Ergonomics: What is it?

Clearing away the confusion

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When people ask what I do for a living and I tell them that I am an ergonomist, I typically get a confused expression, followed by "Oh, so that has something to do with ergonomics, right?" The conversation then goes one of three ways:

1. "I notice some pain in my hand. Do you think I have carpal tunnel?"
2. "Ergonomics, that stuff costs a lot of money, doesn't it?"
3. "Can you help me get me a new chair for my office?"

The truth is: I am not a doctor and cannot diagnose their disorders; ergonomics is not a cash cow; and I do more than provide new chairs for people. Although public awareness of the word "ergonomics" has increased during the past several years, public understanding of what "ergonomics" actually means is limited. Most people who are queried will say that ergonomics is "about chairs" or "something to do with health and safety."

In today's marketplace, an increasing number of products are promoted as "ergonomically designed." Some are, but many wear the label as a purchasing enticement for consumers. On the other hand, there are products that were truly designed with ergonomics taken into consideration, but the "ergonomically designed" label is nowhere to be found. The phrase "ergonomically designed" is misleading the public to believe that ergonomics has something to do with weird things that should be better for us, such as a strangely angled or divided keyboard, a special wrap around a tool handle, or a foot-operated mouse.

Ergonomics is more than getting a new chair or keyboard tray. It is about more than physical fit of the workplace. Ergonomics is the field of study concerned with finding ways to keep people productive, efficient, safe, and comfortable while they perform tasks. The basic premise is to make the task fit the person, rather than making the person adjust to the task. ErgoWeb Inc. defines ergonomics in a proactive sense:

"Ergonomics removes barriers to quality, productivity, and safe human performance in human-machine systems by fitting products, equipment, tools, systems, tasks, jobs, and environments to people."

Many people I speak to are surprised to learn that numerous college ergonomics programs are embedded in industrial engineering departments. There is a strong linkage between ergonomics as part of industrial engineering. Simply put, industrial engineers figure out how to do things better. They engineer processes and systems that improve quality and productivity and eliminate waste. Since the ultimate goal of ergonomics is to optimize the performance, health, safety, and comfort of people within human-machine-environmental systems, it is a sensible fit to the industrial engineering field.

There are several domains of specialization within the ergonomics discipline. The Internal Ergonomics Association divides the field into three domains: physical, cognitive, and organizational.

PHYSICAL ERGONOMICS

Physical ergonomics deals with the human body's responses to physical and physiological stress. It takes into account characteristics of the human such as anatomy, physiology, and biomechanics as they relate to physical activity. Physical ergonomics issues, primarily in the workplace, typically dominate the public view and understanding of ergonomics.

It is certain that when ergonomic principles are ignored in the workplace, musculoskeletal disorders (MSD) are a potential outcome. However, the reduction of MSD-risk or decrease in worker's compensation cost is only one of the many goals of physical ergonomics. There are many other benefits:

Increased productivity: It is common for ergonomic improvements to increase productivity by 10–15 percent. In fact, studies have shown a 25 percent increase in output at computer workstations when using ergonomic furniture, while concurrently improving employee well-being.

Improved quality: With increased comfort, errors and, thus, product defects are less likely.

Improved efficiency: This can come about by bringing items closer to the work area or completing a task with fewer motions. In each case, the task can take less time and there is a lessened chance of muscular fatigue.

Reduced downtime: Maintenance tasks can be optimized by improving access points during changeover tasks. This allows for a faster task time, which leads to a decrease in machine downtime.

Improved employee morale: Ergonomics allows businesses to spread the "I care" message to all levels of the organization, from the plant floor to the office employee.

Reduced turnover and absenteeism: When people are comfortable at their workstations, they are less likely to take time off from work or leave the company because of discomfort.

An ergonomist analyzes the risk factors that a given job brings. Task variables in the workplace that may each increase the risk of MSDs or cause decrements in performance are examined. Risk factors can be broadly classified into task physical characteristics and environmental characteristics.

Task Physical Characteristics

Awkward postures: Examples include reaching behind the body, twisting, working overhead, kneeling, forward or backward bending, and squatting. People working in awkward and uncomfortable postures are not in positions to do their jobs right the first time. Mistakes are more common. From an MSD-prevention standpoint, the more the joint departs from the neutral position, the greater the likelihood of injury.

Excessive force: Examples include lifting, lowering, pushing, pulling, pinching, and using the hand as a hammer. Generally, a task will take longer as more exertion is required to perform a task. In addition, precise movements are more difficult to perform under a heavy load, which can affect quality and efficiency.

Repetition: Repetition is a measure of the number of times the same motion of exertion is completed in a given amount of time. Line or machine rates, piece work, and incentive programs can influence the repetition rate. The risk of an MSD increases when repetition is combined with other risk factors, such as force, duration, and posture. From a performance standpoint, excessive movements may be considered as "waste" in a system. More motions will take more time, and they may not be value added.

Duration: Duration is the length of time of exposure to the task. Duration must be considered with other risk factors assessed in the task.

Contact stress *(also known as mechanical stress):* When any part of the body presses against an external object, the resulting sustained force may cause too much mechanical stress on tissues. It is also possible for excessive contact stress to be produced from the impact shock of an object against a part of the body.

Static muscle loading: Standing, sitting, or otherwise remaining in one posture for a long duration while performing a task can increase the likelihood of injury. The combination of force, posture, and duration creates a condition that quickly leads to muscle fatigue. There is a direct link between fatigue and lost productivity.

Vibration *(hand/arm):* Vibration transmitted through the hands through direct contact with a vibrating source can lead to vascular, muscular, or neurological disorders.

Task Environmental Characteristics

Heat stress: Summer heat, welding, or heat from processes can lead to an excessive heat load on the body, which can lead to heat-related illnesses, including heat stroke. Heat combined with high humidity results in an elevated risk of illness due to the reduced ability of the body to cool itself.

Cold stress: Low temperatures caused by winter weather, high altitudes, or cryogenic equipment can result in muscle strain, frostbite, or hypothermia because of the drop in core body temperature. Cold stress may also occur with hand tools that release air exhaust.

Vibration *(whole body):* This type of vibration is transmitted to the human body, usually through a seat or a platform. Visual performance—as well as discomfort—can be experienced by people exposed.

Lighting: Improperly placed lighting may cause glare. Too little lighting in a work area may lead to a safety issue. Proper lighting has been associated with enhanced productivity.

Noise: Noise is defined as unwanted sound. It can be loud enough to cause pain in the ears or it may be "nuisance" sound. This can be disruptive, annoying, or distracting, which can lead to decrements in performance. Two recent studies in open-plan office environments show that speech distraction is rated by employees as the number one facility issue that affects their satisfaction and productivity.

Personal risk factors also exist that are inherent to the individual. Factors such as age, pregnancy, gender, strength capability, anthropometry (body dimensions), and level of physical activity can affect predisposition of MSD development. For example, while women account for about 45 percent of all workers, they experience nearly 2/3 of all work-related repetitive strain injuries.

Typical examples of physical ergonomics interventions include:

- Designing of a workstation to allow the proper height and reach to perform the task.
- Selecting a tool with a handle design that reduces awkward postures for the application.
- Reducing unnecessary tasks and movements to increase efficiency or decrease errors.
- Providing a monitor riser on a computer workstation to eliminate neck bending to view the screen.
- Tilting and lifting containers to bring work to a proper height and increase efficiency.

COGNITIVE ERGONOMICS

Cognitive ergonomics is an emerging branch of ergonomics. It is a subset of the larger field of human factors. It focuses on the fit between human cognitive abilities and limitations and the machine, task, and environment. Cognitive ergonomics is concerned with mental processes, such as perception, memory, reasoning, and motor response, as they affect interactions among humans and other elements of a system.

Relevant topics in cognitive ergonomics include mental workload, decision making, human-computer interaction, and work stress. Typical domains of application include process control rooms and command and control centers. Cognitive ergonomics is especially important for operators in modern industries. Human performance must be sustained in work environments where performance may be time constrained, multiple simultaneous goals may be in conflict, and events may be difficult to predict. Typical examples of cognitive ergonomics interventions include:

- User centered design of a software interface.
- Design of a sign to convey the message so that people will understand and act in the intended manner.
- Design of an airplane cockpit or nuclear-power-plant control system so that operators will not make catastrophic errors.
- Design of information technology systems that support cognitive tasks.
- Work redesign to manage cognitive workload and increase human reliability.

With cognitive ergonomics, goals are largely centered on performance and human error. Safety and product quality are the main concerns because automation can result in increased operator decision making and monitoring requirements, which can increase the likelihood of errors and accidents.

The near meltdown of the nuclear-power generating station at Three Mile Island, PA, is an example of how groups of people react and make decisions under stress. The accident, due initially to a mechanical issue, was exacerbated by wrong decisions made because the operators were overwhelmed with information, some of which was inaccurate. Valve failure had ultimately led to a loss of water used to cool the reactor. This should have triggered an emergency core cooling system to commence operation, but the workers at the plant misread the situation and turned it off.

The design of the control room was a factor that played into human error. Controls were located far from instrument displays that showed the condition of the system. Instrument readings were either difficult to read, obscured by poor lighting or glare, or were located on the back wall of the control room. Proper direction of motion stereotypes was not always used. One valve might be opened by pushing a lever up, while another one might be opened by pulling a lever down. During the first few minutes of the accident, more than 100 alarms sounded, and there was no system for suppressing the unimportant signals so that operators could concentrate on the significant alarms.

Information was not presented in a clear and sufficiently understandable form. For example, although the pressure and temperature within the reactor coolant system were shown, there was no direct indication that the combination of pressure and temperature in the coolant system was favorable for the formation of steam. The pressure valve had an unreliable design which made it jam open, and it had a poorly designed indicator which only showed what the valve had been signaled to do, rather than what it had done. This led the operators to believe that it had been closed. Had accurate information about what was going on inside the containment system been given to the operators in a readily conveyable format, the right decisions could have been made to prevent a serious incident.

ORGANIZATIONAL ERGONOMICS

Organizational ergonomics is focused on the optimization of sociotechnical systems, including their organizational structures, processes, and policies. This field is also known as macroergonomics. The area of macroergonomics proves that ergonomics is not just about how an individual interacts with an object. Even organizations need to be ergonomically designed. Organizational ergonomics is concerned with topics such as communication, work design, teamwork, crew resource management, teleworking, shift work, safety culture, job satisfaction, and motivation. How groups of people interact with each other in a work environment is the core of macroergonomics.

The goal of macroergonomics is a fully harmonized work system that results in job satisfaction and employee commitment. The basis of the balance model (Figure 1) is that all elements of a system interact. Any change in one system will affect other elements. If all elements are not designed to fit together, this may lead to safety, productivity, efficiency, or quality problems. The goal is to achieve cost savings or cost avoidance by balancing all elements of the system.

Typical examples of organizational ergonomics interventions include:

- Involving workers in identification and resolution of ergonomic issues, also known as participatory ergonomics.
- Improving total system processes (manufacturing value streams and managerial processes).
- Successfully installing safety as an integral part of organizational culture.

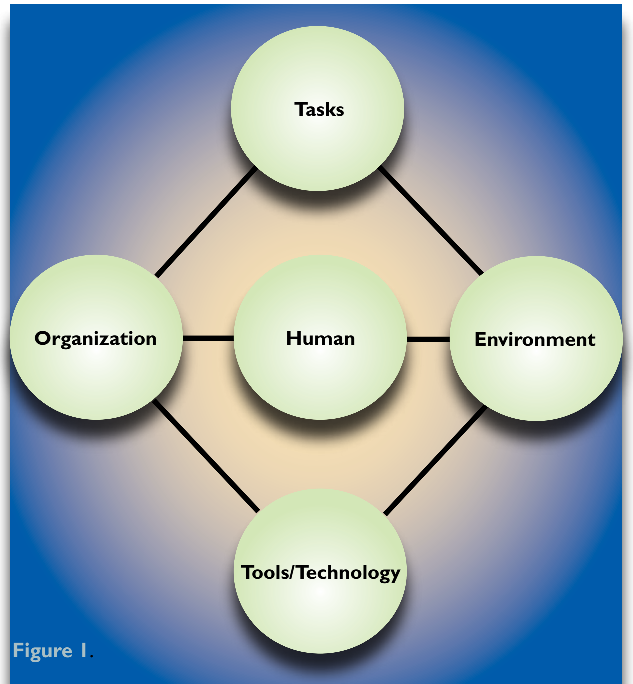

Figure 1.

- Analyzing other tasks to determine the effect if one change will affect other tasks.
- Determining how to motivate people to do inherently boring or unstimulating jobs.

One example using the application of macroergonomics took place when the master's program in systems management was transferred from the University of Southern California (USC) to the University of Denver and was used as the core program for developing a new college of systems science. A macroergonomics analysis was conducted to determine the processes and structure that would be used for the entire work system compared to the program that had existed at USC as several mini-campuses. The analysis allowed a streamline of the organizational structure to ensure compatibility with the college's sociotechnical characteristics. In addition, jobs were designed with a user-centered approach, and better use of technology was either developed or leveraged. As a result, the University of Denver program work system realized a 23 percent reduction in staffing requirements, 25 percent savings in operating expenses, and 20 percent decrease in administrative time demands on study-center managers compared to the work system as it had existed at USC.

CONCLUSION

Ergonomists understand the huge potential of the human factors/ergonomics discipline for improving employee health, safety, and comfort as well as human and system productivity. The science of ergonomics is making tremendous advances and research contributions. It is unfortunate that these positives have been marred by products or systems claimed to be "ergonomic," but which are truly not, and by people who claim to be ergonomists, but who lack the professional training to practice properly.

Effective ergonomists may use different analysis tools or may focus on specialized areas of expertise, such as physical ergonomics, macroergonomics, or human factors. However, they reflect a common understanding and value of what ergonomics can do to help people and employers.

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