

Implications

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Ergonomics and Design: Applying the Laws of Work

Ergonomics is critical to design. Yet in spite of the fact that many products are marketed as being ‘ergonomically’ designed it remains a widely misunderstood discipline.

The name ‘ergonomics’ means ‘the laws of work;’ derived from the Greek ‘ergon’ (work) and ‘nomos’ (natural laws). Formalized in Great Britain after the end of World War II, it was founded as a human performance oriented engineering design discipline. In the United States the equivalent discipline was called ‘human factors.’ Today both names are used interchangeably, but ‘ergonomics’ probably has greater public recognition because of its use as an advertising adjective.

The discipline is defined by the International Ergonomics Association (2000) as follows:

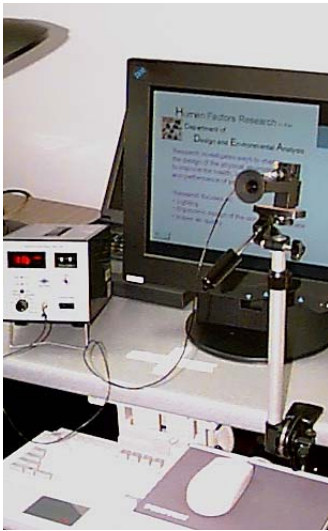
“Ergonomics (or human factors) is the scientific discipline concerned with the understanding of the interactions among human and other elements of a system, and the profession that applies theory, principles, data and methods to design in order to optimize human well-being and overall system performance.”

What Do Ergonomists Do?

Ergonomists study ways of optimizing the design of people-technology systems, using a variety of sources, including information on human physical and mental abilities that affect performance and reliability, anthropometrics, work physiology, biomechanics, social behavior, and work environment conditions. Usually, ergonomists use a **human-technology system framework** to analyze and help to improve a design. A professionally trained ergonomist will have skills in several specific areas:

—**Physical interface design:** to effectively interact with any technology, the physical dimensions of the object must fit the user’s anthropometric dimensions. Anthropometric dimensions are usually expressed as percentiles and most ergonomic designs try to satisfy a range of users, typically from a 5th percentile woman to a 95th percentile man, for any given dimension.

—**Cognitive interface design:** knowledge of the principles of information displays associated with the equipment, such as warning signs, labels, instructional materials, and the arrangement of controls (knobs, dials, etc.) are critical to product success. Understanding peoples’ reactions to how something looks and their expectations about how it works are critical components of usability.



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“Ergo Tips” Leg Position

—**Workplace design and workspace layout:** the way in which any work space is arranged can impact a worker’s health and performance. An optimal layout ensures a person stays in the best posture and

uses the least effort to perform the work. Principles of optimizing workplace layout include: 1) **convenience**—frequently used equipment is most conveniently located; 2) **location**—equipment can be easily accessed without postural deviations (bending, leaning, or twisting); and 3) **frequency**—frequently performed tasks are located together.

—**Physical environment conditions at work:** ergonomists address issues of lighting, thermal comfort, indoor air quality (IAQ), noise, disturbances, vibration, and electromagnetic fields.

—**Job design, selection, and training:** these are ways of organizing work activities to maximize work output and quality without adversely affecting workers.

—**Organizational design and management:** includes peoples’ motivations and how to best organize them into teams.

Ergonomic Design: Application of Principles

Ergonomists analyze and modify designs based on all of the principles. For product design they primarily focus on cognitive and physical changes to ensure that the new design will be easier to use and will reduce injury risks.



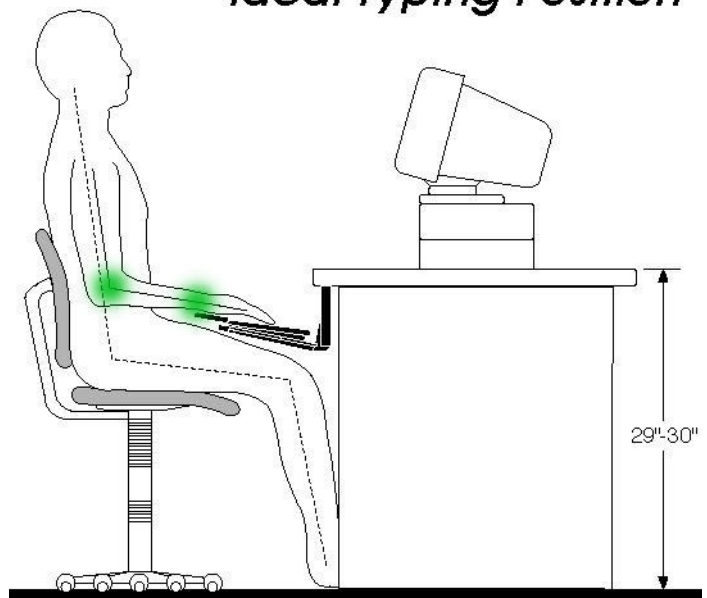
Keyboard Use Study

Ergonomists generally agree that the risks of musculoskeletal injuries, such as sprain and strains, are associated with three interrelated factors (Putz-Anderson, 1988):

—**Force:** movement requires force, but high forces increase injury risks. The amount of force exerted by a muscle group also depends on the body posture.

—**Repetition:** high rates of repetitive movements without pauses for recovery can cause cumulative microtrauma, that may result in an injury.

Ideal Typing Position



Ideal Typing Position with 29”-30” Workstation Height

—**Posture:** every articulating joint in the body has a neutral zone of movement that does not require high muscular force or cause discomfort. Injury risks are minimized when working with body segments in their neutral range rather than outside this in a deviated posture.

Poor posture plays a central role in the etiology of musculoskeletal injuries, and ergonomists use postural targeting methods to evaluate product designs and estimate injury risks.

Judging Ergonomic Design

To determine if a product really is 'ergonomically designed' Hedge (1998) suggested that an informed user should ask at least the following questions:

1. Does the design of the product make intuitive sense given the goal of the design?
2. Does the product feel comfortable to use?
3. Does the product put the user into a more neutral posture?
4. Can the manufacturer/designer clearly articulate what the ergonomic objectives are for specific design elements? In other words, why is the product designed this way?
5. Does the manufacturer have any research evidence to demonstrate that their product works? How good is this evidence? Is it undertaken by reputable external bodies? What published evidence is there that the product works?
6. Can the manufacturer give contacts for others already using the product?
7. If you are still in doubt and if it is appropriate, is the manufacturer willing to let you have a 30-day trial period using the product?

Any negative answers should raise doubts about the veracity of any ergonomic design claims.

Conclusions

The goal of ergonomics is to continually strive to develop new and better ways to optimize the performance of people using products (technology), by changing the design of the product, the training, the job, the workplace layout, the work environment conditions, the organizational system, or some combination. Ergonomists aren't designers, but often they work with designers and design teams on the development of products and places. Ergonomists typically adopt an "inside-out" approach to designs that start with the capabilities and limitations of the users (Hedge, 2004), and early involvement of

ergonomists in the design process will help designers to create highly usable and desirable designs.

—Alan Hedge, Ph.D., CPE, Cornell University

References:

- Hedge, A. (2004). Inside Out, *iVT International*, 48-53.
- Hedge, A. (1998). Introduction to Ergonomics, Chap. 1, In D. Murphy (Ed.) *Ergonomics and the Health Professional*, New York: American Public Health Association, 1-23.
- Putz-Anderson, V. (Ed.). (1988). *Cumulative Trauma Disorders: A Manual for Musculoskeletal Diseases of the Upper Limbs*. Philadelphia: Taylor & Francis.

Recommended Readings on Ergonomics:

- CUergo - Cornell University Ergonomics Web Site (<http://ergo.human.cornell.edu>).
- Galer, I. (Ed.) (1987). *Applied Ergonomics Handbook*. London: Butterworths.
- Oborne, D. J. (1982). *Ergonomics at Work*. Chichester: John Wiley & Sons.
- Sanders, M. S., & McCormick, E. J. (1993). *Human Factors in Engineering and Design*, 7th Ed. New York: McGraw-Hill.
- Wilson, J. R., & Corlett, E. N. (Eds.). (1995). *Evaluation of Human Work: A Practical Ergonomics Methodology*, 2nd Ed. Philadelphia: Taylor & Francis.

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Ergonomics Lab in Action

CU Ergo Established in the mid-1990s, Cornell University's Human Factors and Ergonomics Research Laboratory (CUergoLab) is located in the Design & Environmental Analysis Department in the NYS College of Human Ecology.

The lab's goal is to conduct fundamental and applied research on ergonomic design topics. CUergoLab is designed as a flexible facility for research about usability, human performance, comfort, stress, health, environmental simulation, and user preferences for all aspects of modern work environments.



CUergoLab Eye Tracking Equipment

CUergoLab is well equipped with state-of-the-art eye tracking, electrophysiological measurement, automatic postural assessment, electrogoniometry, video-motion analysis, environmental assessment equipment (heat, infrared video/photography, light, sound, electromagnetic), and performance and productivity assessment software. Researchers also work collaboratively with other Cornell faculty, such as the Supercomputer Visualization Group at the Cornell Theory Center on data visualization. Research studies conducted to date in the laboratory include:

Ergonomic Product Design Evaluation Research

- Design of keyboarding systems, including new keyboard designs such as the multitouch keyless keyboard;
- Design of keyboard platform systems, especially negative-slope keyboard trays;
- Design of mice and other input devices;
- Furniture workstation design issues;
- Chair design issues, such as backrest and armrests;
- Effects of chair design on body thermal insulation;
- Design of hand-operated devices, such as videogame controllers;
- Computer monitor design, eyestrain, and anti-glare filters; and
- Ergonomic interface design evaluation research.

Web Usability and Design

- GUI usability and design;
- Visual information acquisition processes; and
- Warnings, labels, and instructional materials.

Work Environment Effects

- Alternative ambient lighting systems, including daylight, artificial lighting systems, and ambient/task lighting system combinations;
- Alternative ventilation system designs, including overhead versus under-floor delivery systems, and

- ambient/task ventilation system combinations;
- IAQ variables, including fragrances and odors;
- Ambient thermal condition effects on comfort and performance;
- Privacy, communications, and crowding issues with alternative furniture workstation layouts;
- Ambient noise effects on stress, health, and performance;
- Effects of environmental design variables, such as color and texture;
- New approaches to controllable ambient environment conditions; and
- Effects of ambient conditions on productivity.

In the past decade studies from the lab have influenced business practices, especially in the design of keyboards, mice, keyboard trays, and chairs. For more information on the research studies conducted at this innovative facility at Cornell University, go to <http://ergo.human.cornell.edu>.

—Alan Hedge, Ph.D., CPE, Cornell University

Related Research Summaries

InformeDesign has many Research Summaries about ergonomics, workplace variables, and related, pertinent topics. This knowledge will be valuable to you as you consider your next design solution and worth sharing with your clients and collaborators.

“Floor Plan Complexity and Signage Influence Navigation” —*Environment and Behavior*

“Wayfinding for Patients with Dementia”
—*Journal of Architectural and Planning Research*

“Computers Are Causing Health Problems”
—*Journal of End User Computing*

“Factors Affecting Reach” —*Human Factors*

“Perception of Adjustments to Office Chairs”
—*Human Factors*

“Home Offices and Family Functioning”
—*Journal of Interior Design*

“Visual Cues Help Older Adults Maintain Balance”
—*Journal of Gerontology: Medical Sciences*

“Arm Supports Reduce Back and Shoulder Strain”
—*Ergonomics*

“Fluorescent Light Flicker Affects Occupants”
—*Ergonomics*

“Floor Mats and In-Soles Reduce Fatigue”
—*Applied Ergonomics*

“Posture Affects Workers’ Comfort and Health”
—*Applied Ergonomics*

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CUErgoLab, Cornell University



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