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## ERGONOMICS IN THE OFFICE ENVIRONMENT

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Perhaps the four most popular "ergonomic" office culprits are: (1) the computer or visual display terminal (VDT), (2) the office chair, (3) the work station, and (4) other automated equipment such as the facsimile machine, photocopier, etc. Among the ergonomics issues in the office environment are visual fatigue, musculoskeletal disorders, psychosocial factors and problems, and radiation/electromagnetic (VLF, ELF) field exposure from VDT's. We will address each of these in turn and then review some regulatory considerations regarding such stressors in the office and general industrial environment.

### Visual Fatigue and Related Issues

Visual fatigue typically may involve one or both of two different types of problems, ocularmotor fatigue and general fatigue. Accommodative or ocularmotor fatigue refers to the loss of accommodation, blurring, or shadow images which may be experienced when the muscles that allow one to accommodate or focus on the "near point" VDT screen or other reading task tire and involuntarily relax. One of the primary methods to avoid this effect is to allow the eye an opportunity to focus on more distant objects (e.g., a view out of a nearby window) which relieves the static contraction in muscles. The second type of fatigue is more holistic or general. In this case people may experience headaches and environmentally related problems such as eye soreness and dryness. One of the principal task factors with eye dryness is that the blink rate declines when one focuses attention on a visual task. That is, the eye is open for a longer period of time allowing a greater rate of evaporation. Also, with the use now of contact lenses as corrective lenses as opposed to glasses, the eye is more sensitive to drying or irritation.

The sources of these problems include CRT work station factors such as luminance of the screen, contrast characters, image size and density (how well resolved the image is), and glare. Glare is both a major work station factor and a major environmental factor. In the environmental area we have to deal with the level of humidity in the air, overhead illuminance problems in terms of glare, dust, environmental

tobacco smoke, etc. Task or the software factors include many of the same things involved in musculoskeletal exposures such as required processing speed, total time on task, repetition, forced error rate, task complexity, and frequency of use. Perhaps the largest personal factor is lack of proper vision correction or developing eye disease.

There are many different sources of glare. In addition to external glare sources such as sunlight through a window, internal glare sources often exist above the work station in overhead fluorescent lights. Modifications can be made to lights and/or changes in work station positioning can be made to reduce glare. When work stations are placed up against a window, an individual can periodically change his/her depth of focus and relax the accommodative muscles. However, the direct glare in such a situation can be considerable. To modify the luminance level of light coming in through a window, translucent film can be placed on the surface of the window to reduce the overall luminance transmitted and still allow the person to look out and change accommodation. Desk lights can cause glare by reflecting onto the screen or off of the work surface. Whenever there is a high level of contrast or "luminance ratio" between the task and the surrounding work area, there will be problems with being able to properly adapt to what is appearing on the screen.

### **Musculoskeletal Issues**

Musculoskeletal problems include upper extremity cumulative trauma disorders such as carpal tunnel syndrome, tendinitis, tenosynovitis, ganglion cyst, etc.; low back problems including low back pain, strain, and disc herniation; and other problems such as neck strains and leg discomfort. Most of these problems arise from work station problems such as poor positioning/layout resulting in awkward trunk and upper extremity postures, particularly deviation from the neutral; static loading of low back; and compression ischemia, particularly at the forearm, wrist, and thigh. It is typical to find a work station that is basically a table. That is, it is poorly rounded. People utilize the edge as a wrist support, placing point compression on the tendons just before they enter the carpal tunnel. While this may not precipitate carpal tunnel or tendinitis, it could conceivably aggravate the tendon and perhaps synovium producing typical symptoms of pain and numbness. Regarding low back disorders, a person who has been sitting at a desk all day and suddenly twists around to grab something can easily suffer back strain. Other factors include the amount of force used, which is typically more an issue in manufacturing environments than in office environments.

Nearly all office environments contain these musculoskeletal exposures. People try to economize on the amount of energy expended and, instead of physically moving themselves to an appropriate position, they tend to twist the body. While this is possibly more metabolically efficient, from an exposure standpoint it is potentially harmful, especially when repeated. Other factors involved are length of time on a task, repetition in terms of the keying rate and the total volume of keying done, the time constraints on the work being done, whether the task software itself is causing problems because of the number of keystrokes that must be performed to achieve the performance objective, and lack of recovery time. Hand posture complexity is also an issue. If one has to simultaneously hit the Control/Alt/F1/Shift/F6 keys at the same time (an exaggeration), groups of muscles within the hand, particularly the interossei, will be placed in conflict with each other. The muscle groups between the metacarpal bones are not adapted to multiple function or even dual function tasks. As an example, if one grasps a screwdriver and tries to thread or start a screw with the part of the same hand that is free, he/she will find that the hand goes into a fatigue state very rapidly. This is because two competitive performance objectives have been set up for those groups of muscles, and they are actually straining against each other to achieve both at the same time -- holding an object in the hand while trying to manipulate another object at the distal end of the phalanges. An example of static posture familiar to nearly everyone is tilting the neck to hold a telephone in place, in some cases combined with other upper extremity work. Static contraction creates an imbalance in the demand for and supply of blood and metabolites needed for cell respiration. In static exertions there is an isometric contraction; one is not moving, just maintaining a position, but the blood supply is reduced because of the tourniquet effect of the contraction. The arterioles and veins in that particular muscle tend to be shut down substantially because of the amount of force generated and maintained -- it is not dynamic and does not vary -- and a fatigue state is reached much more quickly.

Surprisingly, seated work can be more uncomfortable than standing work. Seated work increases spinal compression, may involve poorly supported manual lifting (seemingly innocuous weight), and can contribute to poor reaching practices or designs. In a study performed by the Georgia Tech Research Institute involving industrial operators who worked either seated or standing, we found that a seated task is not necessarily more comfortable, even though it requires a lower level energy expenditure. Our standing operator population reported less discomfort than our seated operator population. In fact, a greater percentage of seated operators experienced discomfort in

the neck, upper back, middle back, and low back. Except for the feet, the standing operators did not experience the number or types of problems experienced by the seated workers.

In the sitting position the spine actually rotates back and the body assumes a more c-shaped or kyphotic curvature. The pelvic girdle rotates up and back. This tends to take a load that was centered over the lumbar vertebrae and extends it out and away, creating an increased moment in the low back and increased intradiscal pressure. The disc in the lumbar area is actually wedge-shaped, not a uniform shape, and sitting places a greater amount of pressure on the anterior portion of the disc. This forces the gel-like material in the center of the disc back to the other end of the structure where the spinal cord is located. Long-term, repeated activity involving this asymmetric stress can produce degradation. This may contribute to irritation or bulging around the disc and, in some cases, problems with leakage of material through the external or annular disc wall. This is the postural consequence of sitting.

The typical office worker is seated erect initially because that is what all of the physical therapists and orthopedists recommend, and, in fact, this tends to keep the spine in a more lordotic configuration. However, it does not take very long until one slumps forward. The reason for this is the static contraction of the low back musculature. When seated erect, the back muscles are more active, even when compared to standing erect. So, there is a very high level of EMG activity in the trapezius and latissimus dorsi muscles and the left and right sacrospinalis (as illustrated from Lundervold's work summarized by Grandjean), and as soon as one slumps, that activity is dramatically reduced. In fact, the externally applied loads are not reduced, which means that the muscles are relaxing at the expense of something else. The something else's are the passive tissue systems such as the intervertebral discs and the many ligaments which hold the spine together and provide support in the absence of muscle activity. So, slumping occurs as a result of fatigue in the back muscles. One has a choice: to either slump and stress the passive tissue elements, or sit up straight and stress the active ones. The active ones tend to fatigue quickly and noticeably tend to get relief.

Ideally, the posture of the seated employee would be tilted back to support the majority of the load on a chair's back rest and to widen the trunk/thigh angle, actually returning the back to a more lordotic configuration. There are several ways of accomplishing the same thing, but two of the most typical are to put the backrest back,

or to tilt the seat pan forward while the backrest stays fairly vertical. The problems with the latter include increased compression on the feet, so people must become familiar with a different configuration of postural stresses and sensations. One worker here came up with a creative way to support the upper torso mass by using the knee as an alternate support point. This created some relief in the low back because the upper torso mass was no longer being supported at that point; however, his trade-off is compression at the knee.

## **Psychosocial Issues**

The issue of psychosocial stress and its contribution to work-related disorders has not been exhaustively investigated. Of particular interest is an article that appeared in the *American Psychologist* in the mid 1980's concerning the Australian RSI (repetitive strain injury) epidemic. This article contends that the RSI epidemic in Australia was a result of "technoshock." The technology was introduced rather rapidly -- the transition from the typewriter to the personal computer was rapid and poorly supported. This created a heightened state of tension and evoked psychological factors related to physical disability in the work population, and a wave of RSI resulted. Certainly, introducing this office technology into the workplace can result in some angst or unhappiness among the work population, and not all of the responses will be positively adaptive. There is some research evidence that when a person working at his/her maximum output is asked to perform the job faster, they do not actually move faster but they begin to recruit other muscles not really required. This precipitates unnecessary strain on the muscle system and contributes to discomfort and fatigue. The research challenge, then, is to ascertain where the psychological aspects end and the physical aspects begin, because they are fairly well interlinked.

Software and hardware have a big role to play in terms of user friendliness. How easy is it to accidentally erase the work that you have spent many hours generating (which might send your blood pressure through the roof)? At Georgia Tech, we once used a VDT in our consultation program that had the Delete Page key right next to the Delete Line key, with no "Are you sure?" type of redundant protection on it. This used to send quite a few people through the roof. Of course that is a hardware example, but the same type of thing is possible in software. How easy is it to make an error? How fast is the program proceeding? Do you have a program that requires a lot of processing speed on a very slow machine so that you can get five, six, or seven keystrokes ahead

of yourself before the machine catches up and you see the consequences? These kinds of problems are common and can contribute to psychological stress.

Organizational factors also have to be considered, such as whether or not there is organizational electronic monitoring. If there is monitoring, it could be monitoring of output in terms of words per minute or monitoring of people's telephone conversations, etc. Another factor is support for the task. How well are individuals trained for the task or the technology being introduced? For example, a new machine is brought in and each worker is given a mouse. Do you simply give each employee a mouse and say "good luck," or do you actually provide them some education on how to install and use it properly? These issues are often neglected in the office environment because there is an assumption that "anyone can figure it out." Often there is a problem with actual technical support in that everyone does not have immediate access to a computer sophisticate who is available to assist in the event of a "crashed" disc or a "catastrophically" modified program.

Personal factors can also be in stress. Included are standard psychosocial factors such as basic mental health, marital status, age, and type of home environment. To a certain extent these factors can be reflected in the workplace in terms of labor/management relationships.

### **Electromagnetic Field Exposure Issues**

Research evidence to date does not indicate that a substantial risk is presented either from extremely low frequency or very low frequency electromagnetic fields, voltage fields, or any other type of field emanating from the VDT. A recent study by NIOSH researchers (Schnorr, et al., 1991, *New England Journal of Medicine* 324:727-33) determined that there was no impact of the VDT in terms of field exposure on a very large population (4,246 women telephone operators and 882 pregnancies) in terms of spontaneous abortion outcomes. However, most of the traditional factors such as tobacco and alcohol use that one would anticipate to be important or influential were present. Another study (Walsh, et al., 1991, *American Industrial Hygiene Association Journal* 52[8]:324-331) looked at 54 work stations and 1,166 workers. The levels they monitored did not exceed levels from the overhead lighting, building wiring, or anything else in the exposure environment. In fact, most of the complaints and problems the employees presented with were related to ergonomic factors such as screen positioning,

work station design, etc. Dr. Edward Rinalducci presented at this conference in 1990. His paper appears in the 1990 *Proceedings*, and provides a very good overview of VDT-specific issues. It is intensive toward design and engineering aspects of the VDT work station and gives the reader a good review of radiation studies.

### **Regulations and Other Standards**

Some U.S. VDT ergonomics design guidelines (not all-inclusive) are:

- o ANSI/HFS 100-1988 Human Factors Engineering of Visual Display Terminal Workstations.
- o MIL-STD-1472D or more current version.
- o OSHA 3092 (general, easy to apply principles).

The ANSI/HFS 100-1988 Human Factors Engineering of Visual Display Terminal Workstations tends to be very technical. Some of the military standards are easier to read. OSHA 3092 is very condensed and gives the reader a general work station outlay and a good sense of what a work station should look like.

With respect to mandatory standards, there have been a series of failed municipal efforts to regulate use of VDTs in the workplace. Some recent U.S. attempts at regulation include:

- o Suffolk County, N.Y., passed a VDT law in May, 1988 requiring:  
  
Adjustable furniture, VDT equipment, maximum time on task without break (3 hours), employers pay 80 percent of cost of eye exams, lenses, and frames, and training on potential health hazards.  
  
December 1989, N.Y. State Supreme Court struck down the law in civil suit filed by employers, finding that the county "lacked authority" to promulgate law.
- o A New York City VDT law passed by City Council but was vetoed by Mayor Ed Koch in December, 1989.
- o The City of San Francisco passed a VDT Ordinance in December in 1990 which was similar to the Suffolk County law. It required up to \$250

expenditure per work station for corrective action. It applied to employees with greater than 4 hours per day on a VDT and set minimum work station standards, work/rest requirements (break after 2 hours), and training requirements.

Bay area employers filed a challenge to the law in September, 1991, in California Superior Court. On February 13, 1992, the Court overturned the ordinance eliminating the second major municipal VDT regulation effort. The Court cited "lack of jurisdiction."

- o Draft Cal-OSHA (state) ergonomics standard was circulated during the summer of 1992. This standard includes a VDT Appendix and is still under review.

In most cases, these were attempts to require employers to survey the work force to find out what types of problems were there. They also included work limitations in terms of how long one could work before a break (some of the research evidence documents that long-term exposure can lead to greater symptom presentation than exposure on a short-term basis). They further required employers to provide employees with vision exams and corrective lenses if needed. The San Francisco law also called for the provision of a specific dollar figure for work station corrective action. Both of these attempts at regulation failed because in both cases the state courts responded to employer suits which challenged them. The typical finding was that the rulemaking was not under the scope of the municipalities authority (that it was a reserved State or Federal function). Partly in response, California now has a draft standard under review. This is a more generic ergonomics standard and is not specific to VDT's, although it does include a specific sub-part that deals with VDT's. This Draft Standard is "subject to a lengthy review."

Some of the driving forces behind the regulatory actions include:

- o Disorders associated with repeated trauma are the leading occupational illnesses in the nation, representing more than half of all reported occupational illnesses.
- o Pending class action, product liability suits against computer manufacturers including Apple, IBM, Northern Telecom, AT&T, NCR, Atex (Kodak), and Wang concerning keyboard design.



- o The Americans with Disabilities Act (ADA) may threaten worker's compensation as the "exclusive remedy" for workplace injury. In a recent case against Boeing under an ADA-like Washington state statute, the company was ordered to pay an employee with work-related, chronic tendinitis \$1.16 million in compensation and damages.
- o The American National Standards Institute (ANSI) and the American Society for testing and Materials (ASTM) both have voluntary, consensus standards activities underway in ergonomics.

Ergonomics is becoming one of the leading occupational health and safety concerns in the nation because of the rate at which musculoskeletal disorder incidence has increased. When looking at this data, the tendency is to believe that about half of all of the occupational illnesses and injuries in the United States are cumulative trauma disorders. But, in fact, this BLS category actually includes other types of trauma issues such as occupational hearing loss, and most of the incidents that were reported in 1981, 1982, and 1983 probably represented occupational noise-induced hearing loss and other types of vibration or pressure problems. So, while the growth has been substantial, it is not all cumulative trauma disorders of the hand and wrist. In fact, in the period 1985 to 1987, OSHA undertook a major crusade to improve recordkeeping and reporting and increased the sensitivity of the system. This has certainly contributed to the growth in this category.

Litigation is currently underway against a number of VDT station manufacturers, including Kodak, IBM, Apple, and NCR. There does not appear to be a good defense for these keyboard manufacturers other than no one knew that VDT's would present such problems.

Another driving factor is the American Disabilities Act (ADA), which is probably more relevant to private than public employers. There is a growing perception that ADA is becoming a way around workers compensation as exclusive remedy. In other words, it is becoming the next remedy. We are seeing cases such as the one Boeing recently had settled against it where \$1.16 million was awarded to a single employee who experienced a work-related, chronic tendinitis. This worker went through the medical management system, was arguably mismanaged in the medical management system, and the company failed to make reasonable accommodation. This was not an ADA case, per se, but the State of Washington has its own version of the same type of law, and the

finding was that, for failure to make reasonable accommodation to this work-related or work-aggravated or work-created tendinitis, the company owed this individual \$1.16 million. This was not for a congenital birth defect, an accident, or anything that was pre-existing, but rather for these types of repetitive motion injuries becoming defined as disabilities and therefore potentially compensable under the reasonable accommodation provisions of that Act.

ASTM and ANSI both have voluntary, consensus standards activities underway in ergonomics. All of this is pushing the Occupational Safety and Health Administration's agenda to release their Advance Notice of Proposed Rulemaking (ANPR) for the Standard in August of 1992. The ANPR is a call for information from employers/labor on ergonomics effectiveness and feasibility. The model they propose using is the model used in the Meatpacking Standard of 1990. OSHA needs evidence of effectiveness and feasibility to convince the Office of Management and Budgets (OMB) and overcome employer resistance. Organized labor has applied substantial pressure on OSHA, including requesting, in the summer of 1991, an Emergency Temporary Standard (ETS). The Department of Labor (DOL) denied this request in the spring of 1992 because of lack of appropriate legal consideration; that is, it was not deemed an hazard of sufficient severity and immediacy to warrant foregoing the normal rulemaking process.

There are other pressures as well, including Pepperidge Farm's citations. When this review appeal concludes it will probably be one of the longest-running review cases in OSHA history. The Administrative Law Judge is, as of the present date, still pondering the results of a case in which arguments closed in March of 1991. If the citation is overturned, it would provide substantial incentive for the Agency because it could restrict their ability to use the general duty clause to regulate ergonomic hazards.

The Comprehensive OSHA Reform Act did not pass this year but may, in fact, pass with the new administration and new Congress. The original bill came with its own regulatory agenda attached. If this Act had passed in the format in which it was originally proposed, it would include, among other deadlines, a deadline for promulgation of an ergonomics standard. The proposed ANPR format is very similar to the meatpacking safety and health guidelines in that it might require surveillance, systematic hazard analysis, prevention and control measures whether engineering or administrative, health management, and training and education of employees and medical specialists. The ANPR is asking whether there should be qualifications for program

managers and analysts, because presently there are very loose definitions of what an ergonomist actually is, what type of person is needed to perform these types of analyses, and what the analyses might entail. They want incidence data and information on what the impact of ergonomics intervention has been for companies. They are beginning to emphasize the concept of a "systematic" approach to analysis. This is odd since we really do not have very good definitions of what the exposure/outcome relationships are, and the belief that there might be a way to systematize the analyses without that knowledge seems inappropriate.

Following is a series of generic recommendations and office task considerations:

1. Consider upper extremity repetition in software development (perhaps most important for CTD's).
  - "Enlarge" the task so that keyboard activity is distributed with other, non-repetitive tasks (reading, copying, faxing, etc.).
  - Use programmed rest breaks (short duration) to break up keyboard activity.
  - Include repetition and ease-of-use considerations into new software purchasing decisions.
  - Build macros (user programmable shortcuts). Simplify most frequently used operations. Macros can reduce repetition, the opportunity for error, and may also improve efficiency.
  - Minimize "unfriendly software." Forced errors increase repetition.
  - Seek out automation for repetitive tasks (e.g., large-volume stapling, collating, hole punching).
  
2. Visual distance, viewing angles, glare
  - Top of screen at 1" to 2" below seated eye height.
  - Watch for direct and reflected glare.
  - Recommended distance is 20" (50 cm, ANSI/HFS-100), although distances of 51 to 100 cm have been found to reduce visual fatigue.
  - Use document holders to reduce eye/neck activity.

- Frequent slumping toward or squinting at screen may indicate lack of proper correction or fatigue.
  - Have employee vision evaluated.
3. Work surface height/Posture
- Position hand work at elbow height whether seated or standing.
  - Avoid flexion/extension of wrist through proper keyboard height.
  - Adjustable designs will reduce musculoskeletal strain.
  - Headset telephones may help to minimize neck strain.
  - Look at height of community/support personnel equipment (e.g., facsimile, desktop copier, printer).
4. Static exertion
- Provide chairs with armrests which a VDT operator has the option of using.
  - Provide support for arms on work surface.
  - Provide larger work areas around keyboard/mouse.
  - Design work to incorporate frequent changes in posture.
  - Provide adjustable workstation and chair components.
5. Minimize reach distance/Moments on spine
- Limit frequent reaches to in front of the body and 18 inches from the shoulder.
  - Avoid extended reaches, reaches up above shoulder and eye height.
  - Tasks requiring frequent extended reaches should be standing tasks.
  - Avoid handling items or lifting at a distance from the body.
  - Design lifts so that object mass can be brought as close as possible to the center of the body.
  - Reduce forward bending of the torso (stooping) and avoid tilting of the head.
  - Obtain and use materials handling aids: hand trucks, carts, etc.
  - Design loads for lifting ease/minimize weight.
  - Use foot rails to relieve spine loading for standing workers.

6. Edge compression
  - Watch for edges cutting into wrist, palm, arm, elbow, thigh.
  - Pad edges of workstations, chair armrests.
  - Use adjustable, upholstered work chairs.
  - Use footrests where the feet are unsupported.
  - Use antistress mats or pads to relieve compression on feet (standing at the copier, fax, etc.).
7. Ingress/egress
  - Are awkward postures required to get in or out?
  - Use swiveling chairs (lockable feature).
  - Use wheeled chairs (watch friction issues, lockable castors).
8. Seated work/Chairs
  - Adjust existing chair to popliteal height.
  - Adjust/use backrest.

Objectives:

- o Maintain more natural lordotic curvature (slight forward tilt, backrest).
- o Support weight where possible to reduce muscle fatigue and spinal load (backrest angle, arm rests).
- o Avoid compression of soft tissues (buttocks, thighs, calves, arms).
- o Have seat adjusted to proper height for work (1 to 2 inches below popliteal crease).

Features to look for in new chairs:

- Adjustable height
- Adjustable backrest: height, angle, distance
- Adjustable pan tilt
- Adequate padding and a waterfall front edge to reduce compression
- 5 leg base
- Easy to adjust
- Texture of material; does it breathe, does it resist slippage?
- Swivel; improve egress and reach situations

- Wheels; improve egress and reach situations.  
(Caution: Wheels and swivels and other aspects are highly task-dependent as to their desirability.)

Problem-solving approaches:

- o "Enlarge" task to incorporate frequent changes in posture or position.
- o Increase frequency of rest breaks/microbreaks.
- o For seated tasks, use adjustable seating to accommodate as much of the population as possible. Provide arm support where feasible to relieve low back compression. Look for characteristics noted previously.

## 9. Stress

- Provide appropriate training for users/operators. (Common error: four years using a spreadsheet program is often not sufficient background to use a slide or graphics program.)
- Provide adequate support for systems (e.g., the "computer guru").
- Practice proper O&M (copier/fax toner replenished, efficient repair/recovery systems).
- Minimize use of organizational monitoring.
- Minimize monotony by diversifying task activities, increasing control/responsibility.
- Poor environmental conditions may also contribute to psychological stress. Respond to environmental stressors including temperature, ventilation problems, noise.
- Practitioners: treat workers as customers; not as organisms under study.

## 10. Medical Management (based on OSHA 3123 and draft ANSI recommendations)

- Know your population (screening)
- Know your exposures (walkthroughs)
- Return specific restrictions
- Develop a structured treatment algorithm
- Identify modified or light-duty alternatives to minimize lost time
- Encourage reporting of discomfort; refer serious cases.

## 11. Other Considerations

- Watch employees carefully for problem indications: pain complaints, workstation modifications.
- Train employees: postures to avoid, CTD's, work practices, how to adjust devices.
- Have high-risk (incidence) tasks evaluated by ergonomics professional.
- Recruit employee feedback and monitor effects of any change you make.
- Last, but not least, watch out for the sometimes self-evident employee workstation modifications.

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