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An Overview in the Ergonomics of an Office Computer Workstation

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AN OVERVIEW IN THE ERGONOMICS OF AN
OFFICE COMPUTER WORKSTATION

by

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University of North Dakota, 1995

An Independent Study
Submitted to the Graduate Faculty of the
Department of Physical Therapy
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in partial fulfillment of the requirements
for the degree of
Master of Physical Therapy

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This Independent Study, submitted by James Matetich in partial fulfillment of the requirements for the Degree of Master of Physical Therapy from the University of North Dakota, has been read by the Faculty Preceptor, Advisor, and Chairperson of Physical Therapy under whom the work has been done and is hereby approved.

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Department Physical Therapy

Degree Master of Physical Therapy

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ABSTRACT

Ergonomics is an applied science concerned with adapting a workplace environment to match the capabilities of a worker and ensure the worker's safety. The study of ergonomics is one of increasing interest to American business. Specifically, the ergonomics of the office computer workstation has come under growing scrutiny due to a tremendous rise in the reported incidence of work related injuries. Workers, in this work environment, appear to be at a greater risk of injuries to the back, neck, shoulder, forearm, wrist, hand, and leg. These injuries, classified as cumulative trauma disorders or CTDs, can be attributed to ergonomic hazards such as poor workplace design, repetitive movements, awkward body mechanics, and prolonged static positions.

The impact of these ergonomic related injuries is being felt by many businesses in the form of increased workers' compensation and health insurance costs, decreased productivity, increased worker absenteeism, and often decreased worker morale.

Physical therapy can play an important role in helping reduce the effects of the growing problem of CTDs in the workplace. Consultation with employees and employers regarding education in proper body mechanics, posture,
exercise, and workstation design is one way in which the physical therapist may aid in decreasing the incidence of work related injuries.

The purpose of this paper will be to give an overview of ergonomics and ergonomic related injuries in the computer office workstation. This review will be done to examine the effects that these injuries have on employees and employers alike, and any benefits that ergonomics may provide in the prevention of these injuries. These benefits are not only for the safety and comfort of a worker, but also for the profitability of a business.
CHAPTER I

INTRODUCTION

Today, an ever increasing number of the American workforce is finding itself in a seated position for the majority of the work day. It has been estimated that approximately three quarters of all workers in industrialized countries have sedentary jobs. Sedentary work is defined by the United States Department of Labor as "work exerting up to 10 pounds of force occasionally and/or a negligible amount of force frequently or constantly to lift, carry, push and pull, or otherwise move objects, including the human body. Sedentary work primarily involves sitting; however, it may also involve walking or standing for brief periods of time." As defined by Eastman Kodak in 1983, seated tasks require or feature the following characteristics: visual acuity; repetitive movements, particularly fine manipulation of the forearms and hands; and sitting for more than four hours.

The advent of the computer and the visual display terminal (VDT) has revolutionized the manner and amount of information handled and processed in the office setting. It has enhanced the ability to gather and exchange information and resources. The access to information and data from around the
world through telephone modems and other communication links allows for business transactions to be completed through the use of a computer monitor.

While this "electronic office" has altered the way business is conducted, it has also changed the manner in which the people working in this environment do their jobs. People spend long hours at computer terminals performing repetitive tasks.

Technological advances in information processing have risen faster than the changes in the work environment. As this demand for information increases, so does the demand on data entry personnel and other information workers. These people spend hours in fixed positions either entering data or gazing at monitors or printouts. Jobs that once had a wide variety of tasks, which allowed workers to get up from their work areas and change body positions, now require sitting for long periods. This contrast is apparent in industries such as banking, insurance, publishing, and airlines. Computers are now being used by clerical workers, dispatchers, machine operators, medical workers, and in numerous other situations.

The increased demand for information and the stresses that it has placed upon the workers processing it has led to an increase in these workers experiencing what have become known as "cumulative trauma disorders" (CTDs). These injuries occur over time as workers are exposed to such things as repetitive tasks or prolonged postures. These injuries may be appearing now in the office environment because many workers are spending more time at a
computer monitor and keyboard. Much of their movement is isolated to typing without the additional movement required to move a manual carriage return or withdraw and insert paper into a typewriter as was done before the advent of the computer. Adding to the lack of motion may be the advent of the modem which allows for telephone communications without picking up a receiver. For a data entry worker, this allows more time to be spent with his/her hands on the computer keyboard while taking fewer breaks from this task.\(^2\)

This work environment has led to increased concern about the safety of the seated workstation and the negative effects which it may have on workers. Researchers began studying the effects of the seated workstation in the 1940s. Studies reveal that pressure in the discs of the human vertebral column is greater when a person is sitting than when he or she is standing. Because of this, a worker remaining in this position for the majority of the workday places a great deal of stress on the discs increasing the chances that they will be injured over time. Extended periods of sitting with poor posture also places a great deal of stress on muscles of the back and neck. The prolonged muscle contraction required to maintain these postures results in a subsequent lack of circulation and increases the risk for fatigue and injury to these structures.\(^1\) Finally, exposure to environmental stresses (such as noise, temperature, poor lighting, and glare), along with certain psychosocial stresses, may have an effect on the health of a person working in this atmosphere. Consequently, the computer
work site is coming under greater scrutiny in today's office computer workplace in an attempt to determine a way of preventing workplace illnesses or injuries.

One method of helping to decrease the risk of injury and ensure the safety of a worker at an office computer workstation involves adapting the job environment to better fit the physical and mental capabilities of the worker. This method is at the heart of the applied science of "ergonomics."

Ergonomics looks at the human, tools and equipment, job task, workstation, and environment as a complex system of interacting components. At the center of the system is the human or worker. Areas affecting the worker are the tools or equipment used, the task undertaken, and physical components of the workstation. These areas, along with the overall workplace environment, including management, are studied to determine how each may have a direct or indirect influence on the human/worker and his/her ability to safely and productively complete the task.

The purpose of this paper will be to give an overview of ergonomics and ergonomic related injuries in the computer office workstation. This review was done to examine the effects that these injuries have on employees and employers alike, and any benefits that ergonomics may provide in the prevention of these injuries. These benefits are not only for the safety and comfort of a worker, but also for the profitability of a business.
CHAPTER II
HISTORY OF ERGONOMICS

The science of ergonomics is approximately 40 years old. It was founded by a group of British anatomists, physiologists, psychologists, and engineers who advocated a multidisciplinary, scientific approach to the study of work efficiency. A similar discipline emerged in North America and was called human factors. Both are associated with the science of ergonomics. The term ergonomics was introduced into the literature by Wojciech Jastrzebowski (1799-1882), a Polish educator and scientist. The term finds its origin from two Greek words, "ergos," meaning work, and "nomos," meaning laws of. Thus, in its simplest translation, ergonomics means "the laws of work."

Today, the definition may include all of the following: "the study of human behavioral and biological characteristics for the appropriate design of the living and working environment"; "the science of designing workplaces with the capabilities and limitations of the human body in mind"; "an applied science concerned with the design of workplaces, tools, and tasks to match the physiologic, anatomic, and psychological characteristics and capabilities of the worker"; "the science of adapting products and processes to human characteristics and capabilities in order to improve people's well being and to
optimize productivity,"7 "to optimize the functioning of a system by adapting it to human capacities and needs,"8 "human factors engineering,"9 "the science of adapting products and processes to human characteristics and capabilities in order to improve people's well-being and to optimize productivity."10 As can be seen, the definitions are varied and many, but all center on the idea of fitting the work to the worker!

Much of the interest in and study of ergonomics originated in response to the recognition of occupational hazards in the workplace many decades ago. Recognition of "certain violent and irregular motions and unnatural postures of the body, by reason of which the natural structure of the vital machine is so impaired that serious diseases gradually develop therefrom" was noted more than 200 years ago by an Italian physician named Bernardino Ramazzini.6

The basic concept of ergonomics, that of adapting one's workplace, is not a new one. People throughout history have innately modified their environment to better suit or "fit" themselves. Thomas Jefferson, being rather tall for his time, organized his furniture at Monticello to better accommodate his size. Wishing to work as efficiently as possible and to place as little stress as possible on a sore wrist, he combined a swivel chair equipped with candles held in the armrest for lighting, with an armless, backless couch that could be slipped under his writing table so he could write sitting upright or with his legs stretched comfortably in front of him. A book stand allowed him to work with five books at once, rotating the stand to the material he wished to view. Documents were all stored in file
cabinets within reach of his special chair. Jefferson's understanding that the need for comfort and support to promote his productivity is a testament that ergonomics is applied common sense.\textsuperscript{11}

The history of formal ergonomics can be traced back to the late 1800s and the early 1900s. This was a period which began the "industrial revolution." Industries in the United States and around the world increased their productivity through the advent of assembly line mass production. Many individual workers no longer participated in multiple job tasks, but rather performed a smaller set of tasks over and over again.\textsuperscript{8} Frederick W. Taylor, a work management theorist, began to quantitatively look at ways to organize work and manage workers to increase output.\textsuperscript{3} Although he did not use the term ergonomics, Taylor performed detailed studies that provided the foundation for the study of ergonomics. He emphasized that one must observe, measure, and study human behavior during work if there is to be an improvement in organizational efficiency.\textsuperscript{1} He developed the concept that by simplifying worker tasks, production would be increased.\textsuperscript{12} His books, \textit{Principles of Scientific Management} (1911) and \textit{Shop Management} (1919), are considered by many to be classics in ergonomics and industrial engineering. At about the same time, Frank and Lillian Gilbreth were working on time and motion analysis techniques for consistently analyzing work activities. The work by Taylor and the Gilbreths generally is regarded as the beginning of the scientific study of the relationship of workers and work.
During World War I, the military became interested in this relationship. They were interested in being able to rapidly select, classify, and train their available men for a variety of jobs. Military researchers were interested in any relationship that could be found between the criteria for selection of personnel and their subsequent performance; in other words, how they could most efficiently match the work with the worker. However, post war research was hindered by scarce funding due to the Depression, and an ample supply of inexpensive laborers decreased interest in utilizing workers more efficiently.

However, when World War II began, interest in personnel selection and performance was once again revived. Early in the war, the British started the first true ergonomic research center, the Applied Psychology Unit of Cambridge University, directed by Sir Frederic Bartlet. Bartlet is also considered one of the pioneers in the field of ergonomics. In the United States, ergonomics, or engineering psychology as it was called, gained the status of a recognized discipline. The purpose of these institutions was to try to make the men and women in the armed and civilian forces more efficient at manufacturing and operating the advancing military technology and machinery of the day.

In both Britain and the United States, unexplained problems and incidents were occurring with this technology. One of the most notable occurred at United States military flight schools where there was great pressure to train as many pilots as possible and get them involved in the war. In a 22-month period, it was noted that over 400 crashes had occurred which was a truly
inordinate number. An investigation into the accidents led to the discovery of two significant findings: first, the control lever for the landing gear was right next to the lever for the wing flaps; second, the handles were identical in design. It was determined that the pilots, under the stress of landing their aircraft, believed that they were lowering the wing flaps but were actually retracting their landing gear. The results of this "ergonomic" error were obvious and exemplified how the design and demands of the machinery and work site had not been successfully fit to the worker.

Following the war, several military human engineering research facilities were established in the United States to help understand and solve human-machine problems. In addition, research grants were given to several universities to begin building the knowledge base about people and their relationship to military equipment. In these facilities, ergonomics became a part of the design and development of most military related equipment and technology.

The science of ergonomics grew further in the 1950s. Several ergonomic professional organizations were established encompassing and including many scientific disciplines, such as engineering and medicine: The British Ergonomics Research Society in 1950, the Human Factors Society in 1957, and the Society of Engineering Psychologists, a division of the American Psychological Association, in 1957.
Today, the science of ergonomics continues to be an interdisciplinary field adding to its ranks the areas of computer science and business to help in studying and instituting the goal of matching the demands and requirements of the job to the abilities and capabilities of the worker. Interest in this science has grown rapidly as the number of workers displaying ergonomically related injuries has risen dramatically during the past 15 years. Influenced by rising health care, workers compensation, and production costs, American businesses are encouraged to apply ergonomic concepts to their operations in order to ensure profitability and the safety of American workers.\textsuperscript{13}
CHAPTER III
ERGONOMIC RELATED INJURIES

Cumulative trauma disorders (CTDs) were the fastest growing occupational illness of the 1980s and have become the occupational injury of the 1990s.\textsuperscript{13,14} They now account for more than 60\% of all occupational illnesses in the United States.\textsuperscript{9} This translates to approximately 14 to 18 million cases of CTD each year according to the National Center for Health Statistics.\textsuperscript{15} Cost estimates to American businesses vary from $20 billion in workers compensation expenses,\textsuperscript{16} $20 billion in medical costs and lost wage benefits,\textsuperscript{17} to a total of $100 billion in lost wages, medical, workers compensation, and other related costs.\textsuperscript{9} The Bureau of Labor Statistics reports that documented work related trauma illnesses have risen from approximately 25,000 in 1982 to 306,000 in 1993.\textsuperscript{18} Liberty Mutual Insurance Company, one of the largest providers of workers' compensation insurance in the United States, reports that since 1987 the cost of upper extremity CTDs as a percentage of all of their compensation costs have quadrupled.\textsuperscript{8} As a whole, CTDs now account for approximately 62\% of all workers' compensation claims based on 1993 Bureau of Labor Statistics.\textsuperscript{19} The National Council on Compensation Insurance estimates that the lost wages and medical expenses for an average CTD claim are $29,000.\textsuperscript{20} The National
Institute for Occupational Safety and Health (NIOSH), in a Health Evaluations and Technical Assistance report of the Los Angeles Times, found that the percentage of upper extremity work related musculoskeletal disorders among randomly selected employees using computer terminals was 41%. Hand/wrist symptoms were the most prevalent (23%), followed by the neck (17%), elbow/forearm (13%), and shoulder (11%) symptoms. Overall, NIOSH reports an increased incidence of ergonomic problems, such as repetitive motion and postural straining, associated with the increase in computer terminal operators. Today, it is estimated that over 40 million people (approximately 40% of the labor force) work at computer keyboards. It has been estimated that 50 cents of every workers' compensation dollar in the 1990s will be spent on CTDs attributed to the use of computers and keyboards. It has also been estimated that the cost of lost productivity and the cost of treatment of computer related injuries are approximately $7 billion a year. Musculoskeletal injuries have now become the leading cause of disability among persons during their working years (18 to 64 years of age).

As these figures suggest, the magnitude of the cumulative trauma disorder is immense. Costs to employers can be both direct and indirect. Direct costs include those mentioned previously, such as workers’ compensation payments for lost work time, increased insurance premiums based on frequency and total costs of claims (experience), and medical and rehabilitation costs for employees. Indirect costs include payments related to employee absenteeism,
replacement wages, training and development costs, productivity losses, lower employee morale, and increased turnover. As it is difficulty to calculate these indirect costs, the total economic effect of occupational cumulative trauma disorders is probably much higher.

Injuries resulting from repetitive motion or prolonged static postures have been known to medical science for centuries. Bernardino Ramazzini, an Italian physician and regarded by many as the father of occupational medicine, described pain in the hands of scribes who were continually performing the seemingly sedentary task of sitting and copying or writing the texts of books over 250 years ago. Herman Oppenheim, a German neurologist, was among the first to show an occupational link to nerve injuries in workers' hands. In his book, *Textbook of Nervous Disease* (1911), he lists laundry women, joiners, locksmiths, milkers, cigar makers, carpet beaters, and dentists among those prone to such disorders.

The advent of the industrial revolution expanded the incidence of repetitive motion and posture related injuries. Work once done by skilled craftsman who had performed a number of different tasks were replaced by assembly line workers who were required to perform the same tasks repeatedly. With the aid of time and motion studies and advancements in equipment, engineers were able to increase the pace of work by eliminating unnecessary movements by workers. Industries around the world enhanced and accelerated
the concepts of greater productivity through assembly line mass production practices. The focus of these workplace adaptations may be considered early ergonomic studies as they were used to reduce the time and motion spent by a worker in order to more efficiently and profitably perform a job. These were early studies in the relationship between worker and job. However, what the engineers did not study or were not aware of were the dynamics of these repeated tasks and the limitations of the human body to complete them. They apparently did not foresee the hazards which awaited workers performing the new job tasks of the Twentieth Century. The result of the ceaseless repetition of motions led to the development of cumulative trauma injuries involving muscles, tendons, ligaments, and nerves.

The injuries Ramazzini and Oppenheim observed and described fit into a classification of injury known as a work or "ergonomic" related illnesses. These are diagnoses whose risk of occurring is enhanced by some ergonomic (workplace) exposure and unlike other injuries in that the onset is gradual. These diagnoses have been given such names as repetitive stress injuries, overuse syndromes, regional musculoskeletal disorders, cervical-brachial disorders, or repetitive motion disorders, all of which are now included in the broader category of "cumulative trauma disorders" or "CTDs." These disorders were first, for the most part, experienced by "blue collar" workers; however,
since the 1980s, the health of white collar, sedentary office workers has currently emerged as a major concern for American businesses.\textsuperscript{7}

Cumulative trauma disorders can be defined as a class of musculoskeletal disorders involving damage to the tendons, tendon sheaths, synovial lubrication of the tendon sheaths, and the related bones, muscles, and nerves of the hands, wrists, elbows, neck, shoulders, and back.\textsuperscript{24} Although the exact mechanism of injury is not known, these disorders are thought to (usually) develop gradually from repeated, cumulative microtearing and trauma to soft tissues in particular muscle groups. Over time, the resulting inflammatory response and injury in the tissue may lead to tendon and synovial disorders, muscle tears, ligamentous disorders, degenerative joint disease, bursitis, or nerve entrapment syndromes.\textsuperscript{13,25} Examples include tendonitis, tenosynovitis, trigger finger, Dequervain's disease, carpal tunnel syndrome, cubital tunnel syndrome, Guyon's canal syndrome, rotator cuff syndrome, epicondylitis, and a number of neck and back disorders.\textsuperscript{13}

Risk Factors

In the computerized office work station, key risk factors contributing to excessive wear and tear on tendons, muscles, and nerve tissue resulting in CTD include:

- Repetitive movements: Tasks that require high repetition rates (such as computer keyboard data entry which, at 60 words per minute, may involve up to 18,000 keystrokes per hour) require increased muscle function and allow for
decreased recovery or rest time.\textsuperscript{9} Because of this, the muscle has less time to get rid of waste products and replenish much needed nutrients to the tissues leading to muscle fatigue. Muscles which are fatigued are more susceptible to injury. If the cumulative stress is too great, the tissues may tear, become inflamed, and possibly result in tendon damage disorders or nerve entrapment syndromes.\textsuperscript{25} According to the Occupational Safety and Health Administration (OSHA), a potential ergonomic hazard exists if a task requires the performance of the same motion or motion patterns every few seconds for more than two hours.\textsuperscript{26}

- Forceful movements: Circulation to muscles decreases as the muscular effort increases in response to a high task load. If the force requirements are too high, the soft tissues in and around the muscle or joint may be torn or may not be able to recover and rest sufficiently resulting in injury.\textsuperscript{9}

- Prolonged, static postures or awkward body mechanics: When the muscles of the hands, arms, neck, shoulders, back, and legs are held in a fairly continual state of contraction without relaxation, a condition known as static loading occurs. In this condition, because the muscles are contracted but not rhythmically relaxed, circulation is decreased and waste products, such as lactic acid (a waste product of muscle metabolism), are not carried away from the muscles at a normal rate. Also, due to the decreased circulation, nutrients carried in the blood are not supplied in sufficient amounts. A combination of waste accumulation and poor nutrition results in muscle fatigue and pain. If
such a condition continues for a prolonged period of time, injury can occur. Postures contributing to this fatigue include a forward head or shoulders; a back which is held in a slumped forward position; or arms that are held away from the body, wrists held in hyperextension, hyperflexion, or turned outward or inward. These are postures that may, if held for a prolonged period of time, increase the risk of excessive stress on tendons and surrounding tissues leading to inflammation and damage. Any resulting injury could involve pathologies such as tendon disorders or nerve entrapment syndromes. Studies of computer users reveal that although the small muscles of the forearms and hands undergo almost constant dynamic contractions, the proximal muscles of the shoulders and neck provide postural support through static contraction.

The intervertebral disc is another structure which may be influenced by static positioning. The interior of the intervertebral disc in the human spine relies not on blood supply for nourishment, but on fluid and nutrients being drawn into the disc and pushed out during movement. Frequent movement and changes of postures produce changes in intradiscal pressure acting as a kind of pump mechanism. Movement actually keeps the discs and joints healthy. Fixed, static postures do not allow for efficient waste removal and nourishment replacement within the discs. This form of static loading is further aggravated when seated in a flexed forward position. This is due to the fact that intravertebral disc pressures are increased in this position. If this occurs over a
prolonged time period, the possible cumulative effect of increased stress on the
disc with poor nourishment may result in injury and pain.\textsuperscript{28}

- Poor work environment: Probably the greatest contributing factor in
this area is that of poor lighting. A work surface or computer monitor which is
not illuminated sufficiently or which allows for glare may cause eye fatigue or
strain. Head, neck, or back pain or injury may also result as body postures are
adjusted to compensate for poor lighting on the work surface or monitor.\textsuperscript{12}

- Psychosocial factors: Stress placed upon increased production and
work load, lack of autonomy, poor morale, lack of job satisfaction, and lack of job
security all can play a role in increasing a person's risk of CTD.\textsuperscript{29}

- Non-occupational factors: Personal factors, such as age, gender,
medical history, poor physical condition, stress and tension from recreational or
home activities can contribute to a worker's predisposition to incurring a
cumulative trauma injury.\textsuperscript{29}

CTDs occur when the body is unable to keep up with the wear and tear
placed upon it. This lack of time and inability to heal may be a function of some
ergonomic related factor in the work place, some other factor away from work, or
a combination of these factors.\textsuperscript{29}

Symptoms

Workers in the seated position of the office computer work environment
may experience a variety of symptoms felt in a number of areas of their bodies.
These symptoms may be the result of a variety of factors which may contribute
to the onset of pain, discomfort, tenderness, numbness while sleeping, tingling, decreased movement or manual dexterity, weakness, or fatigue in specific areas of the body indicating that a cumulative trauma disorder could be developing.12

The following is a brief description of symptoms which may be experienced by someone at an office computer workstation along with possible precipitating factors.

Symptoms in the head, neck, shoulder, and upper back region include:

- eye strain or dryness, headache
  - computer screen too close, poor lighting, glare coming from monitor screen, decreased blinking of eyes
- pain, loss of motion on one side of the neck
  - prolonged rotation of the head to one side in order to view a computer screen or document which is located on one side of desk
- headaches or pain in the neck
  - chin or head positioned forward while seated, computer screen too high, muscle tension or improper eyeglasses which do not correct for computer work or work on the desk top
- pain in neck and shoulder on one side
  - typing while holding telephone receiver between the neck and shoulder or consistent holding of a telephone in this position while talking
• pain anywhere in the neck and shoulder
  - poor physical conditioning allowing for muscle fatigue, tension,
    slouched posture, arm rests, or chair seat too high
• pain in upper back
  - poor physical conditioning allowing for muscle fatigue, poor posture,
    poorly supported seating
Symptoms in the hand, wrist, and forearm include:
• pain in the elbow
  - keyboard slanted up at too steep an angle, table or desk too high,
    overuse of keyboard or computer mouse
• numbness in the elbow
  - supporting upper body by leaning on elbows during work or during
    home or recreational activities
• pain on top of forearm along side of little finger
  - typing with hand bent toward little finger, little finger held up while
    typing or flat-fingered typing
• pain on bottom of forearm
  - overuse, typing with wrists extended (hands bent up from wrist) or
    wrists flexed (hands bent down from wrist)
• numbness in the fingers or pain in the wrists
  - wrists bent up, resting wrists on edge of desk or wrist rest while
    typing, holding a pencil, pen, or other object too tightly
• pain in thumb or on thumb side of wrist
  - holding thumb up while typing, hitting space bar too hard or overuse of thumb, holding pen, pencil, or other object too tightly
• pain in fingertips
  - pounding or pressing on keyboard keys with too much force
Symptoms in the lower back and legs include:
• lower back pain
  - poor physical conditioning, poor sitting posture (slouching, forward head or shoulders, etc.), sitting with one foot under buttocks or poor seating (chair design)
• numbness in the legs
  - chair seat cuts off circulation, feet dangle from chair (chair too high)
  sitting with one foot under buttock

Why now? Why has the incidence of ergonomic related injuries increased so dramatically in the past 15 years? Why did CTDs not occur in the past when workers performed typing tasks on a typewriter similar to the data entry workers of today's computerized office work station? The exact reasons in the computerized office are not completely clear, but the following may give some insight to the problem.

First, the shift in the U.S. economy from one based on manufacturing to one based on service and information processing has brought about a dramatic
growth in the number of white collar office workers, with a corresponding large increase in the number using computers.

Second, the continuous use of computers in the workplace generally has meant an increase in sedentary jobs. Employees simply are moving less as they work. Also, work is becoming a little more abstract. There is a decreasing incidence of people actually getting up to file actual papers in real file folders and cabinets; instead, they move icons that represent documents into icons that represent file folders on computer monitors without ever leaving their chairs.

Third, demographics in the American office have changed. The Baby Boom Generation makes up a large share of the computer users; so, a whole generation of employees is aging at one time. The effects of age on our body's systems have been well documented. As an example, "old age" for the eyes may begin in the forties with the inability to focus on near objects. Musculoskeletal injuries are more common after age 40 as well, with slightly more than half of the occurrences of injuries such as carpal tunnel syndrome occurring between the ages of 40 and 60. There, also, is some evidence that certain disorders may occur more among females than males, and there has been an increase in the number of females in the American work force in recent years.

For all these reasons (and more), ergonomics has become a focus of concern in the computerized office. Physical, cognitive, and socio-technical factors are interacting in a complex manner which is not yet well-understood to
bring discomfort and ergonomic related injury to workers in the computerized seated work station.\textsuperscript{7}
CHAPTER IV

ERGONOMICS OF THE OFFICE COMPUTER WORKSTATION

Review of Anatomy, Biomechanics and Anthropometrics of Sitting

The problem with most office computer workstations generally involves two areas. The first comes about because the United States is made up of a wide variety of cultures and heritages. This results in a work force with varying body shapes and sizes. No two people who work in this environment will fit a workstation the same way. The second occurs because the tasks involving information handling with a computer keyboard and monitor often results in static postures and repetitive movements.31

To help better understand how ergonomics in a computerized office work station may help solve the aforementioned problems which may eventually result in stress or injury to a worker, a review of the anatomy, biomechanics, and anthropometrics of the seated position may be beneficial.

The body's bony skeletal system, made up of over 200 bones, provides the framework and support upon which the rest of our anatomy is built. While the shoulders, arms, wrists, and hands all contribute to a worker's functioning in the computerized work station, probably the single most important element in this system as it pertains to the biomechanics of sitting is the spinal column.
The spine is made up of 33 segments or vertebrae which increase in size as you descend down the column. The vertebrae make up cervical, thoracic, lumbar, sacral, and the coccyxgeal areas of the spine. The bony vertebrae are stacked one on top of the other and are separated by one of 24 intervertebral "discs." The discs can be compared to a jelly filled donut with a relatively rigid fibrous outer covering and a gelatinous inside. They serve as the weight bearing portion of the spinal column and also acts as a shock absorbing cushion for the spine. It is the disc which allows for the spine's (and thus our body's) great flexibility of movement by molding and changing shape as stresses are placed upon it.

A well balanced spine forms three natural curves in standing. The cervical curve is directed toward the front of the body (lordosis), the thoracic curve is directed toward the back (kyphosis), and the lumbar curve is directed toward the front (lordosis). Proper biomechanics in the posturing of these curves aids in efficiently distributing the load of the body through the spinal column and down to the legs. Ligaments provide stability to the vertebrae and are located on the anterior and posterior walls of the spine. Muscles along the spine help to maintain posture and provide stability to the trunk. The nerves that compose the spinal cord are protected by the vertebrae and pass to the extremities, allowing motor and sensory information to pass to and from the brain. The sacrum is essentially fixed and moves in relation to the pelvis; therefore, pelvic movement affects the shape of the lumbar spine. A forward
rotation of the pelvis causes the lumbar spine to move toward an increased inward curve or lordosis to help to maintain an upright trunk posture. When the pelvis is tilted backward, as when in a slumped seated position, the lumbar portion of the spine and its curve tend to flatten.

The biomechanical effect of decreasing this curve, as with poor posture in the seated position, has been shown through many studies to change the hydrostatic pressure within the discs placing greater stress by the gelatinous inner disc material against the fibrous outer walls of the disc. Disc pressures can increase dramatically when a person moves from the standing position to one of sitting, in some cases up to 35% greater. This is an important disadvantage of sitting. The highest level of disc pressure at 220 pounds per square inch (psi) occurs in unsupported sitting with the spine in a kyphotic position. The anatomy and biomechanics involved in sitting are important areas to be considered when discussing the ergonomics of a computerized work station.¹

Anthropometrics is another area of important consideration in the ergonomics of the computerized seated work station. Anthropometrics involves the physical measurements of the human body:² height, weight, arm reach, and hand size are all important considerations in the designing of a computer work station. Since the people working in a computerized office setting come in more than one size, attention must be given to designing a computerized work area. Proper dimensions of chairs, desks, work surfaces, and the positioning of
ancillary equipment on the desk top are important to allow for efficient and safe sitting, reaching, writing, and typing. However, averaging human body dimensions is not an efficient way to address anthropometrics in the design of a work station as very few workers will “fit” the average measurements. Because of this, the computerized work stations must be made to adjust and change to each worker’s size and shape.¹

Prevention of Ergonomic Injuries: Fitting the Worker to the Job

The study of ergonomics stresses the goal of adjusting or fitting the job conditions to the human body and in preventing or managing ergonomic related injuries. However, this author believes that this subject would not be complete without addressing the physical conditions of the body and the manner in which it is used in the computer work station.³,²⁹ Even if a worker’s body has the capability of fulfilling a particular job task, the body must be used in a biomechanically correct manner. If it is not, the result may be that no amount of ergonomic adjustment to a work station will allow for the continuous, successful completion of the task. Three important areas to be considered in ‘fitting the worker to the job’ are proper posture, body mechanics, and exercise.

Posture

A ‘rule of thumb’ for proper posture at an office computer work station is for a person to assume a position directly in front of the computer screen;³² the hips, knees, and ankle joints flexed to 90 degrees with feet firmly on the floor or foot rest; shoulder girdle over hip girdle; and the head over the shoulders to
promote the three natural curves of the spine. Another way of thinking of a proper sitting position would be to imagine a plumb line hanging along side of the body. This line should run through the middle of the ears, shoulders and hips to facilitate a proper seated posture. With this in mind, the benefits of proper posture in the prevention of cumulative trauma disorders (CTDs) at the office computer work station can be summarized by the following.

- Decreases ligamentous strain and overstretching.
- Decreases muscular strain and overstretching of back musculature which can result in muscle imbalance and fatigue.
- Decreases intradiscal pressure.
- Promotes a healthy spine because of a reduction in stress on the lumbar, thoracic, and cervical spines and shoulder girdle.
- More efficient muscle work and a reduction in fatigue because muscles are at a mechanical advantage as the postural muscles are used to support the spine and rib cage while the extremities are used to conduct work.
- Greater range of motion of the upper extremities when reaching to shoulder level and overhead because the upper body is not flexed, which limits this range of motion.
- More efficient diaphragmatic breathing because there is a greater distance between the sternum and pelvis (more room).
• Allows for more air to enter the lungs (see above), providing more oxygenated blood to vital organs, including the brain. Efficient breathing decreases fatigue, allowing for an increase in worker productivity and accuracy of work.
• Improved lower extremity circulation with proper seat tilt and depth.
• May contribute to the promotion of a more positive worker self-image.¹

Body Mechanics

A complete book could be written (and surely has been) explaining the biomechanics and physics of the body's motions while working at an office computer work station. Although the study of the dynamic and static forces along with corresponding torques and vectors of this work environment may make for an interesting discussion, it is beyond the scope of this paper. Rather, this author would like to sum up the subject of proper body mechanics in the prevention of CTDs by reviewing some recommendations for proper motion during activities generally occurring in this seated work station.

• To safely bend over to pick up an object, first slide to the edge of the chair. Then support the back with one hand on the desk and one foot in front of the other.

• When turning, an attempt should be made to turn as a single unit, rather than twisting. Also, try to keep the hips and feet pointed in the same direction as the turn.
• Reading material should be angled in a near vertical manner rather than in a position which forces a person to lean over it.

• When using the telephone, support should be given to the arm holding the phone in order to keep proper neck and shoulder alignment. Position of the telephone is also important as some research has found that reaching and lifting of a telephone results in an increase in intervertebral disc pressures.

• While writing, the arms should be supported by the writing surface (desk) which helps to transfer a portion of the body's weight through the arms and decreasing the load on the spine.

• In order to facilitate a biomechanically sound method of keyboarding or typing, the arm position should be comfortable and relaxed. The upper arms should be positioned straight down at the sides of the body with as little forward flexion of the shoulders as possible. The elbows should be at approximately a 90° angle and the wrists should be held in as neutral a position as possible.\textsuperscript{4,34}

• When lifting objects, a few basic principles should be emphasized: use a wide base of support with feet flat on the ground surface, bring the load to be lifted close to the body throughout the lift, do not twist while lifting, keep the load symmetric and balanced, lift with both upper extremities, and maintain a slow controlled motion during the whole lifting motion.\textsuperscript{4}
Exercise and Conditioning

The benefits of a home exercise program for physical conditioning have long been emphasized as a way to help decrease the risk of heart disease, high blood pressure, and other pathologies. A person can certainly contribute to his/her workplace well being by keeping his/herself in good physical condition which will help to ward off the physical and sometimes psychological stresses of the work environment. Efficient cardiovascular, respiratory, and musculoskeletal systems can all contribute to a worker's ability to meet the physical demands placed upon him/her by a job task.27

In addition, the importance of exercise, in the office computer work station, cannot be overemphasized as a method of helping to increase worker comfort and decrease the chances of incurring CTDs. The purpose of exercises in the workplace should emphasize general body movement and stretching which are effective ways in which to help relieve the effects of repetitive motions, awkward prolonged postures, and visual demands of a computer monitor. Workplace exercise should serve to increase the body's circulation, thereby decreasing the risk of muscle fatigue due to static loading; rest and relax ligaments, tendons, and muscles which may be strained by repetitive motions; and give relief to the eyes that may be strained by prolonged gazing at text on a work surface or computer screen.8 Exercises may include:

• Rolling the shoulders forward and backward.
Making a fist with both hands and then spreading the fingers as far out as possible.

• Tilting the head toward each shoulder.

• Lowering the chin toward the chest and raising the chin up toward the ceiling.

• retracting the chin straight back while keeping the head level.

• Turning the head slowly from side to side.

• Bending backwards with the hands placed on the hips while standing.

• Reaching both arms overhead.

• Bending and bringing both elbows backward and holding for a few seconds.

• Looking up, down, to each side with the eyes.

• Shaking both arms.

• Bending both wrists up and down.8,27

Most of these exercises will only take a few minutes out of the work day. However, the potential relief and reduction of office computer workstation stresses leading to possible CTDs may last a lifetime.

Prevention of Ergonomic Stresses and Injuries:

Fitting the Job to the Worker

The Chair

Almost 40 years ago, anthropologist Gordon Hewes wrote that the human body is capable of assuming about 1,000 different postures. Some, like standing
upright, are common to all cultures and times; others, however, like chair sitting, are not. The architect Ludwig Mies van der Rohe said that it was easier to design a skyscraper than a good chair. It has been said by others that human beings are designed for motion and activity, not for prolonged static sitting. Yet 70% to 75% of the work force in the United States sit for the majority of the work day. Sitting is blamed for most of the lower back pain that 90% of all Americans eventually experience in their lives. Backaches are second only to the flu as the most commonly cited ailment in the United States contributing to missed work days.

It seems obvious that the most important piece of office equipment in the computerized office work station is the computer. However, in reality, it may be the chair which plays the most important role in determining the success of this office environment.

What makes for a good, ergonomically sound chair? Well, the $9 billion office furniture industry has a variety of ideas in this regard. Even ergonomists have some varying ideas. Some feel that a person should be positioned in a backward leaning posture, while others believe that chairs should be designed to tilt forward to retain the back's lumbar curve. Still others think that a chair which holds a person in an upright posture is the correct design. The differences in opinion may be due to differences in the tasks being performed. Certain job tasks may lend themselves to specific worker positions for optimum comfort and efficiency. A reclined position may be better for someone involved
in a meeting, a telephone call, or reading assignments. The upright position may benefit people working with a computer. Finally, a forward tilted position is one which someone performing writing tasks may find the most comfortable and least fatiguing.34

While there remain differences in some areas of chair design, there are certain principles in which there is general agreement in making a chair ergonomically sound.

- The chair should provide height adjustability. The seat should allow for a comfortable height to support the thighs while the feet rest on the floor or on footrests, and the knees bent to a $90^\circ$ angle.
- The seat edge should not press against the underside of the thigh. There should be between one to three inches from the front edge of the seat pan to the back of the knee. This is important so that the flow of blood to the legs is not constricted. The edge of the seat pan should curve away from the legs.
- Backrests should provide lumbar support and height adjustability is also desirable. Support for the lumbar area is crucial as poor support is a major factor in lower back pain.
- The chair should allow freedom of motion to permit a person to change position easily and frequently without loss of support. Seat pans and back rests should have some movement when pressure is exerted.
against them. The seat pan should also be able to be locked in various positions to accommodate different tasks and personal preferences.

- The base of the chair should provide stability and protection against tipping. A five-pronged or star base is recommended.

- Armrest should be provided when necessary. Armrests can minimize neck fatigue along with decreasing back and leg loading when arising or sitting. However, using an armrest while entering data on a computer is not recommended as increased stress may be placed on the upper extremities, shoulders, and neck.\(^\text{34}\)

- The seat covering material should not allow for easy slipping within the chair. Also, it should reduce heat transfer in warm environments. Because of this, a cloth covering is recommended in the computer office work station.

- Footrests are recommended when needed in order to maintain proper body posture (knee angle, etc.).

An ergonomically correct chair, like all ergonomic equipment, will not function well if a person does not know how to use it properly. People must be educated in the proper use and operation of a chair in order to make it beneficial in providing comfort and support, and help to prevent or manage cumulative trauma to a person's body.\(^\text{1,35}\)
The Work Surface and Equipment Position

The physical layout of the computer work station involves the dimensions of the desk and the placement of the computer monitor, keyboard, and document holder, as well additional equipment on the desk top. A example of this layout can be summarized by the following.

- Desk or work surface height should allow for approximately a 2-inch clearance between the knees and the desk. Ideally, the desk top should have two levels; one acting as a work surface and one holding the keyboard. The keyboard should be positioned to ensure an approximate elbow angle of 90° when a person’s hands are placed on the keys.

- The arrangement of equipment and those items used most frequently should be located within the operator's 'safe zone' in order to decrease excess reaching distance and frequency. The safe zone is the area on the desk top which is within easy reach of a particular person. This area is found by sitting up to a desk, placing arms on top of work surface with fingertips on top, and bending the elbows at approximately 20°. Then, the arms are moved in a semicircle and the area underneath the fingertips and back to the body is considered the 'safe zone'. A telephone, memo pad, reference material, calculator, and computer 'mouse' may all be desk top equipment that should be within easy reaching distance to decrease strain on the upper extremities.
• The top of the monitor display screen should be slightly below eye level (approximately 5° to 10° below the horizontal and the entire primary viewing area from the top of the screen to the keyboard or copy is recommended to be less than 60° below the horizontal).

• An adjustable monitor screen is suggested in order to aid in eliminating glare from work station lighting by varying the angle of inclination.

• A monitor distance range of 13-19 inches is recommended from the operator's eyes to the monitor screen. However, as with the viewing angle, proper viewing distance is also influenced by any visual problems and acuity of the operator.

• The monitor should generally be located directly in front of the operator.

• A document holder should be the same height and distance from the eyes as the display screen. The stand should be located close to the monitor and angled at approximately 30°.

• The keyboard should be located directly below the hands and allow for an elbow angle of approximately 90° (between 70° and 135°). Also, alternate keyboard design with varying key location (geometry) should be explored in order to find the hand position most comfortable and biomechanically beneficial.

• A wrist rest is recommended for periods of rest between data entry sessions, but should not be used during typing.434
The Environment

Proper design of an office computer workstation would not be complete without addressing the environment in which a worker completes his/her job tasks. Areas of particular importance include the following.

- Proper lighting should allow for illumination of needed work copy and surfaces without causing strain to the eyes. Indirect lighting should be able to be adjusted or shaded in order to reduce glare.9

- Temperature and humidity are also considerations in the office computer work station as the computer generates from 100 to 400 watts of heat (the human body generates approximately 100 watts). This heat can dry out the air and, along with an increase in temperature in a small, enclosed work area, lead to operator discomfort.27
CHAPTER V

ERGONOMIC INTERVENTION

Call for Implementation of Ergonomics in the Office Computer Workplace

Reducing effort and improving the efficiency of workers movements while completing job tasks has been the focus of ergonomics at the industrial level in the United States for many years. More efficient production meant greater profitability. The mass production of the assembly line is an example of this as the pace of work increased with new equipment and the elimination of unnecessary movements by workers. However, with all of the advancement in worker production efficiency, there has been, in the past, a lack of study and awareness of the physical limitations of the human body. The tremendous increase in the incidence of cumulative trauma disorders (CTDs) over the last 15 years has changed this, however. It has brought about the evolution of ergonomics as the study of the interaction between people and their work environment for increased production to that of increased worker's safety and the prevention of ergonomic related injuries.

Public awareness of CTDs has come about mainly through the efforts of the Occupational Safety and Health Administration (OSHA), the Labor
Department agency created to carry out the Occupational Safety and Health Act of 1970. The law, which took effect on April 28, 1971, introduced a worker's legal right to a safe work place. Employers in America were required to meet federally imposed safety standards issued along with the new law.

The federal law covers nearly all employees of interstate commerce. It applies even to employers of only one person, and "employee" includes everyone, including supervisors and corporation executives. Although the act originally applied to civilian workers in private employment only, executive orders extended the act to federal employees also.

The law does not set specific standards, but it gives the Secretary of Labor the power to do so. OSHA inspectors can enter private businesses without notice to check on compliance. If a violation is found, a citation may be issued. If the citation is challenged, a hearing will be held before an administrative law judge representing the Occupational Safety and Health Review Commission, another agency established by the 1970 law.

The judge's decision is final in 30 days unless it is sent for the review of the full commission. Employers may appeal to the full commission or to federal court. Fines of up to $1,000 may be imposed for each violation and for each day of failure to correct the violation. Criminal penalties may be invoked if a death occurs from a willful violation.

The law also provides for research and training of personnel. Many observers consider the research function as the most important since standards
on toxic substances depend on scientific findings. Responsibility for research is given to the National Institute for Occupational Safety and Health (NIOSH), the third agency created by the 1970 act.\(^{18}\)

In the 1980s, OSHA placed an emphasis on ergonomics as a method to address the rise in occupational illnesses, specifically CTDs. The shift in ergonomics went from improving productivity to reducing the incidence of CTDs and the related medical, workers compensation, and lost work day costs.\(^{37}\)

While OSHA originally did not set specific mandated standards for the prevention of CTDs, it has, in the past, issued guidelines to help slow the rate of ergonomic related work site injuries. In 1990, OSHA issued an ergonomic program for meat packing plants written to address the growing number of CTDs and other work related ergonomic problems in the meatpacking industry. These guidelines, which have come to be known as the "Red Meat Guidelines," are now looked upon as a standard for ergonomic program design in other industries and work environments. The OSHA guidelines give four main steps in establishing an ergonomic program:

1) Obtain management commitment for a policy of ergonomic responsibility and accountability at all levels of the organization.

2) Document the program in writing; communicate it to all employees.

3) Educate and involve employees in the recognition, reporting, analysis, and resolution of ergonomic problems. Organize teams to systematically perform this work.
4) Establish means to monitor the progress of the program.

The OSHA guidelines discuss four main elements of an ergonomic program:

1) A worksite analysis to determine if any ergonomic hazards exist in the workplace.

2) Hazard prevention and control through an effective design of the worksite, removal of any hazards present at the worksite, guard the worker against any hazard that cannot be removed, and warn the worker of any potential hazards which may exist and may not be engineered out of the worksite.

3) Medical management to treat and prevent worksite injury.

4) Training and education of the workers about the ergonomic hazards of their jobs and prevention methods. In recent years, OSHA has looked to expand these guidelines into ergonomic standards for mandated implementation into America's worksites.

On August 3, 1992, OSHA gave notice of a proposed rulemaking entitled Ergonomic Safety and Health Management - Proposed Rule. This announcement of proposed ergonomic standards affecting an estimated six million workplaces and 96 million workers announced forthcoming standards on which OSHA had been working since 1990. A preliminary draft was due out in 1994 or 1995 and was to include ergonomic standards such as:
• A broad requirement to identify ergonomic hazards with no exemption for small businesses; record-keeping requirements, as well as a mandatory review of records for the two years that precede the standard's effective date.

• A requirement to evaluate the workplace and individual worksites using either injury and illness logs, an ergonomics-risk-factor checklist, or both with companies required to take corrective action whenever there is a repetitive motion injury or illness. The key risk factors (especially in the computerized office work setting) are: force, the repetitive nature or frequency of a task, awkward postures, the time spent on a task, and the pace of work.

• Training requirements for both management and employees.

• A performance oriented standard that lets companies develop site specific solutions.16

In the past, the Occupational Health and Safety Administration has used the "general duty clause" of the 1970 Occupational Safety and Health Act to attempt to protect workers from injury due to CTDs. This clause puts an obligation on employers to provide a workplace free of recognized hazards that are causing or are likely to cause death or serious physical harm.18 However, in 1993, an Administrative Law Judge greatly limited OSHA's ability to use the "general duty clause" as a means of implementing ergonomic controls on American businesses. A $1.3 million fine assessed by OSHA against
Pepperridge Farm Inc. (a division of Campbell Soup Co.) for disregarding CTD problems was disallowed because there was no federal standard dealing with this form of injury. The judge stated that OSHA did have the right to invoke the general duty clause in order to regulate against CTDs; however, the agency must prove specific deficiencies in a business's prevention of worker injury. The judge also declared that, without a specific set of OSHA standards in place, the government could not force employers to experiment with untested methods of hazard prevention.

Organized labor and employee rights groups have been lobbying the Labor Department and Congress for many years to enact national ergonomic standards. A spokesman for the AFL-CIO recently stated that, "We consider repetitive motion-related injuries and the pain and suffering they cause as some of the most significant hazards faced by the majority of workers today. We intend to see that something is done about it." Peg Seminario, director of occupational safety and health, AFL-CIO, says, "Given that this (CTD) is the biggest workplace health problem, it's very appropriate for the Occupational Safety and Health Administration (OSHA) to develop and issue an ergonomics standard addressing it." Additional early calls for some form of ergonomic standards have been initiated by state and local governments proposing various forms of regulation on office computer ergonomic issues. These proposals have included: a request to the Arizona Division of Occupational Safety and Health to develop regulations to
ensure the safety of computer terminal workers, a proposal by the Commonwealth of Massachusetts to provide health safeguards to computer users in the workplace, and the State of Maine enacting a law which requires ergonomics educational programs for most of the state's office computer users. The State of New York attempted to regulate worker exposure to computer terminals, but the law was challenged and was overturned. Probably the most far reaching, non-Federal attempt to provide regulation of office computer work occurred in San Francisco in 1992. The San Francisco ordinance set minimal standards of acceptability with regard to chair adjustability and support, video display viewing area and quality, workstation height and support, work area lightening, glare and noise levels, document placement and screen image and flicker, job design, rest breaks, and employee ergonomic training. However, this ordinance was repealed one month after being challenged in a Superior Court.

It is due to these calls for implementation of ergonomics in the American workplace, along with various legal rulings, that OSHA now feels it is necessary to implement mandated ergonomic standards for the prevention of CTDs in the computerized office work station and the rest of America's work places.

However, with the return of conservative Republican Party control in the congress, the proposed federal ergonomic standards have come under intense scrutiny at the Department of Labor, which is reviewing the cost to businesses estimated to be $16 billion and the feasibility of its implementation.
of this scrutiny and great pressure from the business lobby, the future of the proposed OSHA ergonomic standards is uncertain and their journey through the halls of Congress (and eventually to the computerized office workstation) appears to be stalled for the time being.
CHAPTER VI
CONCLUSION

Twenty billion dollars in workers' compensation costs along with $20 billion in medical costs and lost wages costs, due to a dramatic rise in cumulative trauma disorders (CTDs), have encouraged American businesses and labor groups to take increasing notice of ergonomics in the computerized office workplace. These increasing costs are too significant to go unnoticed and the resulting disability to workers too severe to allow what has been called the 'e-word' (ergonomics) of the nineties in the computerized office, to be ignored.\(^7\) Ergonomics is now being looked at by many to hold the answer to solving the problem of CTDs for both employees and employers.\(^{36}\)

A number of companies in the United States have benefited, along with their employees, from successful ergonomic programs. Sara Lee in New Hampton, Iowa, estimates a savings of up to $750,000 a year in costs of workers' compensation and lost labor. Milton Bradley experienced a 90% increase in employee work quality and productivity along with a decrease in CTDs after implementing ergonomic changes in the company.\(^6\) Ford Motor Co. has been able to reduce workers' compensation costs significantly by making
ergonomic changes which reduce the stress on muscles related to the incidence of CTDs.\textsuperscript{16}

Others in America's business community are less certain of the benefits and value of ergonomics. Many are especially suspect of the validity of ergonomics and especially any ergonomic standards that may be mandated by law requiring their compliance. The major concern of some American businesses appears to not so much be the e-word, 'ergonomics,' but rather the e-word, 'economics.' There needs to be an understanding that there is a beneficial relationship between injury prevention practices (i.e., ergonomics) and financial savings through improved efficiency, productivity, and employee attendance and morale.

Employers must understand that ergonomics is a productivity and quality issue which should follow the philosophy that companies make money by taking care of people, because of the increase in morale, reduction of turnover, thus contributing to an improved bottom line.\textsuperscript{16} Solid evidence supports the connection between worker productivity and attention to quality and the worker's being equipped with the proper tools, work area, and environment.\textsuperscript{31} While the definitive extent to which good ergonomic computer workstation design can alleviate the occurrence of CTDs is not known, the majority of all "experts" in the field of ergonomics emphasize the importance of ergonomics in their prevention.\textsuperscript{38}
Employees must be educated in the advantages and benefits of applying ergonomic principles to their work environment, and must be convinced that change will result in their feeling and working better. Education is the key in helping to solve the problem of understanding the benefits of ergonomics in its relationship to decreasing the incidence of CTDs in the office computer work station. Employees who are well informed will be good observers of problems at the beginning stages before there is significant discomfort, injury, and resulting expense. Employers who are educated will ensure that ergonomic programs are implemented and followed through, resulting in action being taken to help decrease risk of injury.7

Employees and employers can be taught the basics of ergonomics by simply looking at three areas of the office computer work station: seating and how to sit properly; visual concerns, such as monitor location and glare reduction; and keyboard location and the importance of keeping the upper extremities in a neutral position.31

For those in business concerned about the e-word, 'economics,' awareness of the fact that much of the resolution of ergonomic problems do not cost a significant amount of dollars and are rarely solved by the purchase of new equipment is important. Many times, the only change that needs to be made is the relationship between the worker and the current equipment being used. Alterations and education in areas such as proper chair, desk, or computer monitor height are just a few of the relatively simple ergonomic changes that are
required for a successful adaptation of the computer work station to the worker. This fact was very evident during the Fall of 1995 when physical therapy students from the University of North Dakota conducted approximately 500 office work site analyses for a large insurance company in North Dakota. Workers whose job task involved sitting and using a computer work station were observed for proper ergonomic principles of posture, biomechanics, and anthropometrics in order to help reduce the risk of CTDS to these workers. After analyses were completed, it was apparent that the most significant changes would not be those of purchasing expensive equipment, but rather of educating workers on how their present equipment (chairs, etc.) worked and where this equipment would be most beneficially placed. Altering chair and computer monitor screen heights, rearranging desktop items, adding foot and wristrests, and educating management and employees in proper posture and body mechanics accounted for the majority of the "ergonomic" changes made for this company. These changes were all made for a relatively small dollar expenditure.

However, ergonomics is not a cure-all for the incidence of cumulative trauma disorders in the computer office work place. Employees need to understand that everything they do has an impact on their health. The human body does not know the difference between an activity done for pay and one that is done for enjoyment. A person who keeps him/herself in good health, follows a simple exercise program, and uses proper, ergonomically sound body mechanics during work and at home can go a long way toward reducing the
chances of ever incurring a CTD. Employers must understand that ergonomic problems are not totally solved with accepting and starting a program. There must be a commitment to continuous monitoring and improvement of any ergonomic program being used. Ergonomic injury exposures, methods of treatment, and prevention all must be enhanced, adapted, and molded with time.
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