# Ergonomics in the Library

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Ergonomics is a science that has been around for hundreds of years. In 1713, an Italian physician, Bernardino Ramazzini, wrote in *De Morbis Artificum*:

> So much for workers whose diseases are caused by the injurious qualities of the material they handle. I now wish to turn to other workers in whom certain morbid affections gradually arise from other causes, i.e. from some particular posture of the limbs or unnatural movements of the body called for while they work. Such are the workers who all day long stand or sit, stoop or are bent double; who run or ride or exercise their bodies in all sorts of ways.[1]

In the nineteenth century a Polish educator, Wojceich Jastrzebowski, was the first to introduce the term "ergonomics" when it appeared in a Polish newspaper.[2] Ergonomics is from the Greek word *ergos*, meaning "work," and *nomos*, meaning "natural laws." In other words, ergonomics is the laws of work. Not much was heard again about ergonomics until World War II when a great deal of mismatch was discovered between military equipment operators and the equipment they operated. This resulted in significant performance problems for the military.

Today one of the simplest definitions is: *Ergonomics is the scientific study of human work*. Since ergonomics is concerned with the interaction of human beings with tools, machines, and systems involved in performing work and daily activities of living, the following phrase is more comprehensive and summarizes the general approach of ergonomics: *Ergonomics is the science of matching the job to the worker and the product to the user*. The goal of ergonomics is to adapt the job or workplace to fit the person, rather than force the person to fit the job or workplace, with the ultimate goal of making the job or workplace safe, comfortable, and efficient with no adverse health effects.

## Why the renewed interest in ergonomics?

In recent years, concerns about adverse health effects as well as productivity and job satisfaction have increased, producing a renewed interest in ergonomics. Ergonomics traditionally focuses on designing tasks and work environments so that people can work within their capacities. When people must work beyond their capacities they are more at risk for developing musculoskeletal disorders (MSDs). MSDs create major health and financial problems in the workplace. MSD is a term used to describe syndromes characterized by discomfort, persistent pain, impairment, or disability in joints, and soft tissue (muscles, tendons, ligaments, skin, connective tissue), with or without physical manifestations. MSDs account for 66% of occupational illnesses. Slightly over 6 million MSDs occur each year, requiring lost work time or medical treatment beyond first aid. MSDs are sometimes referred to as cumulative trauma disorders (CTDs).

Factors that place individuals at risk for developing a musculoskeletal disorder in a library or office environment are:

**Repetitive Motion** – performing the same motions repeatedly without adequate recovery time. Examples of repetitive motion are data entry tasks such as in cataloging, and using a hand-held bar code scanner to sensitize or desensitize library materials.

**Awkward Posture** – prolonged use of non-neutral joint positions causing stress to the tendons, nerves, or other tissues. Examples of awkward postures are work performed above shoulder height, such as when re-shelving books, or keying tasks when keyboards are at improper heights.

**Sustained Static Posture** – prolonged use of a single posture, causing static muscle loading and fatigue. Static postures may occur while holding a telephone in one position for a long period of time or when pressing large books down on scanners.

**Forceful Exertion** – any activity that requires excessive force such as gripping, lifting, pushing, or pulling. Examples include pushing book carts

or lifting boxes such as in a receiving area.

**Contact Stress** – compression of tissues between the bone and a hard, external surface such as a table edge. Contact stress can occur on the forearms at computer workstations or from simply holding a pen or pencil too tightly.

Months or even years may pass before the risk factors listed above are identified as sources of an MSD. During this period, a great deal of money and time can be spent to return a worker to good health when the true culprit is the work area design. This underscores the importance of ergonomically-designed furniture and equipment in library work environments. When ergonomics is incorporated into the design of the workplace, exposure to the risk factors (which may lead to a musculoskeletal disorder) can be minimized or eliminated. One case study involving over 200 library employees at a university in the southeast demonstrated that the frequency and severity of pain and discomfort dropped significantly after ergonomic improvements were made to workstations. The average cost of these improvements was $150 per employee.[3]

Proper planning and attention must be given to the design of workstations and workspace. Some questions that must be answered in order to achieve this include

- Why is there concern over sitting and chairs?
- What features make up an ergonomic chair?
- What is the ideal workstation arrangement?
- Where is the best location for monitors?
- What are lighting requirements for computer workstations?
- How important are accessories (like copy holders, glare screens, and footrests)?
- What about other (non-office) work areas in the library?
- What are the best designs for disabled workers?

## Why is there concern over sitting and chairs?

Although musculoskeletal disorders of the upper extremity such as carpal tunnel syndrome are often the focus of the media, most common among office workers is back pain. Cases involving lost work days due to back injuries are four times more likely than cases involving repetitive motion of upper extremities.[4] Lifting heavy objects is just one mechanism for back pain. The manner in which people are injuring their backs has changed over the years as the number of seated jobs has increased. The adverse effects of prolonged sitting and poor chair design are the culprits in cases of low back pain in office workers.

Humans are designed to be upright, walking, running, and on the move rather than sitting for extended periods of time. Prolonged sitting can be detrimental to health and productivity. Poor sitting posture is actually one of the leading causes of back pain in seated workers. Statistics show that back pain is still the number one reason for lost work time and that approximately 90 percent of Americans will suffer from a significant episode of back pain in their lifetimes. Of those, 7 percent will become chronic back pain sufferers.[5]

Poor sitting as a cause of back pain is multifaceted. Sitting in a typical slumped posture stretches the ligaments and muscles that extend the back. Over time, stretching the ligaments and muscles weakens them so they are less likely to be able to work correctly when called to action. The stretched position causes the back extensor muscles to become chronically active. This low-level activity can cause a decrease in circulation to the working muscles. Alterations in circulation like this can cause pain.

Stress on muscles, tendons, and ligaments is only part of the story when it comes to back pain. Consider what sitting does to intervertebral discs, the "shock absorbers" separating the vertebral bodies. Standing or lying down puts little pressure on the intervertebral discs of the lower back. Simply sitting correctly more than doubles the pressure, while sitting in the slumped position increases the pressure four times. Leaning back into the backrest of the chair relieves much of the pressure. As workers sit poorly over extended periods of time, they subject their discs to prolonged pressure elevations. Also, the slumped posture tends to push discs out of their normal alignment. The nucleus of the disc pushes toward the back and can press against the outer layer of the disc, called the annulus fibrosis. Prolonged pressure could cause a bulge or a herniation of the disc and back pain. Pushing the nucleus toward the back puts the disc at risk of injury from something as simple as bending over and picking up a pencil.

Poor sitting posture causes workers to disrupt the normal curves of their spines. They create one long, flexed curve. This posture causes stress within the spine at places stress is not meant to be absorbed. It also forces them to sit more on their sacrum and less on their ischial tuberosities (sit bones). Therefore, they put abnormal stresses on their bones, ligaments, tendons, muscles and discs.

In an attempt to make the libraries and offices of today as ergonomically efficient as possible, workstations are designed so that workers hardly have to move. Bodies are poorly positioned and movement is minimized. This decreases the flow of nutrients to parts of the body that are working which results in increased back pain and contributes to musculoskeletal disorders. Many workers stay in the same position much of the day, without proper exercise breaks or altering their work position from sitting to standing, and then don't understand why they have back pain.

Needless to say, the chair is an important component in the total workstation design. The "perfect workstation" cannot be used to its fullest extent if one is unable to sit at the workstation in the proper posture. Well-designed chairs allow workers to function in a supported, healthy position which is crucial for long term health and productivity. Some studies have shown that proper seating can increase productivity anywhere from 40 to 80%. Good chairs have been shown to have a positive influence on reduced error rates.[6]

Providing ergonomically-designed chairs that are correctly adjusted for workers can be shown to pay for itself through reduced medical and workers' compensation costs. Medical costs associated with low back pain are approximately $20 billion per year. Some estimates of costs (including medical and non-medical) lost to back pain reach $100 billion per year. The cost to industry from a non-surgical back injury is about $7,000 and a surgical case is about $100,000.[7]

## What features make up an ergonomic chair?

A well-designed ergonomic chair allows 95% of the population to sit properly while working efficiently at their workstations. Individuals should be able to get close to their work while maintaining proper posture. Movement and postural changes should be easily achieved throughout the day without having to get out of the chair. Listed below are several features to look for when evaluating ergonomic chairs. According to the authors' review of available research and

ANSI standards, chairs should have, at a minimum, the seven features listed below. Different chair manufacturers may choose to incorporate these features into chairs in many different ways. Of prime importance is that all of the chair's features must be easy to reach, and adjustment should be possible while the user is sitting in the chair.

**Backrest** – The backrest is for resting and supporting the back. A backrest should be adjustable in height and should not protrude in order to support the spine. It should be placed high enough to allow space for the buttocks between the seatpan and the prominent area of the backrest to maintain the lordotic curve of the lower back. Unless the job requires the user to lean back much of the day, a high-backed chair is not needed. A small backrest that does not get in the way of turning and reaching for objects is best. The backrest should be mounted so that it moves as the chair moves. Although some believe the backrest must move forward with the body, this movement does not provide lumbar support.

**Armrests** – In general, a person should not rest his arms on the armrests while working. If this occurs, fewer joints participate in performing the movement or activity. The fewer joints participating in the activity, the more stress those joints have to absorb. For example, if a computer operator uses a wrist support or wrist rest while entering data, a motion that once used the shoulder, elbow, wrist, and fingers now uses fingers only. Thus, the fingers are at risk due to a greater amount of stress the fingers must absorb.

If one sits for a fairly short period of time, performs a task, and then gets up, armrests are not needed. If one sits for most of the day, armrests may be helpful if used during rest periods. Armrests should be set back far enough that they do not interfere with sitting or with getting close to the work surface. Also, they should be individually adjustable for height and width.

Many workers carry their shoulders too high because of stress in the upper trapezius muscles (the muscle used to shrug the shoulders). When armrests are adjusted, the shoulders should be dropped to a relaxed position with the upper arms relaxed against the body and forearms either parallel to the floor or slightly angled away from the user. This is the proper position for armrests.

**Seat Height** – The chair should easily adjust so that the hips are just slightly higher than the knees. This is contrary to how many individuals learned to sit, tilting backwards with knees higher than the hips. This position is acceptable for short periods of time; however, most work tasks are in front of users, therefore they must sit upright to reach their work while maintaining a low back lordotic curve.

**Seat Pan** – The seat pan is the most important part of the chair and many times the weakest. A traditional seat pan should be fairly flat with some contour and should include a high-density foam pad. It should feature a contoured front end or a "waterfall edge" to help relieve pressure from the back of the knees.

Highly-molded seats and edges are not recommended. If a user does not fit the mold exactly as intended, it will be uncomfortable. Even if a person does fit the mold, the chair tends to lock the body in one position and does not foster movement. Also, highly molded seats with a great deal of contouring puts additional pressure on the hips.

The seat pan should adjust front to back. The seat pan depth should adjust approximately 3.5 inches. Since most individuals are proportioned differently from the hip to the knee (femur bone), the length of the femurs should fit in the chair with approximately a fist distance from the back of their knees to the front edge of the chair. This is an important adjustment. If the seat pan is too short, it will make a person feel like he is falling out of the chair. If it is too deep, he will feel too much pressure behind the knees and will tend to perch on the edge of the chair without adequate back support.

The seat pan should freely tilt forward and backward which allows free rocking without additional adjustments to the chair. Locking mechanisms are available, although they are not necessary. Allowing the chair to rock encourages movement. The seat pan should be stable at any angle. In forward-leaning tasks, a forward tilt of four degrees is good. In backward-leaning tasks, 17 degrees is good. If a task requires a large forward tilting angle, a chair that supports the chest rather than the back may be required.

**Tilt Tension** – The tilting seat pan should have a tension adjustment that allows a small person to make full use of the chair and a large person to tilt back without feeling like he is going to fall over. The tension should be kept fairly stiff so you have to use your feet and leg muscles to push yourself back. This keeps the blood pumping out of the legs and back into the circulatory system.

Swollen feet are a side effect of prolonged sitting. Using a chair that free floats forward and back, and has a tension control that can be set so that a person can exercise his feet during the day by pushing back occasionally, is beneficial. This will help pump some of the fluid out of the feet. Also, standing part of the day has been shown to decrease the amount of swelling in the feet.

**Tilt Location** – Biomechanically, it is logical to put the tilting mechanism at the center of mass, which means directly under the seat. In this position, it is easy to move forward and backward. The chair encourages movement without excess effort, and the design of the mechanism is fairly simple. If the tilting mechanism is located close to the knees, the chair tilts backward easily but is difficult to get forward.

## What is the ideal workstation arrangement?

Workstations that are designed for computers typically use adjustable work surfaces, shelves, and drawers, and are well suited to meet the task demands of today and to accommodate the changing work force. The typical worker is no longer a 5'10", 170-pound male. Workstations need to accommodate men and women of varying sizes, and physical abilities, particularly if disabilities are involved. Therefore, adjustability is the key issue. A good workstation should be accessible to all populations, and should be height adjustable to fit whoever is working.

Studies indicate there is a wide range of "preferred heights" for work surfaces and not one true standard height. A work surface should be adjustable so an individual can position himself in a good seated posture with arms positioned correctly.[8] Studies have shown that, if given the opportunity to alternate between sitting and standing at the work surface while performing daily tasks, workers will experience decreased back strain and feet swelling, and pro-

ductivity may actually increase.[9]

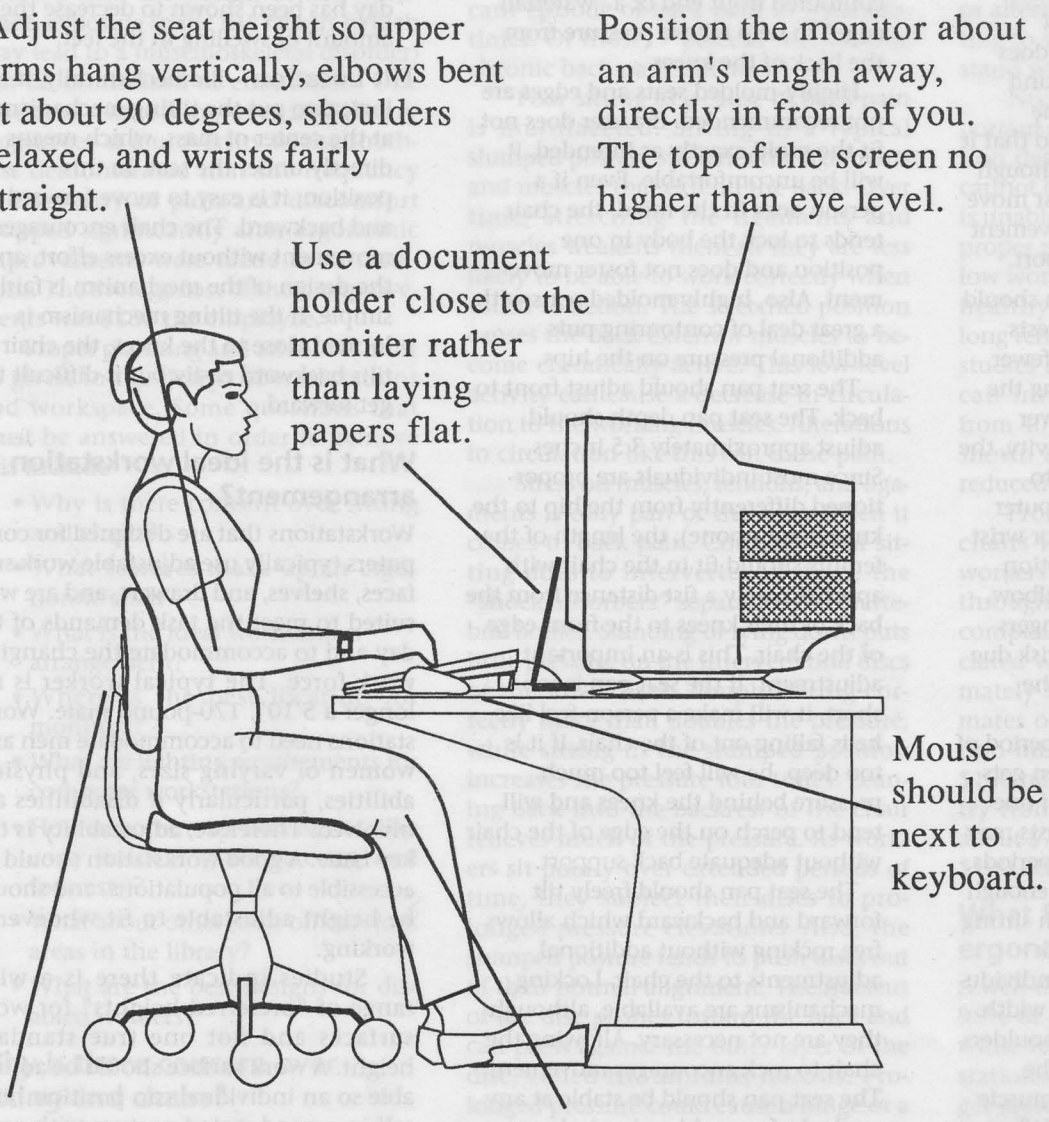
Computer workstations should be designed to handle the different components of a computer system (see figure below). There should be adequate workspace for the monitor to be placed correctly (distance and angle); adequate placement of the CPU in an accessible location; height and angle adjustable keyboard surface or tray; and an adjustable mouse surface or tray. The work surface should have sufficient space for general paperwork, reading, and other tasks. All paperwork should be within easy reach. Edges of work surfaces should be rounded or beveled.

Workstation shelves are usually placed over the work surface. Frequently used materials and supplies should be placed within easy reach without the need to twist, or reach overhead. Heavy items should be stored at waist height; light items should be stored between waist and shoulder height. Small portable file cabinet (pedestal) drawers should pull out easily and should be attached to the work surface to allow for flexibility in work surface height. Pedestals should be placed under the workstation to ensure there is plenty of room for knee space (approximately 36 linear inches). In order to encourage movement within the workstation, place shelves, drawers and files so that they require users to get up to access them. This may mean locating some components such as printers outside the workstation.

Keyboard trays should pull out easily, be sturdy enough to withstand impact force, but not so stiff that they cannot absorb some of the shock. Users should be able to get their legs under the table and the keyboard tray comfortably. The tray angle should be adjustable from a flat position to slightly tilted away from the user in a negative tilt. Height adjustability is equally important. The keyboard should be aligned with the monitor. For jobs that primarily require keying, a high quality keyboard tray should be used.

Shoulder pain in computer users is often caused by poor positioning of the mouse. If the mouse is too high or too far to the side, the shoulder muscles will have to support the arm for long periods of time. This static muscle loading leads to a decrease in circulation, muscle spasms, and pain. Bringing the mouse into the functional reach position (upper arms at side of body, forearms slightly below the horizontal, and fairly close to the side of the body) will minimize the risk to the shoulders and make mousing easier. For this reason, mousepad trays or a mouse "bridge" which fits over the keyboard should be available for all mouse users. Mousepad trays should adjust independently of keyboard trays. They should also adjust up and down and swing in and out so the mouse can be placed within the functional reach position.

Individuals who injure their fingers while mousing may be holding or clicking the mouse too hard. Adjustable mousing accessories and appropriate input devices that are properly sized to fit a user's hand can solve many mouse-related problems. Trackballs, glide pads, stylus devices, and foot mice are all alternatives to the mouse. For jobs that require intensive mouse use, forearm support boards, which attach to the worksurface and have a large support area as well as a mousing pad, may be an option.




*Designed by Duke Medical Arts, Duke Ergo Program*

In recent years, a number of split and angled keyboards have been introduced. A few studies have shown a positive effect for some of the alternative keyboards; however, most of the evidence shows that these keyboards do little to reduce pressure in the carpal tunnel or significantly reduce muscle strain. One has to significantly ulnar deviate (turn wrists to the side) to the end range to get a significant increase in pressure in the carpal tunnel. The standard keyboard, positioned correctly, with the shoulders in a relaxed position, upper arms at the side, forearms in a slight negative tilt, wrists in the neutral position, hands floating over the keys, and arms free to move, is the best solution.

## Where is the best location for monitors?

The computer monitor is one of the most common pieces of equipment in libraries and offices today. Coincidentally, eye strain is the most common complaint for computer users. There are many causes of eye strain such as the glare from light, poor quality screen resolution, poor screen angle, poor screen height, decrease in eye blinking, dust particles hitting the eye, and preexisting eyesight difficulties.

Substantial evidence exists for proper monitor placement, although there is still some confusion and disagreement about monitor location. The typical resting gaze for eyes is 15-20 degrees below the horizon. One can comfortably see 10 degrees above or below that. In addition, the head can tilt slightly forward approximately 10 degrees without an increase in muscle activity. Therefore the most comfortable angle for the monitor is anywhere from 15 to 40 degrees below the horizon, depending on what is most comfortable for the user and practical for the workstation.

One thing to consider in monitor placement is the location of overhead lighting fixtures and the location of exterior windows. To avoid both direct glare from external light coming through windows and also indirect glare from light reflected off the screen, monitors should not be placed directly in front of windows. Likewise, to avoid indirect glare from light reflected off the screen, monitors should not directly face windows either. When monitors are angled towards the ceiling, indirect glare can result from overhead light fixtures. Whenever possible, monitors should be placed perpendicular to light sources to minimize the effects of glare. Appropriate window coverings or reduced overhead lighting can help to minimize these effects.

Monitor distance from the eyes can play a major role in eye strain. If the monitor is too close to the eyes, the eye muscles will have to overwork to focus the eyes. If too far away, users may have to squint. The typical focal length for the adult is 28–36 inches. The monitor should be placed somewhere within that distance according to the vision of the user.

Once the monitor is properly positioned, significant eye strain could still be a problem if the operator sits in a poor, slumped over posture. It is not uncommon to see users sitting at the forward edge of the chair, leaning back against the backrest, with head tilted up and forward to see the screen. This position stresses the neck extensor muscles, which are used to keep heads up and parallel to the ground. If the neck muscles are strained, the eye muscles attempt to compensate. The stress on the eyes of doing two jobs instead of one leads to premature eye strain. Also, blinking is helpful to remove dust particles from the eye and to keep the eye from drying out. Yearly eye examinations are also important.

## What about lighting?

Lighting experts recommend using uniform indirect lighting to reduce glare and reflections on work surfaces and VDT screens. Indirect lighting eliminates direct glare and produces diffused lighting that minimizes problems with indirect glare and reflections. Light sources should not be placed within 30 degrees of a worker's horizontal line of sight when his eyes are in the working position, and all light sources should be shielded from workers to avoid direct glare.

In offices with high VDT usage, 20 to 50 footcandles* is an adequate illumination level for the overall room or ambient lighting. In general, the ambient light level should be lower than the lighting level at the work surface but should not vary significantly so as to minimize contrast. The contrast ratio between the task and adjacent areas should not exceed 3:1.[10]

Task lighting is used to individually light the worker's specific task area. Task lighting fixtures should be easily movable and changeable so that light can be directed to suit the needs of the individual and the task at hand. The fixtures should have a fully articulating arm, an opaque shade, and an asymmetrical light distribution to help reduce glare, shadows, and reflection.

## How important are accessories?

In some cases, the use of computer "accessories" such as footrests, palm rests, glare screens, document holders, and lumbar cushions may help increase user comfort. Accessories can be an inexpensive way to make a poorly designed work area more tolerable. Manufacturers often use the term "ergonomically-designed" in their advertising literature; however, not all products help and some may actually harm. Listed below are a few of the more common computer "accessories."

**Footrests** – Provide support to the feet and legs when sitting in an elevated chair with feet "dangling." Sometimes a chair must be elevated to accommodate a work surface that is too high. Because unsupported legs and feet can lead to backpain and leg discomfort, using a footrest increases the comfort for these users. Stool height footrests are also available.

**Palm rests** – These attach to keyboard trays and may help keep the wrist in the neutral position and provide a place to rest the hands when not keying. These should not be confused with wrist rests, which most people use to rest their wrists while keying. Resting the wrists while keying increases the pressure in the carpal tunnel area of the wrist and promotes poor keying posture. Proper use of palm rests eliminates both of the problems associated with wrist rests.

**Glare screens** can help reduce glare on monitors, thereby reducing eye strain. Many types of screens are available. Plastic screens should be avoided since there is evidence that they do not adequately reduce glare. Mesh screens reduce glare effectively but they also reduce screen resolution. Coated glass screens are the best option for reducing glare without sacrificing screen resolution.
Some guidelines to use in evaluating glare screens are:

- It should be approved by the American Optometric Association;
- It should have antiglare glass and adhesive free;
- Wrap-around models aid in keeping dust off the screen;

* Footcandle – the unit of illuminance when the foot is taken as the unit of length. It is the illuminance produced on a surface all points of which are at a distance of one foot from a directionally uniform point source of one candela (formerly candle).

- Contour filters keep light from passing between the glare screen and the monitor;
- Antistatic models help eliminate dust.

**Document Holders** – These accessories are highly recommended for most computer work areas to reduce awkward neck postures and reduce eye strain. Document holders can attach to the monitor or be free-standing. Text should be placed as close to the monitor as possible so the focal length for the eye is the same. Ideally, free-standing text holders should be height adjustable. Consideration should be given to the type of item to be held. For working with items such as sheet music or large bound volumes, specialized document holders are available.

**Lumbar cushions** – When chairs have inadequate lumbar support, a lumbar cushion can be used to provide greater support. Some models may help reduce the depth of the seatpan for petite individuals whose chairs are too large and who therefore are unable to utilize the back support.

## What about other (non-office) work areas in the library?

Ergonomics should be incorporated not only into the electronic and computer work areas throughout the library but also into the design of non-office work areas. For example, circulation desks are not traditional office areas, yet most have a number of computers. Circulation work surfaces are typically designed for standing height since patrons generally stand. Consideration should be given to providing proper seating for employees in these areas. Stool-height ergonomic task chairs should be provided. Adequate knee space and appropriate foot support should be considered as well. Adjustable monitor arms and keyboard trays are also recommended to ensure proper placement of keyboards and monitors.

Circulation and reference desks often require the use of computers that can be shared with patrons. Some libraries utilize a "lazy susan" swivel table. This feature is helpful for patrons but sometimes places employees in awkward work postures when leaning over or twisting to offer assistance. As an alternative, dual monitors allow patrons to view the screen without compromising the employee's posture.

Storage sites and book stacks are other non-office areas where ergonomics should be considered. Simple material handling systems, ladders with electric lifts, or step stools can all aid in reducing awkward postures and the forces demanded by lifting and lowering library materials. Workers in book stacks should avoid reaching over shoulder height to prevent shoulder-related musculoskeletal disorders. Step stools are inexpensive and allow employees to work at or below shoulder height in most cases.

Receiving areas are ripe for ergonomic improvements, particularly when lifting-related injuries are not uncommon. Through the use of simple, inexpensive, material handling devices, injuries can be prevented. In cases where there is a mismatch between dock heights and vehicle heights, a dock plate may help with loading or unloading vehicles. Scissor lifts are excellent for unloading vehicles in areas where no dock exists. Dollies are invaluable as an aid for moving boxes of library materials. Pallet jacks are highly recommended for libraries that ship or receive palletized materials.

## What are the best designs for disabled workers?

The Americans With Disabilities Act (1990) was the first civil rights law aimed at protecting people with disabilities against discrimination in the most important areas of life. The ADA introduced the notion of "reasonable accommodation." According to the law, reasonable accommodations have to be provided for people with disabilities in order for them to access or retain employment. Because this usually involves modifications to the work environment or work procedures, it is clear that one of the best ways to achieve this is to use ergonomic science and principles. The principles of universal design should be incorporated into workplace designs for disabled employees. These are

**Equitable Use** – The design is useful and marketable for people with diverse abilities. An example is the use of powered doors at entrances to libraries. This type of door allows easy access for all individuals regardless of ability and level of mobility.

**Flexibility in Use** – The design accommodates a wide range of individual preferences and abilities. An example would be purchasing keyboard trays that are designed for using a mouse on the left or right side of the keyboard. This accommodates left-handed or right-handed individuals. This design also allows users to switch to using the other hand when one hand is fatigued or injured.

**Simple and Intuitive Use** – The design is easy to understand regardless of experience, knowledge, skills, language, or concentration level. An

example is the use of instructional signs that utilize diagrams and provide clear instructions without text. "No smoking" diagrams that display a cigarette with a bar through it are intuitive and are easy for everyone to understand.

**Perceptible Information** – The design communicates necessary information regardless of ambient conditions or the user's sensory abilities. For example, elevators in libraries could better communicate floor numbers and materials on each floor through the use of tactile, visual, and audible displays. This information would provide users who have sensory disabilities the ability to better navigate the facility.

**Tolerance for Error** – The design minimizes hazards and the adverse consequences of accidental or unintended actions. An example would be making sure that computer screens for catalog systems allow users to easily correct mistakes without penalties. In other words, pressing the wrong key should not send you back to the beginning of a search.

**Low Physical Effort** – The design can be used efficiently and comfortably with minimal fatigue. An example in libraries is the use of door levers rather than door knobs. Levers can be easily opened using a fist or an elbow, whereas knobs require gripping with the hand.

**Size and Space for Approach and Use** – The approach, reach, manipulation, and use is appropriate regardless of the size, posture, or mobility of the user. In libraries, an example is the use of security/entry gates that can accommodate users in wheelchairs as well as users carrying briefcases, bookbags, or pushing strollers.

## Summary

Libraries involved with long-term furniture planning have the opportunity to see dramatic, positive effects on the health and productivity of their employees by purchasing furniture that adjusts to fit individuals. Spending slightly more for a chair or workstation now can save workers' compensation benefits, which can amount to thousands of dollars.

There is an important trilogy to consider when thinking about ergonomics: education, training, and product. Through education, the well-being of employees can be improved by explaining why it is important to sit correctly, alter posture often, adjust furniture and equipment, and by demonstrating and reinforcing good sitting posture. Teaching the "how and why" to adjust furniture, establishing a program of healthy work breaks, and purchasing furniture and equipment that meet the criteria presented in this article, are steps in the right direction toward reducing certain health problems. These changes will likely contribute to increased productivity and a more pleasing work environment.

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[10] Jeffrey Anshel, *Visual Ergonomics in the Workplace* (London; Bristol, PA: Taylor & Francis, 1998), 78.


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***Errata ...***

In Summer *North Carolina Libraries*, the photo captions on pages 55 and 56 were reversed. Please excuse this error.