the experiment allows the subjects to base their conclusions on actual perceptions experienced and acquired through their work experiences as oppose to drawing conclusions on what they might feel to be the right answer(s) based on trails of the experiment. Once the experiment is done, input can then be gathered to find out which factors and variable were the most effective for the subject(s).

A limitation of this study was how it dealt with the physiological part of the experiment. Only three subjects were tested. Additionally, nothing was stated about the age of the test subjects. The sample size of the survey participants was not clearly stated in the experiment, leaving one to wonder and guess at how big the participation level of the baggage handlers were. There was one reference to 67 baggage handlers commenting on the prevalence of musculoskeletal symptoms. Having a sample size of three subjects leaves the experiment open to criticisms of population bias. Also the lack of a control group made it impossible to compare the validity of the results purposed by the isolated sample population.

Ignoring these factors the results from this evaluation seem promising, and did gather conclusions that appeared to be noteworthy in reducing musculoskeletal problems for baggage handlers associated with their work environment.

3.6 Back Belt Literature

The notion that one should use back support belts during material handling is not an uncommon one. Many people while performing everyday tasks related to lifting, i.e. working out, or moving furniture etc, use back belts with full confidence that this practice serves as a proactive support towards maintaining a healthy back. Little might they know that the use of back support belts may not be as good for you as the promotional literature on the back support belt may lead you to believe. Scientific literature on the back support belt is still weighing in on whether or not this practice does more good than harm.

For the baggage handler, not many studies have been published that focus on the pros and cons about wearing back support belts, and definitively, and establishing the case for benefits or determent of the use of the belt. There is one study that focused particularly on baggage handlers provided some insight on the subject. This article is "An Evaluation of a Weightlifting Belt and Back Injury Prevention Training Class for Airline Baggage Handlers" (Reddell et al., 1992), and is still relevant today.

3.6.1 History of Industrial Back Belts

Back injury is one of the leading causes of on the job injuries per year according to the bureau of Labor statistics. It is estimated that there are at least 1 million back injury claims every year in the U.S. Moreover, it is believed that more than half the working population would have experienced back injury sometime during their working careers (NIOSH, 1994).

In the mid seventies, the National Safety Council found that over 54% of the baggage handlers claim towards back pain could be attributed to baggage and cargo handling (Reddell et al., 1992).

Traditionally, education on lifting technique and back injury has long been the answer for many establishments faced with this problem. Although most companies thought that this technique was rewarding, continued research on this topic revealed that this was the least effective means, especially when it was implemented as the only means of control. It was shortly thereafter in the middle 80's that companies, in the attempt to be more proactive, started to use weightlifting belts as a protective means against lumbar back injury.

Research theorized that increased intra-abdominal pressure (IAP) reduced the compressive forces in the lumbar spine area while lifting, and it was shown in experiments that weightlifting belts aids in increase the intra-abdominal pressure during lifting. It followed that weightlifting belts should then act to reduce the lumber injury to the lower back and spine. There was also a study that experimented with an inflatable corset that decreased abdominal muscle activities while still increasing intra-abdominal pressure, which supported the earlier findings (Morris, J.M, et al., 1961). In a study by McCoy, it was shown that even more weight could be lifted with this type of inflated support belt (McCoy, 1986). Studies done by Hawaiian Airlines claimed that back injuries had taken a reduction during a time period of usage (Okada, 1987).

Despite the favorability of earlier findings, there was a contingent of studies that yielded unfavorable results for the usage of weightlifting belts, which left safety professionals divided on this topic. It was theorized that having a test subject get injured during the course of a study is the only accurate way to determine the effectiveness of the weightlifting belts as a preventative means of lumbar injury (Lander et al, 1990).

It was out of this necessity for definitive proof for the effectiveness of weightlifting belts as a means to prevent lumbar injury that this study was realized.

3.6.2 Experiment

This study evaluated the effectiveness of weightlifting or back belts on material handling, but more specifically on baggage handlers. The sample population consisted of 642 baggage handlers working across four airport stations over a span of eight months. The 642 subjects were broken up into four treatment groups. One group was given a weightlifting belt and told to use it. Another group was given the weightlifting belt along with an instructive class on how to incorporate the belt with lifting tasks. A third group was given a one hour training class on lifting, and the last group was given nothing; not given any back support or a training class. In this experiment it was hypothesized that baggage handlers with the training class and weightlifting belt should fair better than those with just the weightlifting belt, being least likely to suffer a lumbar injury due to lifting.

The weightlifting/back-belt used in this experiment was the *Back Safety System Belt,* model SS-6. This belt is a loose one that does not attach to the trousers of the wearer. It measures approximately 150mm across its center, narrowing down to about 100 mm at both of its ends. This belt also came in varying of sizes. The belt is adjusted by a belt buckle and double back with Velcro on one of its sides. This belt was chosen over three other types of belts: the airbelt, spandex belt, and the leather belts, based on an earlier mini study of Fleet service clerks performed in Austin Texas.

Each of the subjects was fitted for a weightlifting back-belt and was instructed to wear the belt for the duration of the workday. They were told that they could loosen the belts when not engaged in any lifting task and to tighten it once re-engaged with lifting.

3.6.3 Study Objectives

The following were the main objectives of the study.

- Analyze the total lumbar injury incident rate, lost workday case injury incident rate, and restricted workday case injury incident rate for each treatment group to determine if the group receiving both belt and training had a significant lower incident rate.
- Analyze lost workday rate and restricted workday rate values per treatment group to determine if any one group had a significantly lower rate of lost or restricted days.
- Analyze worker's compensation cost rate (i.e., claims, medical, and miscellaneous expenses) per treatment group to determine if any one group had a significantly higher cost rate.
- Analyze questionnaire data for the groups receiving the belt to measure degree of help and comfort perceived by the participant and to determine if training increased the perceived level of help provided by the belt.
- Determine realistic voluntary compliance percentages for wearing weightlifting belt on a long-term basis for manual material-handling employees who worked outside.

3.6.4 Methodology

There were a total of 896 fleet service clerks that were randomly selected to participate in this experimental study, of which 642 were actually selected and interviewed at the end of the eight-month trail period. The subjects, from the fleet service clerks, were chosen from a pool of four international airports: Dallas-Fort Worth, Los Angeles, Raleigh-Duhram, and Nashville international airports.

The fleet service clerks, or baggage handlers, worked in the inside and outside aircraft, baggage transfer, mail facility, cabin service and the baggage room. Some other duties of these baggage handlers included but were not limited to manual baggage and mail transfer, from one location to another.

The training class consisted of a video, booklet, hands-on training, and a booklet. A video was developed by a medical professional that discussed the anatomy of the back and spine, biomechanics related to lifting, a how-to on warm-up exercises, and home and after injury care. The video also used real airline employees to keep its degree of realism and relativity.

In conjunction with the video, the baggage handlers in this group were required to participate in a 30-minute class, where they would perform each lifting exercise and warm-up technique(s) expressed in the video before an instructor. Lifting props were provided. The instructor critiqued the handlers on their abilities to perform each instruction. A booklet was used which reiterated of the techniques shown in the video and was used in class.

Data collected and used in the study included a belt questionnaire, lost workdays, restricted workdays, total number of lumbar injuries, number of lost workday case lumbar injuries, and number of restricted workday case lumbar injuries, total workers compensation cost, and the number of hours worked.

3.6.5 Incident Rate

Over half of the baggage handlers stopped using the weightlifting back-belt: 158 out of 272. Fifty eight percent of them stopped using the back belt before the eight-month study period had ended. Of this fifty eight percent, two new treatment groups were created to account for them. These treatment groups now were made up of those who initially received the belt and training, and the other which initially received a belt only. These groups were called the dropout groups, which were monitored to survey any effects, which may occur after the period of wearing the weightlifting back belt.

There were a total of 31 injuries observed during the eight-month study period of which 28 were on-the-job injuries, which were used in the analysis. Three injuries were non job-related. These three injuries came from a belt group, a training only group, and from a control group. It was noted there was no correlation between the incident rate and previous injury with $r=0.0529$.

Overall, this study indicated that neither the belt nor training group had a significant effect on decreasing the lumbar injury rate, rendering the question *are back belts helpful in reducing back injury,* inconclusive.

Statistical analysis of for lost workday case incident rate showed a marginal significant difference between the dropout groups, and the training group and the control group. There seemed to be some connection between the increase in the number and severity of lumbar injuries rates, and those who wore the belt in the beginning, but decided to stop wearing the belt towards the end of the study. It was concluded that back belts may increase the risk of injury to the lumbar area on occasion when the user is not wearing the supportive belts. It was noted in their survey that some baggage handlers felt that they could develop a physical dependency on the belt, thus making lifting without the belt more dangerous. The increase of the intra abdominal pressure (IAP) of the wearer also came with some discomfort according to the baggage handler survey. The increase in IAP can increase the systolic blood pressure hampering blood flow back to the heart resulting in possible heart failure.

The dropouts reported great dislike about wearing the belt. A questionnaire given to the all the baggage handlers who wore the belt at some point of time showed that many of them felt that the belt got excessive hot when they were worn in and around aircrafts. Some handlers experienced profuse sweating around the belt area, while others developed rash around their mid sections where the belts were worn. Baggage handlers were constantly shifting from indoor to outdoor whereby the body experiences discernible temperature change which could be exaggerated by restrictive personal protective equipment worn about various parts body area.

The biggest problem with the study is that the belt wearers did not always wear the belt while working flights. Out of 896 participants only 642 subjects qualified for the study. Two hundred and fifty four participant failed to qualify due failure to report to the surveyor.

Table 3.15 Statistics from Back Belt Survey

642	Qualifying number of subjects
370	Qualifying number of subjects started w/o belts
272	Qualifying number of subjects initially given back belts with and without training
158	Number of subjects that stop using belt with and w/o training (dropouts)
114	Subjects that used belt for entire period with and w/o training
28	Total number of subjects injured on the job.
23	Number of non belt wearing subjects with and w/o training injured
5	Belt wearing subjects injured with and w/o training
3	Belt wearing subjects that never had injury before (of the 5 injured)

Source: Reddell, et al., 1992

3.6.6 Author's Comments on the Study of Back Belt Usage of Baggage Handlers

This study of the use of back belts for baggage handlers was thorough. The sample size, 642 randomly selected baggage handlers, was a large and effective. The four treatment groups of baggage handlers with belt and training, with belt only, with training, and without belt or training—was used appropriate to determine effect of belt or training. The detailed information about the type, and the dimensions, of the belt used was also helpful for future studies on the subject.

A concern for this study is the male female ratio of the test subjects. Out of 642 test subjects, only 70 were female (11 percent). Although the majority of baggage handlers are male, having only 11 percent of the subject pool female is questionable. The second point of concern was that the initial pool of baggage handlers was 896, of which 254 were not accessible, or could not be located. It was not clear why these 254 subjects were not located or reachable, which leaves the reader to speculate about why their data was not used. There was no mention of how many women was initially part of the 896. If the majority of the 254 dropouts were women then this factor might have had a bearing on the results.

The baggage handlers were surveyed using questionnaires before and after their treatments sessions. The questionnaire before the treatments included general questions about age, sex, and previous back injury. The survey that followed the completion of the treatments discussed questions about the treatment. The problem with this type of survey is that it does not give the surveyor any input about the baggage handlers concerns and comments about their job, which could have been used to improve the study design. Outside of these concerns this study was efficient and through, although it yielded no conclusive results.

CHAPTER 4

SUGGESTIONS FOR FUTURE SURVEYS AND RESEARCH

4.1 Model for Future Survey

To fully understand the ergonomic issues that surround workers in the material handling industry it is necessary to investigate the many aspects of a particular job or task to gain a better understanding to the question *why are things this way?* It is important to establish the theory of *the why* to develop questions and a hypothesis that will lead the research in the right direction(s). These questions can then be asked from the test subjects of a target population to develop and better understanding of *the why.*

It is also very important to have access to the accident and injury incident rate log (OSHA 300 log) of the company or establishment that is being researched and investigated for the years of interest. It is necessary to get the statistical injury rates for particular types of injuries across that industry to compare it with the target company's finding. Once the commonalities of the injuries are established for a particular field or industry, the next step should be to hypothesize on what preventive measures and remedies can be formulated to help solve or provide relief for these problems. This allows the researchers to best estimate the results anticipating what the possible solutions could be once the surveys and observed results are collected, processed and finalized.

Once the ideas for what the potential problems might be are developed, based on the injury statistics available, questions for the survey should be reflective of these (the injury statistics) results.

A body chart diagram to assess work related pain for the joints and body area could be used to gauge worker's backgrounds and experiences with injury. Once a survey is developed along with the body chart pain diagram, it should be administered at the beginning, as well as at the end, of the study so that the researcher can gauge any effects as a result of participating in and/or completing a study. Most of the research studies reviewed in this work followed similar formats.

The author has created a body chart pain diagram along with a set of questions (see Appendix) based on Dell's survey, and the author's personal experience with observations made at an international airport that may be useful for researchers who wanted to perform further ergonomic evaluation or studies on baggage handlers.

CHAPTER 5

CONCULSIONS

5.1 Author's Original Goal

The goal of this thesis was to highlight the ergonomic afflictions endemic to baggage handlers and their work environment. The first step in this process was to establish contact with the safety professionals of the major airline circuit at the local international airport. The second process was to perform an extensive literature review on the relevant topics specific to the subject of baggage handlers and ergonomics. The third stage of the process for this thesis was to remotely monitor and observe baggage handlers performing everyday tasks such as working flights, and transferring baggage.

Unfortunately, given the stringent political climate that now exists since the tragedies of 9/11, monitoring transportation and airport operations were almost impossible to establish. With the heightened state of national, as well as airport and airspace, security my access to the baggage handlers, along with the interviews, was severely restricted.

On the topic of baggage handlers and ergonomics afflictions, scientific literature and research is limited. This topic was not seriously being followed until about the late 70's, early 80's. Since this time period there have been a few scientific papers related to this issue, which I have reviewed in my thesis.

5.2 The Future of Baggage Handling

Assessing the ergonomic afflictions of baggage handlers is not an easy task. Unlike other material handlers, the baggage handler's job is extremely dynamic. Other material handlers that work in factories, production and assembly lines, do not deal with the same issues that baggage handler do. Baggage handlers have to work both inside and outside during all types of weather, work in confided spaces, have to deal with very little uniformity when it comes to package weight, size and dimensions, and commonly have to push, pull, grab, and reach for materials that are being handled. Considering this, it is clear that these nuances make the baggage handler's job different from that of a typical material handler's and thus should be researched differently.

Most literature focusing on the ergonomic issues of the baggage handler focus on back pain and injury. Like most material handling jobs that involve repetitive heavy lifting the back tends to cause the most frequent problem, with the baggage handler being no exception to this phenomenon. Many reviews for material handling feel that the back belt is the answer for this.

However, for the baggage handler recent scientific literature states that the back belt is not ideal for baggage handlers due to the dynamic nature of their work. Baggage handlers need to have a full range of motion while working, as they reach, pull, push, lift, twist, bend and carry their materials in various awkward positions. The back belt restricts certain ranges of motion, by design, to prevent awkward lifting, which some baggage handling entails. From the feedback gathered by the surveys for baggage handlers it was stated that some handlers felt that the belt rode up and down there torsos pinching and irritating their skin causing the baggage handler to discard the belt after a few uses (Reddell et al, 1992).

The back belt keeps the abdominal walls (muscles) warm which can lead to sweating around the belt area especially when working in hot weather (Reddell et al., 1992). In cold and freezing weather the sweat produced by the abdominal wall and the belt can lead to the moisture icing up on the belt and leading to more discomfort (Reddell et al., 1992).

Another observation about the belt is how it affects the intra abdominal pressure (IAP) of the wearer. Although early reports in the latter 80's and early 90's, by McCoy (1986), Lander, et al., (1990), and Kumar et al., (1986), claimed that increased IAP reduces the compressive forces about the lumbar spine as well as decrease muscle activity and exertion in the abdominal wall during lifting, there were adverse effects to IAP (Reddell et al, 92). Increased IAP was shown in one study to also increase systolic blood pressure, associated with blood flowing to the heart, there by possibly overloading the heart which may lead to heart failure. Given such serious observation more research is needed before conclusions can be drawn about the effectiveness of the back belt to decrease the rate of lumbar injury.

The National Institute for Occupational Safety and Health (NIOSH) and the Occupational Safety and Health Organization (OSHA) do not endorse or support the use of the back belt as means to protect against lumbar injury. The back belt is not recognized as personal protective equipment (PPE) by OSHA (national safety council 95).

5.2.1 Workstation Redesign

The workstation of the baggage handler is a dynamic one usually rotating inside and outside various parts of the airport, and aircraft. Research has shown that the most hazardous place for baggage handlers to perform their tasks is inside the cargo bin of a narrow body plane (Dell, 1997). Although the advancement of aircraft material handling technology has made it so that baggage handlers no longer have to manually load the cargo holds of wide bodied aircraft, the loading and unloading of narrow bodied aircraft still require that baggage handlers bear the brunt of this task. Baggage handlers have to kneel inside the narrow body aircraft stacking baggage and materials from the walls to the door of the cargo bin. Unfortunately, these unfavorable ergonomic working postures (kneeling and crouching in cargo bin) are not easily controllable without the implementation of engineering controls. Personal Protective Equipment (PPEs), such as back support aids, etc., in this case would only mask the problem(s) instead of eliminated them. This is why the redesigning of narrow body aircrafts, or implementing mechanical aids, would be the best solution. Some narrow body aircrafts are designed with stacking mechanisms. A great example of this is *The System,* a luggage stacking mechanism created by a Scandinavian (aircraft) Belly Loading Company. Thus, far the reviews on this device are very favorable, with reports of 25% reduction in sick leave for baggage handlers, 3% reduction in workers needed for the operation, and 50% reduction in the occurrence of damage luggage and the lining of the cargo bin (Johansen, 1995). Industry reports states that for the 17 aircraft fitted with this mechanism, the savings costs over three years is two million dollars (Johansen, 1995). However, these aircrafts are in a very small minority (Dell, 1997). To add automated stacking mechanisms, such as the

Scandinavian Belly Loading Company, Sliding Carpet Loading System, to the existing fleets of narrow bodies would be extremely costly (Dell, 1997). The ideal scenario would be to factor these conditions into newly designs aircrafts, making it a standardized part of engineering design and control. Unfortunately, the aircraft manufactures main concerns while designing aircrafts are fuel consumption, payload (maximizing cabin space), range (traveling distance), and low operating cost. Until more research can be done to quantify the dollars spent on back injury claims by baggage and aircraft material handlers, manufactures are reluctant to change designs that have been the staple of their business for many years, so only factors essential for the airline's operation is considered.

Another important factor to be considered is the maintenance of the lifting and stacking mechanisms, or baggage transfer systems, used in wide body aircraft. Reports show that when these lifting mechanisms break down the baggage handler is left having to compensate by doing the work of these machines. Surveyed responses from baggage handlers and safety professionals reveal that baggage handlers doing the work meant for these machines lead to high rates of back and bodily injury (Dell, 1997). Airline companies must make the immediate repair of broken lifting and stacking mechanisms top priority, as they do for any other mechanical deficiency of the aircraft needing repair.

The redesign of conveyor belts should be strongly considered for the inside facilities of the airport. Surveyed responses by baggage handlers revealed that almost half of them felt that the conveyor belts in use were not optimally laid out (Dell, 1997). Experiments done on redesigning of conveyor belts considered four factors for optimal design: height, angle, velocity, and clearance underneath the belt. Some reports show that airports with two tier conveyor belt system put workers at a higher risk for lumbar injury because the top and lower belts level are too high low (Vi, et al., 1998). Consolidating two belt systems to one is the optimal. Responses from baggage handlers as well as height optimization tests of conveyors show that 65 to 83cm, from the ground to the conveyor frame's edge, is the ideal height for a single tier conveyor (Vi, et al., 1998, and Thomas et al., 1995). The optimal speed for conveyor belts was shown to be 0.48 m/s, which is considered standard for most conveyors. Faster speeds were shown to cause higher error rates in baggage handling quality, i.e. misread labels on bags and wrong destination choices. Test on conveyors has found that the most optimum angle was found to be an angle of about 25° degrees. Angles much higher than 25°, by 5° degrees or more, tested higher for dropped bags rolling of the convey line, thus reducing the quality and speed of baggage handling (Thomas et al., 1995). It was also recommended that the conveyor have some form of paddling on the sides and edges because it was recognized that baggage handlers would lean on the sides of the conveyor to get leverage or rest when attempting to handle heavy or oversized bags (Thomas et al., 1995). A clearance space underneath the conveyor should be allotted for baggage handlers to position their feet when attempting to lift heavier bags, as research has shown baggage handlers tend to hurt their knees and lower legs in the attempt to position themselves close to the conveyor (Thomas et al., 1995).

In addition to this, it would be better if manufactures of airport equipment could go one step further by making baggage belt systems' height fully adjustable to account for a larger scale of the working population, i.e. woman, and smaller/larger men outside the average population. Moreover, automated or mechanical lifting aids built into or on top of the conveyor systems would allow baggage handlers to lift heavier bags without fear of injury. In Europe such devices are produced and implemented in European airport facilities. AirGro, a, European mechanical lifting mechanisms manufacturer, is one of the leaders spearheading, this effort (Dell, 1997).

5.2.2 Administrative Controls

The importance of stretching and proper lifting techniques is key towards making an immediate difference in the back and injury rate problem for the baggage handler. Surveyed responses of baggage handlers from various airlines show that over 90% felt that training on how to lift with restricted postures in a confine space should be mandatory. Approximately 70% of the baggage handlers surveyed felt that stretching and lifting should be made mandatory for all baggage handlers (Dell, 1997). Interviewing Jason Barrett, a Safety Specialist for a leading Aviation company stated that baggage handlers are given training in lifting and stretching, but the practice and reinforcement of this is left to the baggage handlers. This is consistent with Dell's finding that although airline companies state that they are placing emphasis of back care training, the incident rate of back injury has shown no downwards trend during the three year observation and study period. Given this, a renewed emphasis should be placed on, not just the theory of back care, but on the full implementation of these techniques on a regular basis. The lead or floor supervisor should be responsible for the implementation.

Another area that should be reviewed with great concern is the weight limit set for passenger baggage. Thus far studies have shown that the ideal weight for baggage handlers to lift/carry is about 16 to 20kg (35 to 45lbs). Weights higher then this can significantly increase the risk of back injury (OHSA, 1988). Unfortunately, most airlines have their maximum baggage weight set at 32kg (70lbs). Surveyed responses from baggage handlers as well as aviation safety professionals revealed that overweight passenger baggage is thought to be one of the leading causes of back injury (Dell, 1997). Many airline companies do not put a weight restriction on baggage that must be lifted/carried by baggage handlers. If a weight limit is imposed on passenger baggage, most airlines charge a nominal fee for the excess weight of the bag(s), still allowing the baggage to be checked in. This practice does not help or solve the problem of overweight bags at all, passing the problems along, with all of the negative ergonomic issues, to the baggage handlers (Dell, 1997). On the flip side, airlines are very conscious about potential loss of revenue due to customer dissatisfaction with strictly imposed baggage weight limits. It appears that most airline companies would rather take the chance with the welfare of their baggage handlers, than to make paying customers repack and potentially unhappy (Dell, 1997). These would be returning customers could then go to another airline that does not impose such inconvenient rules for passenger baggage.

Therefore, in order to truly be effective with the weight restriction problem of passenger baggage the airline companies must form a unified front in making this expectation of passengers and their baggage a rule. Without domestic and international unified consistency amongst airline carriers this effort will be trivial. Passengers and their baggage travel all over the world, thus if one airline does not follow this code then all airlines are adversely affected.

On the same note, if airline companies feel that they must maintain flexible due to the fear of the loss of potential revenue, then there are other ways to protect the interest of the baggage handler against overweight baggage. A simple way to do this would be to have a universal or worldwide system of marking bags that are over a certain weight limit regardless of the size of the bag (e.g. smaller bags can be packed with machine parts that are dangerously heavy, as stated by a baggage the author was in contact with).

5.3 Final Thoughts

Realistically, all of these changes and recommendations will cost the airline industry billions of dollars to change, fix, and re-engineer. Given the current financial state of the airline industry, mostly impart to the terrorist attacks on 9/11, these changes do not seem to be very likely in the near future. Most financial efforts are being spent of systems security to meet up with many of the federally imposed safety changes that companies in the airline industry must adhere to. Given the current state of affairs it might be some time before the airline industry can refocus its efforts on ergonomic and employee safety. When this time comes, it will be very important for all company officials of the airline industry to quantify their incident rates of lumbar injury.

APPENDIX

MODEL FOR FUTURE BAGGAGE HANDLING SURVEY

This Baggage Handler's survey was developed for the workers of the Airline that the author was investigating. The survey contains a pain body chart diagram that would be used to better access the aches and pains that baggage handlers might have before and after load/unloading flights.

Questions for Baggage Handlers

The purpose of this survey is to perform an ergonomic evaluation of the work performed by baggage handlers. The information provided in this survey will be used to better understand and anticipate the ergonomic disorders and afflictions common to material handlers, but specific to baggage handlers. This information will be used solely for academic purposes only. The identity of the workers, and the company worked for, will be held strictly confidential.

Please check off the one you feel is most likely to cause ***INJURY*** *(choose only one)*

Manual Handling LOCATIONS Ranked MOST Likely to Cause Injury.	
Baggage room	
Inside narrow body aircraft baggage compartments	
Inside wide body aircraft bulk hold	
Outside aircraft on the tarmac	

Please check off the one you feel is most likely to cause ***INJURY*** *(choose only one)*

Manual Handling TASK Ranked MOST Likely to Cause Injury.	
Loading baggage onto carts in the baggage room	
Loading cans in the baggage room	
Unloading baggage carts in the inbound baggage area	
Unloading cans in the inbound baggage area	
Pushing and pulling loaded baggage carts, cans, pallet dollies, etc	
Transferring baggage from a carts to mobile belt positioned at the aircraft	
Transferring baggage from a carts directly into an aircraft through the cargo Door	
Pushing baggage from the doorway is not the baggage compartment of narrow body aircraft	
Stacking baggage inside the baggage compartment of narrow body aircraft	
Pushing and pulling container and pallets inside wide body aircraft (when inoperative)	
Stacking baggage in the bulk hold on wide body aircraft	
Lifting baggage on &off conveyors	

Please answer with: Yes=Y Not sure=X No=N

Injury experience	
Have you personally experienced back injury while handling baggage?	
Has back injury reduced your ability to handle baggage?	
Has the injury recurred since the first occasion?	
State number	
How many days of work have you lost due to back injury in past year? (if worked less than one year, then year to date.)	

Please answer with: Yes=Y Not sure=X No=N

Strategies to Prevent Back injuries	
Do you wear a back belt?	
Do you think Back belts prevent injury?	
Are all overweight bags tagged with a notice?	
Do you stretch (warm-up) before and after flights?	
Does your training include how to warm up (stretching) before lifting bags?	
Are stretching techniques part of your daily briefing?	
Is this (stretching techniques) enforced before and after flights?	

Please answer some demographic questions.

What is your gender: Male/Female?	
How long have you worked as baggage handler?	
List any health problem(s) that resulted from handling baggage.	
How old are you?	
What is your current job title?	
What are your days/years of experience in your current position as a baggage handler?	
How many shifts do you work on an average week?	

INSTRUCTION: PLEASE CIRCLE WHICH BODY SEGMENT HURTS BEFORE (B) AND/OR AFTER (A) A FLIGHT.

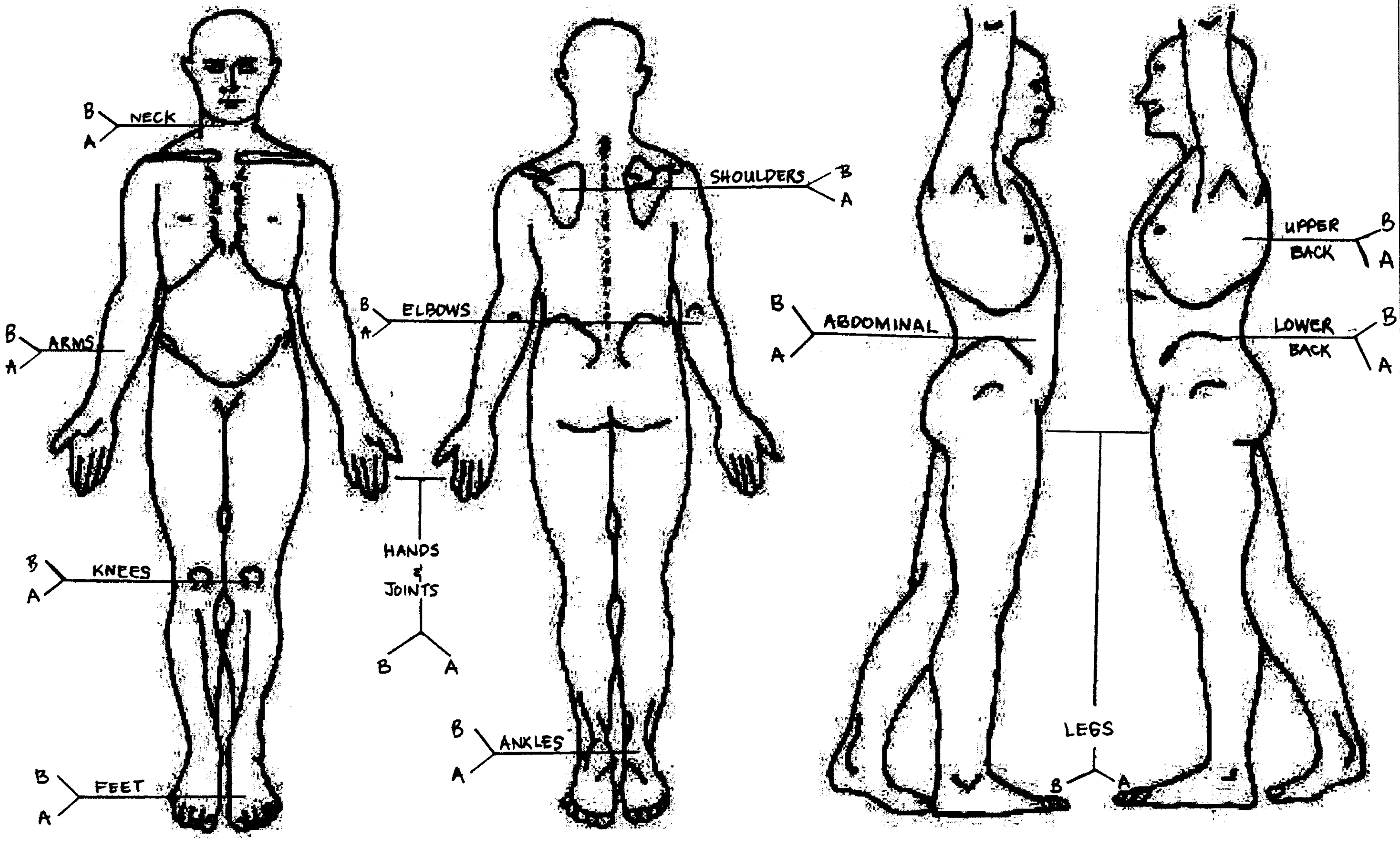

Figure A.1 Pain Body Chart.

REFERENCES

[1] ARTEX, Airline Baggage Handling Back Injury Survey, International Air Transport Section (ARTEX), National Safety Council of America, Itasca, 1981.

[2] Bernard, B.P., Musculoskeletal Disorders (MSDs) and Workplace Factors, U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, Cincinnati, OH, July 1997, http://www.cdc.gov/niosh/ergosci1.html.

[3] Bohr, P.C., et al., Implementing Participatory Ergonomics Teams among Health Care Workers. American Journal of Industrial Medicine, Volume 32, 1997, pp. 190-196.

[4] Borg, G., Psychophysical Scaling with Applications in Physical Work and the Perception of Exertion, Scandinavian Journal of Environmental Health, 1990, pp. 55-58.

[5] Chaffin, D.B. and Anderson, G.B.J., Occupational Bio-mechanics, John Wiley &Son, 1984.

[6] Chappell, D., Di Martino, V., Violence at work, International Labour Office, Geneva, 2000.

[7] Dell, Geoff, Airline Baggage Handler Back Injuries: A Survey of Baggage Handler Opinion on Causes and Prevention, Safety Science Monitor, Volume 2 Issue 2, Article 6, 1998.A

[8] Dell, Geoff, Survey of Airline Baggage Handlers Suggests Methods to Prevent Back Injuries: Flight Safety Foundation Airport Operations, Volume 24, Number 5, October 1998.B

[9] Dell, Geoff, The Causes and Prevention of Baggage Handler Back Injuries: A Survey of Airline Safety Professionals; Safety Science Monitor, Volume1, Issue 3, Article 3, 1997.

[10] Evidence for Causal Relationship Between Physical Work Factors and MSDs, http://www.cdc.gov/niosh/ergosci1.html 2003.

[11] Garg, A, Lifting and Back Injuries: A review of the causes of this Industrial Health problem, and the Major Methods to Combat it, Plant Engineer, Volume 36, 1982, pp. 89-93.

[12] Harman, E A, Rosenstein, RM, Frykman, PN and Nigro, G. A., Effects of a Belt on Intra-abdominal Pressure During Weightlifting; Med Sci Sports Exercise, Volume 21, No. 2, 1989, pp.186-190.

[13] Jensen, P., Can Participatory Ergonomics Become the way we do Things in this Firm: The Scandinavian Approach to Participatory Ergonomics. Ergonomics, 1997, pp. 1078-1087.

[14] Johansen, T., Evaluation Report: Sliding Carpet Loading System Servicing: Braathens SAFE's 17B737-500, Braathens SAFE, Oslo, 1995.

[15] Jorgensen,, K., Jensen, B., Stokholm, J., Postural Strain and Discomfort During Loading and Unloading Flights: An Ergonomic Intervention Study, Trends in Ergonomics/Human Factors IV, North Holland, 1987, pp. 663-673.

[16] Keyserling, W.M., Armstrong, T.J., C.M., Wilson, J.R., Corlett, E.N., Manenica, I. (eds); Job Evaluations Procedures to Identify Ergonomics Stress in Haslegrave, *Work Design In Practice Taylor &Francis, NY, Ch. 14, 1990.*

[17] Kourinka, I., Jonsson, B., Kilborn, A., Vilerberg, H., et al., Standardise Nordic Questionnaires for the Analysis of Musculoskeletal Symptoms, Applied Ergonomics, Volume 18, 1987, pp. 233-237.

[18] Kumar, S., Godfrey, C. M., Spinal Braces and Abdominal Supports in Karwowski, W. (eds), Trends in Ergonomics/Human Factors III, North-Holland: Elsevier Science, 1986, pp. 717-726.

[19] Lander, J.E., Simonton, R.L., Giacobbe, J.K.F., The Effectiveness of Weight Belts During the Squat exercise Med Sci Sports Exercise, Volume 22, Number. 1, 1990, pp. 117-124.

[20] McCoy, M.A., An evaluation of Back Support Devices for Lifting Tasks, Unpublished Master's Thesis, Texas A&M University, College Station, TX, 1986.

[21] McGill, S., Abdominal Belts in Industry: A Position Paper on their Assets, Liabilities and Use, American Industrial Hygiene Association Journal, Issue 54, December 1993, pp. 752-754.

[22] Morris, J.M., Lucas, D.R., and Bresler, B., Role of the Trunk in Stability of the Spine, J Bone J Surg, Volume 43-A, Number 3, pp 327-351, 1961.

[23} NIOSH, Do They Prevent Injury, Publication No. US Department of Health and Human Services, National Institute for Occupational Safety and Health (NIOSH), Cincinnati, 1994.

[24] NIOSH, Workplace Use of Back belts: Review and Recommendations, Publication No. US Department of Health and Human Services,National Institute for Occupational Safety and Health (NIOSH), Cincinnati, 1994.

[25] Occupational Health and Safety Authority, Regulations and Code of Practice for Manual handling, Government of Victoria, Melbourne, 1988.

[26] Okada, F., Personal Communication, Reddell, C. R., Congleton, J. J., Huchingson, R. D., Montgomery, J. F., *An Evaluation of a Weightlifting Belt and Back Injury Prevention Training Class for Airline Baggage Handlers:* Applied Ergonomics, Volume 23, Number 5, October 1992, pp. 319-329, 1987.

[27] Reddell, C. R., Congleton, J. J., Huchingson, R. D., Montgomery, J. F., An Evalution of a Weightlifting Belt and Back Injury Prevention Training Class for Airline Baggage Handlers: Applied Ergonomics, Volume 23, Number 5, October 1992, pp. 319-329.

[28] Rosskam, E., Airport Check Work: Consequences for Worker Health and Management Practices, Socio-Economic Security Programme International Labour Office, Geneva, Switzerland, 2004.

[29] Snook, S. H., The Design of Manual Handling Tasks, Ergonomics, Volume 21, No. 12, 1978, pp. 963-985.

[30] Thomas, R. G., Van Baar, C. E., Van der Stee, M. J., Baggage Handling Postures and the Design of Conveyors, Journal of Applied Ergonomics, Volume 26 Number 2, 1995, pp. 123-127.

[31] Ulin, S. S., Snook, S. H., Armstrong, T. J., Herrin, G. D., Preferred Tool Shapes for Various Horizontal and Vertical Work Locations, Applied Occupational and Environmental Hygiene, Volume 7, 1992, pp. 327-337.

[32] Vi, P., Penyk, R., Brechun, W., Lefebvre, P., Ergonomic Improvements To A Baggage Conveyor System At a Large Airline Company, Proceedings of the 30th Annual Conference of the Human Factors Association of Canada, 1998, pp. 323-327.