OVERVIEW

The word *ergonomics* derives from the Greek words *ergon* (work) and *nomos* (law). The term, which literally means *laws of work*, was coined by Professor Wojciech Jastrzebowski of Poland in 1857. One of the most comprehensive definitions of the word describes it as the matching of the physical, physiological, and psychological capabilities of the human worker with the physical, physiological, and psychological requirements of the task being performed.

Ergonomics is a discipline that seeks to design tools and tasks to be compatible with human capabilities and limitations. It can help solve many problems related to safety, health, comfort, and efficiency through the design of furniture, equipment, and tasks in such a way that they are suited to the people who use or perform the tasks. Poor design is not the only problem; improper use is equally serious.

The focus of ergonomics is on the person. Unsafe, unhealthy, uncomfortable, or inefficient situations at work or elsewhere are avoided by taking account of the capabilities and limitations of humans.

According to the U.S. Occupational Safety and Health Administration (OSHA), up to 85% of workers' compensation costs are related to the types of work injuries that ergonomics can help prevent: back injuries, wrist disorders, and assorted strains and sprains. More than 600,000 such injuries a year result in a loss of time from work.

OSHA is the Occupational, Safety, and Health Administration, www.osha.gov.

For those suffering from carpal tunnel syndrome, the most common injury for computer users, the medium number of days off work is 27 per year. At least 1.2 million workers suffer significant discomfort but are not gone from work.

History

Ergonomics likely goes back to the beginning of civilization. For example, the wheel was an ergonomic solution that reduced exertion. Modern ergonomics goes back to World War II. Scientists and engineers began to systematically study human capabilities and limitations with the goal of reducing injuries to women engaged in manufacturing jobs previously held by much larger and stronger men. They also sought to find solutions to the problems of pilots who found it difficult to adjust to the increasing speed and maneuverability of fighter aircraft. Designers and psychologists worked together to rethink the design of the cockpit to make it more user-friendly.

The automobile and auto parts industries pursued participatory ergonomics beginning in the 1950s. Management and labor ergonomics teams were formed to reduce injury and improve productivity in factories. There were dramatic improvements, especially in short-cycle tasks requiring repetitive turning and twisting actions with tools, frequent lifting, or other forms of manual materials handling. By 1990, two-thirds of labor agreements in mainly manufacturing industries—more than 30,000 agreements according to the AFL-CIO's Washington, D.C., office for governmental relations—included a requirement for management and labor ergonomics teams.

The widespread use of computers beginning in the 1980s led to the extension of ergonomics to the office environment. Before that time office injuries tended to consist primarily of falls. Few office workers had ever heard of carpal tunnel syndrome until popular magazine articles began to report on the potential adverse effects of repetitive motion in the mid-1980s.

The Scope of Ergonomics

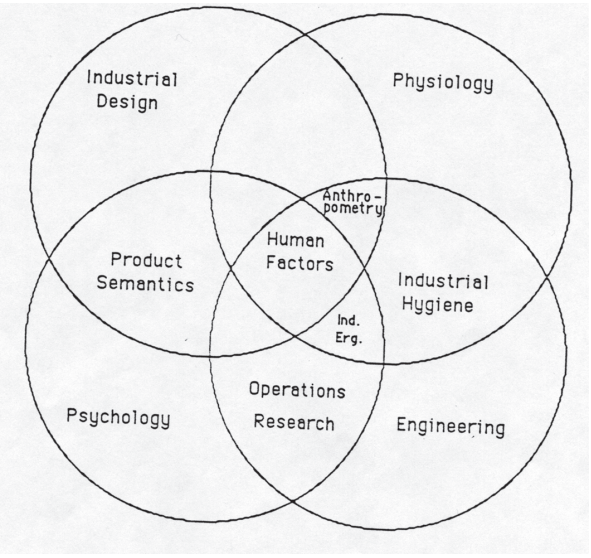
Modern ergonomics is not limited to redesigning the workplace; it is also used in product design. One of the premier product research centers in the world, Xerox's Palo Alto Research Center (PARC), pioneered dramatic changes in technology by focusing on the user, rather than the technology. Among its contributions is the user interface that formed the basis for Apple Macintosh and, later, Microsoft Windows: icons, windows, pull-down menus, and the mouse. Underlying these innovations is the practice of designing the task first, then designing the machine. The result is a machine that is not only easier to use, but one that reduces injury and discomfort to users.

Among the other products designed using ergonomic principles are adjustable office chairs, foot rests, keyboard drawers, wrist rests, and document holders. Catalogs of ergonomics products for offices now list as many as 10,000 items.

The Interdisciplinary Nature of Ergonomics

Modern ergonomics is interdisciplinary, drawing its knowledge from many fields, including industrial design, physiology, psychology, engineering, product semantics, industrial hygiene, human factors, operations research, anthropometry, and industrial engineering. Because ergonomics draws from so many fields, people not trained as ergonomists may find difficulty in accepting some of the research that has been done. Even within the field, sufficient differences in the training of ergonomists commonly result in strong differences of opinion.

Anthropometry is the study of human body measures, especially on a comparative basis.



People Are Different

Fundamental to the discipline of ergonomics is the recognition that people are different from one another. In any organization there will be a great deal of variation in body size: height will range from as little as 4 feet to well over 6 feet, forward grip reach will range from 26 to 34 inches, and sitting eye height will range from 27

to 34 inches. Given these differences, people do not all require the same furniture and equipment specifications.

Older workers may not be as agile as younger ones. Many people, even young ones, are not able to tolerate working in contorted postures for a long time, such as with arms outstretched or the body in a stooped position. Most wrists cannot tolerate excessive motions without injury, nor can most people's lower backs tolerate excessive lifting.

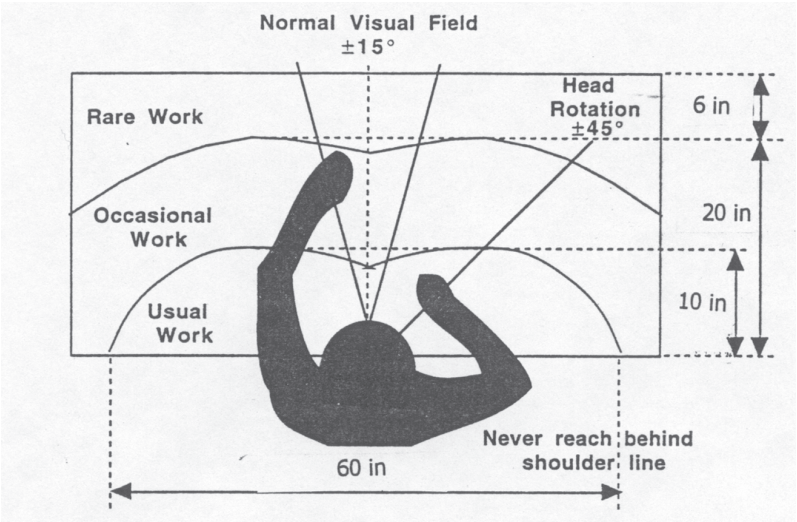
Failure to adjust for differences among people by selecting only furniture and equipment designed for average people with no disabilities increases the likelihood that the furniture or equipment will contribute to the physical stress of at least some users.

It must be possible to adjust the height of a seat, a work surface, or a piece of equipment to accommodate the differences in the sizes of people. The most suitable height will vary with the task being performed. It must also be possible to adjust the distance at which the person sits from the computer keyboard and screen or the other tasks at the workstation.

Principles of Ergonomics

An examination of 23 monographs on ergonomics found general agreement among many principles that should form the broad framework for examining a workplace. In each organization, a more detailed checklist should be developed. Usually, this effort involves tailoring published lists to the specific types of work performed in the organization. For libraries, ergonomic checklists resemble lists for office workers and warehouse workers.

1. Keep work within easy reach. Long reaches can strain the body and make work more difficult. Frequently used work should be within easy reach.

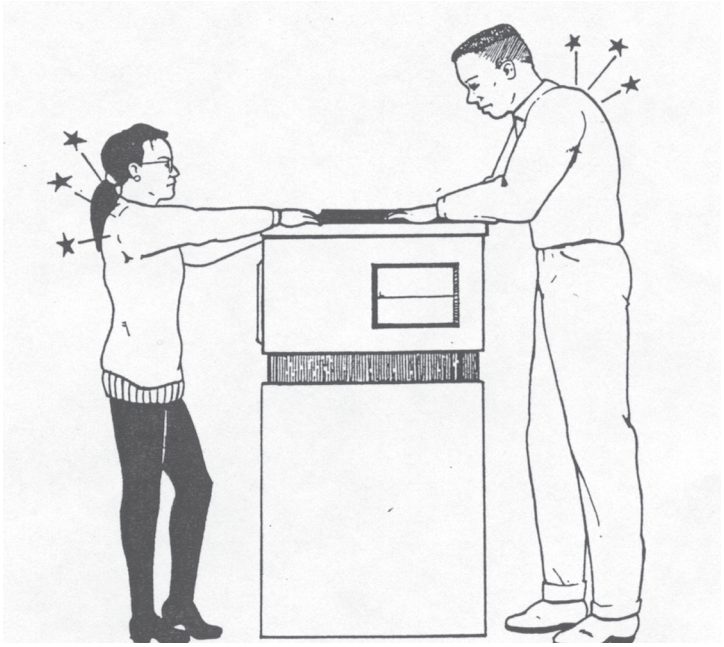


2. Hold anything being lifted close to the body. Stress on the back increases when the arms are outstretched. A 20-pound object held 2 feet from the body puts more than twice as much strain on the back as the same object held against the body.

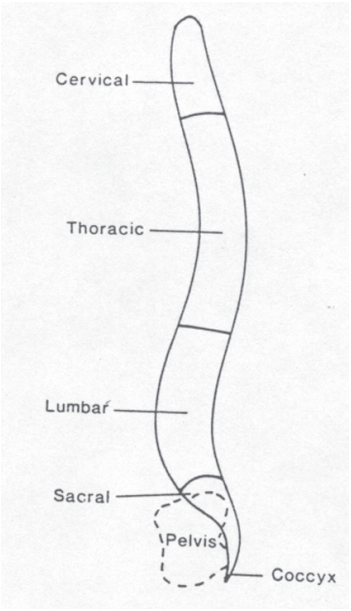
3. Avoid sudden movements; rapid lifting and twisting especially in-

crease stress on the body.

4. Place work at proper heights. Generally, work should be done at elbow height or slightly below. Avoid awkward or contorted postures that can lead to fatigue, discomfort, and injury, causing undue muscular and skeletal stress. (The author learned this principle when he operated a library copying machine in college that was too low for him and too high for the other operators.)



5. Promote good working posture. Stress the need to keep the body in neutral position. In the correct position, the back's natural S curve is intact (see illustrations). Contrary to what most people think, a sitting-up-straight position produces a great deal of spinal distortion. The elbows should be held naturally at the sides of the body, and the wrists slightly forward and slightly inward. Raised arms, bent wrists, bent neck, turned head, bent and twisted trunk are examples of poor posture—the joints are not in a neutral position.



The shape of the normal spine viewed from the side and the body in neutral position.

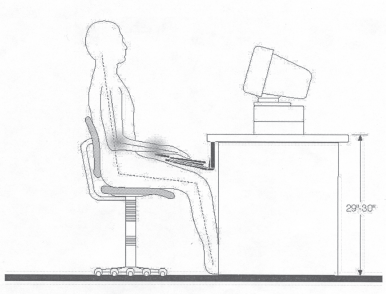
6. Select a sloping work surface for reading tasks. In tasks that require no manual work, a slope of 45 degrees is desirable for reading. For tasks where the hands are used, a slope of 15 degrees is desirable.

7. Keying should be done with the keyboard below seated elbow height and the keyboard base should be gently sloped away from the user so the key tops are accessible to the hands in a neutral position. This positioning requires a negative sloping keyboard, a major

departure from the conventional wisdom of a few years ago.

8. Reduce excessive exertion or force, especially when using tools or lifting.

9. Minimize fatigue, especially that which results from continuous exertion of the same muscle group over a period of time. The greater the muscular effort, the shorter the time the effort can be maintained.



Example of a negative sloping keyboard.

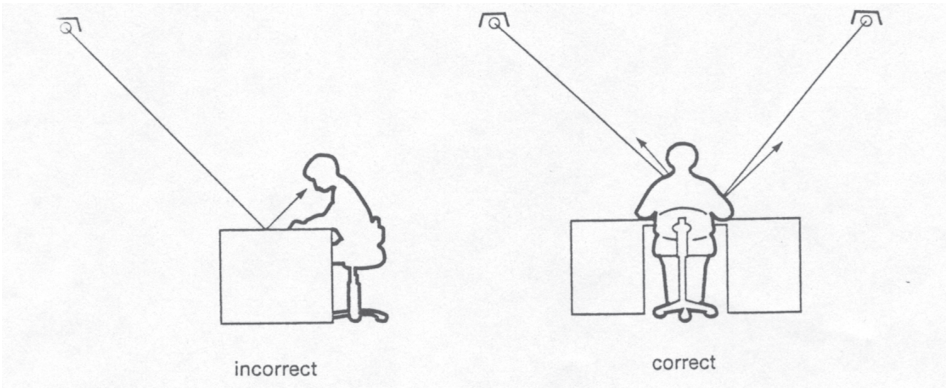
10. Reduce excessive repetition to avoid injury to tissues and joints. Repetitive activities such as typing on a keyboard require regular breaks or changes in activity to reduce injury.

11. Provide clearance and access for heads, arms, torsos, knees, and feet. Legroom is a common problem for desk workers if the space under the desk is filled with storage, including recycling bins, purses, briefcases, and so on. Workers must be able to stretch their legs forward.

12. Minimize contact stress by using padding and contours at key contact points, where the body reaches, rests or rubs against office equipment. Leaning the forearms against sharp or hard edges for support and standing on hard floor surfaces are typical of the conditions that cause contact stress injuries.

13. Provide for worker mobility and change of posture, including changes in positions and alternating between sitting and standing. There is no single correct posture for an entire workday. More frequent short breaks are better than a single long break.

14. Maintain appropriate lighting. Glare is a particularly serious problem, not only because it is uncomfortable for the eyes, but also because the tendency is to unconsciously shift body position to avoid monitor glare that then contributes to neck angle problems. Glare is best avoided by having the light source to the right and left, rather than in front.



Example of proper light sources.

15. Maintain proper temperature, humidity, and air velocity. The proper temperature for seated work is 65° to 75° F; for physical activity such as lifting it is 60° to 68° F. The receiving room should be cooler than the cataloging department. Humidity should be in the range of 30% to 70%. Extremely dry or humid air can affect thermal comfort. Air velocity is uncom-

fortable at more than 0.1 yard per second—the velocity at which most people feel a draft.

Identifying Problems

Problems can be identified through a reactive approach, such as looking at each report of a work injury and determining its cause, or through an active approach, such as systematically evaluating a workplace before problems occur.

Reactive Approach

www.osha.gov

Libraries are not subject to OSHA reporting regulations on injuries now that Congress has overturned OSHA's ergonomic rules for office workers, but they are subject to workers' compensation claims and litigation. Libraries should require employees to promptly report any injury or significant discomfort at work, including when and how the injury occurred, and the possible nature of the resulting injury or discomfort. The employee's work area should then be examined to determine how working conditions may have contributed to the problem. The source may be as simple as a crowded work area with boxes on the floor over which an employee tripped or subtle as an improperly placed computer monitor and keyboard that cause eye, neck, and wrist discomfort.

Repeated injury and discomfort reports should trigger a more active approach: a systematic evaluation of the entire workplace.

In addition to the number of incidents, consider the seriousness of incidents. Even one or two claims that cost thousands of dollars in workers' compensation warrant a systematic evaluation of the workplace.

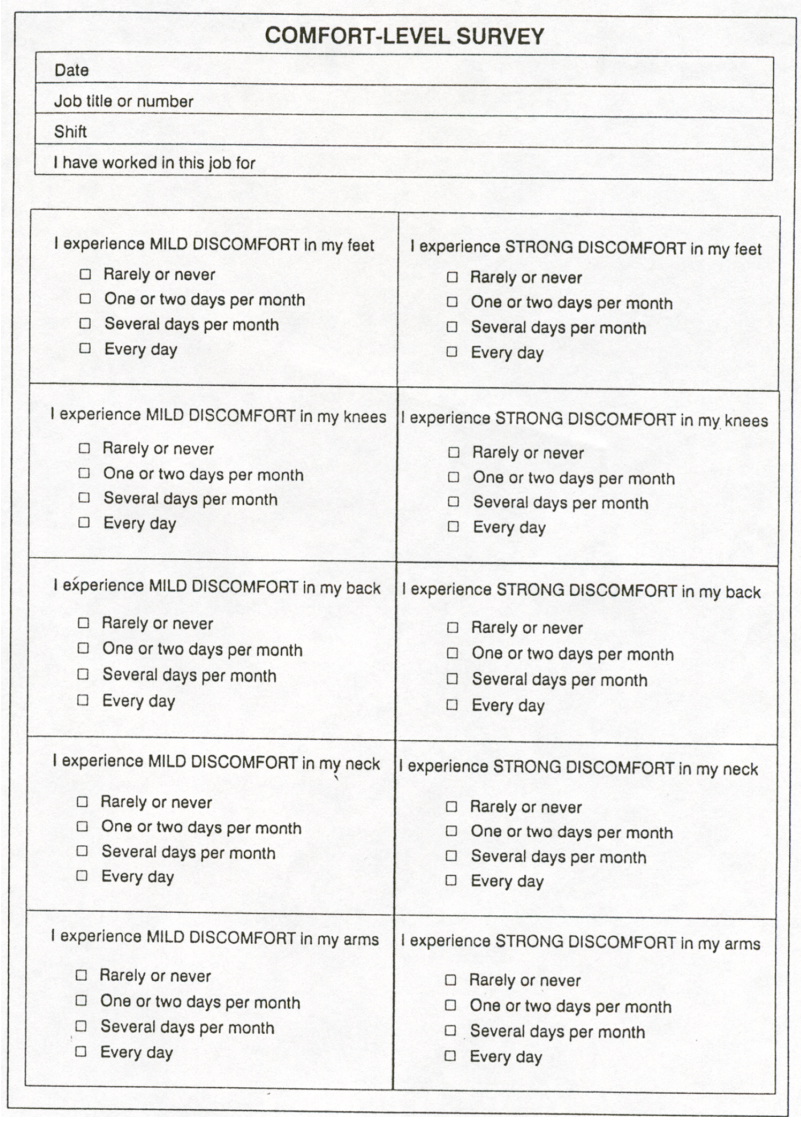
Active Approach

Ergonomics should not be ignored just because there is no history of injuries in a workplace. One reason why employees quit or are absent is dissatisfaction resulting from uncomfortable working conditions such as unsuitable furniture, equipment, or tasks. Even if employees are not injured and come to work every day, poor morale may be a result of uncomfortable working conditions. OSHA estimates that loss of productivity due to discomfort and lowered morale costs up to three times as much each year as the $15 million paid out in workers' compensation claims.

An active approach involves gathering data before injuries are reported. A survey that asks employees to indicate the seriousness and frequency of discomfort in specific parts of the body is a relatively inexpensive and effective data-gathering tool, especially for determining employee discomfort that may lead to injury. A typical form is reproduced on the facing page.

Observation is another important active approach to evaluation of the workplace. It requires considerably greater skill than surveying. Not only must the observer know what to look for, but he or she must also avoid

triggering the Hawthorne Effect, a change in behavior by those aware they are being observed. Skilled observers ask questions and seek examples of the content of the work while people are working so the workers assume normal work posture during observation.



COMFORT-LEVEL SURVEY

Date	
Job title or number	
Shift	
I have worked in this job for	

I experience MILD DISCOMFORT in my feet ☐ Rarely or never ☐ One or two days per month ☐ Several days per month ☐ Every day	I experience STRONG DISCOMFORT in my feet ☐ Rarely or never ☐ One or two days per month ☐ Several days per month ☐ Every day
I experience MILD DISCOMFORT in my knees ☐ Rarely or never ☐ One or two days per month ☐ Several days per month ☐ Every day	I experience STRONG DISCOMFORT in my knees ☐ Rarely or never ☐ One or two days per month ☐ Several days per month ☐ Every day
I experience MILD DISCOMFORT in my back ☐ Rarely or never ☐ One or two days per month ☐ Several days per month ☐ Every day	I experience STRONG DISCOMFORT in my back ☐ Rarely or never ☐ One or two days per month ☐ Several days per month ☐ Every day
I experience MILD DISCOMFORT in my neck ☐ Rarely or never ☐ One or two days per month ☐ Several days per month ☐ Every day	I experience STRONG DISCOMFORT in my neck ☐ Rarely or never ☐ One or two days per month ☐ Several days per month ☐ Every day
I experience MILD DISCOMFORT in my arms ☐ Rarely or never ☐ One or two days per month ☐ Several days per month ☐ Every day	I experience STRONG DISCOMFORT in my arms ☐ Rarely or never ☐ One or two days per month ☐ Several days per month ☐ Every day

Example of a comfort level survey form.

Use a checklist to conduct observations. Although a published list can be used, librarians are wise to use such a list to develop a survey tailored to the specific work being done. The ergonomics basics set forth in Chapter 4 are an appropriate starting point, as is the checklist developed by OSHA as part of its standard development (see Appendix D).

Observation by someone who knows what to look for usually catches many problems. An ergonomist interviewed for this report found problems with more than 90% of all workstations inspected in the past year, including:

- 65% of monitors placed too high
- 53% of workers subjected to too much glare

- 51% of the keyboards too high
- 39% of the monitors too close
- 26.5% of the monitors placed off at an angle instead of straight ahead
- More than 56% of the chairs could not be adjusted
- More than 70% of chairs that could be adjusted were not properly adjusted
- Only 11% of the desks or other work surfaces had adjustable heights

Another ergonomist said that nearly half of the people she observed cradle a telephone under the chin rather than using a headset of a speaker-phone. Many of them could develop neck problems.

Observation may be supplemented with interviews but that adds to the time and cost. Nevertheless, interviews are a good idea because interviewees who are encouraged to keep working while talking are usually less self-conscious about being observed.

An interview should begin in a general way with questions such as "Do you ever experience discomfort while you are working, and, if so, of what type?" If the response is vague, ask specific questions about discomfort to wrists, neck, shoulders, and so on.

Commonly used questions include:

1. Do you ever experience physical discomfort while working or after a day's work?
2. Where is the discomfort? Please describe it.
3. Do you have any idea what causes the discomfort?
4. Are you the only person assigned to this workstation?
5. If you are the only one assigned to this workstation, has someone adjusted the chair, keyboard tray, wrist support, height of the screen, and distance to the screen to your body?
6. If you share this workstation, has someone shown you how to make adjustments to fit your body?

Individual Versus Team Approach

See Appendix C for a list of ergonomists.

A common approach to problem identification is the retention of one or more ergonomists.

The retention of an ergonomist is easy and quick to implement because there is no need to train others in the principles and basics of ergonomics or the techniques of evaluation. The investigator(s), however, may lack crucial information known by others who are familiar with the workplace. Furthermore, employees may not buy into the findings of the investigator(s). This is especially likely when problem identification is conducted primarily through observation, with minimal input from management and employees, whether in interviews or active participation.

The team approach developed in the automobile industry usually involves a group that includes an ergonomist, or at least someone with some training in the field, and representatives of management and staff. The team composition should reflect the various tasks performed within the

organization. Although this approach is more costly because it involves more people and more training, it usually elicits better results because of input from people with varying perspectives. Furthermore, as a result of wider participation, employees are more likely to accept the findings.

Although the ergonomics team can be quite large, an entire team should not be involved in observation because it will distract those being observed. Only one or two people should be involved in the observation of each worker. What team members observe can then be reported to the entire team and discussed.

Training of those who participate in ergonomic analysis should include an introduction to common musculoskeletal disorders and other ergonomic problems (see Chapter 3), ergonomics basics (see Chapter 4), and the use of a checklist to identify unsuitable equipment, furniture, posture, or work habits; and common solutions. The checklist can be developed from the ergonomics basics or by adapting another organization's checklist.

Maintaining Records

Each organization must identify a person who will be responsible for tracking the injury and discomfort reports, and for periodically—typically quarterly—compiling and analyzing the reports. At a minimum, the record should include when the injury or discomfort occurred, to whom, what the job was at the time, the department, the kind of injury or discomfort, and how much time—if any—was lost. OSHA has developed a log for recording this type of information, called OSHA 200.

OSHA's Web address is www.osha.gov.

Compile data and calculate the injury rate at regular intervals. Although no standards for injury rates exist, the number of incident reports in a year is commonly 5% of the total number of office workers. In a quarter, that rate would be 1.25%. A higher percentage should trigger a systematic evaluation of the workplace. Workers engaged in physical activity, especially lifting and reaching (library shelvers among them) typically have an injury rate of 20% to 25% per year. In a quarter, that would be 5% to 6.25%.

Discomfort is more common than injuries. Workers in offices typically report mild discomfort in an average of 2.5% of responses and strong discomfort in 1.5% of responses. In some organizations the figures are much higher. In most cases, the figures can be significantly reduced by implementing an ergonomics program.

Analysis should include identifying the departments in which the injuries and discomforts occur, the type of work involved, and the possible causes.

Solutions

In most cases, the emphasis should be on finding solutions, rather than on documenting problems. Extensive documentation is necessary only if a case must be built to spend a significant amount of money on a solution. If the problem is obvious, spending time documenting the problem is counterproductive because further study may lend no insights into solving the problem.

Several solutions usually exist for any problem. The solution need not be the purchase of special furniture or equipment. One of the case studies used in the training of ergonomists at several universities involves the problem of a desktop computer monitor that is too low for a tall user. The options the students usually identify are:

- Place the monitor on a phone book.
- Build a wooden monitor stand.
- Purchase an adjustable monitor stand.
- Purchase an adjustable desk-mounted monitor arm.
- Purchase an adjustable wall-mounted monitor arm.
- Raise the desk by placing it on blocks.
- Purchase an adjustable-height desk.
- Purchase a special computer workstation that has separate adjustments for the monitor, keyboard, and hard copy.
- Lower the chair.

Looking at several options usually results in less expensive solutions. Many standard recommendations for ergonomically correct solutions can require unnecessary expense. In the foregoing example, the solutions range in cost from nothing to more than $1,000. Although the phone book solution works, it is not an attractive solution. It also does not adjust for distance, usually a problem that is present whenever the height of a monitor is a problem. The adjustment of the chair, although aesthetically more acceptable, also does not adjust for distance, and it may make it difficult for the user to keep the feet level on the floor. The optimum solution, may, therefore, be an adjustable monitor stand or arm that solves not only the height problem, but also a potential distance problem—a modestly priced solution at under $150.

Many modest investments, among them document holders, telephone shoulder rests, lumbar support pillows, foot rests, wrist rests, overhead light diffusers, antiglare screens, and adjustable chairs, and so on, reap substantial benefits.

Pitfalls in Purchasing Ergonomic Products

Ergonomic products that are not properly used are not ergonomic. Many organizations purchase ergonomic chairs, sometimes at a cost of more than $1,000 each, but no one is assigned to fit each chair to its occupant, nor are the users trained in assessing their needs and making adjustments.

A suitable chair does not solve the problem if the monitor is improperly placed, the height or angle of the wrists is incorrect, or there is no room to place the feet under the desk or table. The chair, therefore, functions no better than a $100 chair of standard design.

Short-term Versus Long-term Improvements

Many small and inexpensive improvements can be completed literally

overnight. Typical examples are layout changes to improve heights and reaches, the proper adjustment of chairs, or changing posture. Long-range improvements are sometimes also needed. These may involve changes in lighting or HVAC, the purchase of relatively expensive workstations, or major changes in work methods. Whenever a problem is identified, the analysis and solution should differentiate between the short- and long-term improvements.

One of the most important long-term improvements any organization can undertake is the publication of an employee handout on ergonomics and a series of staff seminars on what problems were identified in an ergonomic analysis, what was done to address problems, and how employees can recognize additional problems.

HVAC is heating, ventilation, and air-conditioning.

Measuring Results

Data on reported injuries should be tracked both before and after an ergonomics program is launched. By tracking libraries can determine whether the number of incidents actually went down following the implementation of solutions to problems identified in an ergonomics study.

Also consider repeating the comfort survey to determine whether employees who have not reported injuries have experienced less discomfort as the result of changes made following an ergonomic study.

If no improvement occurs, repeat the observations and interviews to determine whether conditions exist that are keeping the intended improvements from being realized. These obstacles can be as simple as employees changing the layouts of their work areas or, as was observed in one library, custodial services moving chairs around so that employees were not using chairs adjusted specifically for them.