CIN: Computers, Informatics, Nursing • Vol. 21, No. 3, 150-157 • © 2003 Lippincott Williams & Wilkins, Inc.

FEATURE ARTICLE

Applying Ergonomics to Nurse Computer Workstations

Review and Recommendations

KAREN NIELSEN, RN, MS
ALISON TRINKOFF, ScD, RN, FAAN

Nursing is associated with high rates of musculoskeletal disorders from patient handling, and nurses are at high risk for developing cumulative trauma disorders, which can result from computer usage. Although there are many benefits to using computers in the workplace, nurses need to incorporate ergonomic factors into work settings to promote safe workplace environments. This article reviews recent literature about computer workstation ergonomics, discusses related policies, and makes recommendations about computer workstation design and related research in nursing workplace settings.

KEY WORDS

Nursing • Workstation • Ergonomics • Cumulative trauma disorder • Repetitive stress injury

INTRODUCTION

Nurses are more at risk than construction laborers to sustain work-related musculoskeletal disorders (MSDs).[1] The increased use of computers at home and at work has also resulted in a higher incidence of related cumulative trauma disorders (CTDs).[2] In 1999, RNs in the United States suffered from over 13,000 nonfatal occupational MSDs[1] requiring days away from work, 23% involving the upper extremity.[3]

Many research studies have investigated CTDs because these are the most frequently occurring injuries related to computer use (also called repetitive trauma disorders, repetitive strain injuries (RSIs), or overuse syndrome).[2] These injuries result from repetitive exertion of the body, such as typewriting.[2] They involve recurrent and persistent pain, may involve disability in any body part,[4] and may happen progressively over periods of weeks, months, or years. These conditions are one of the fastest growing problems in the workplace and may prevent workers from performing their jobs or even simple household tasks.[5]

Nursing is an occupation at high risk for developing CTDs because of job-related repetitive tasks, heavy lifting, and awkward postures.[6] Because such tasks as charting, retrieving patient information, entering patient orders, and scheduling require more time working at the computer, nurses' injury risks will only increase unless interventions are implemented before problems occur.[7] Nurses working in diverse settings spend an estimated 2 to 3 hours daily at seated computer workstations, and McHugh and Schaller estimated that nurses will work 1.6 to 4.8 hours per shift at standing workstations in the future.[7] Careful attention must be paid to the design of clinical workstations to prevent injuries in nurses.

Ala et al[8(p50)] defined ergonomics as "a multidisciplinary science, which studies the mental, physiological, emotional and behavioral costs incurred by humans in their interaction with their work environment." The Occupational Safety and Health Administration (OSHA) defined ergonomics as the practice of designing equipment and work tasks to conform to the capability of the worker.[9] In 1993, The National Council on Nursing Research[10] identified the "application of patient care er-

From the Computer Sciences Corporation, Bethesda, MD (Nielsen), and Department of Behavioral and Community Health, University of Maryland School of Nursing, Baltimore, MD (Trinkoff).

This article was written at the University of Maryland School of Nursing and is partially funded by grants provided by the National Institute for Occupational Health and Safety (R01 OH03702) and the Agency for Healthcare Research Quality (R0l HHS11990). This paper has not been presented at this time.

Corresponding author: Karen Nielsen, 6701 Democracy Boulevard, Suite 242 Bethesda, MD 20817 (e-mail:nursenielsen@hotmail.com)

gonomics to the patient–nurse–machine interaction" as a priority for nursing informatics research. Since then, a limited amount of research has been done investigating the relationship between ergonomics and nurse computer workstations.

The purpose of this article is to provide information about ergonomic computer workstation design that may be applied to nursing workstations. A literature review of ergonomic recommendations is included in Table 1. Additional ergonomic factors that pertain to the nurse–computer interaction, such as taking breaks, are also described; recent ergonomic policies are discussed; and recommendations for future research are provided. The design and placement of equipment in computer workplace stations is instrumental in ensuring comfortable, productive, and safe nursing practice.[11]

SCOPE OF THE PROBLEM

Hess[12] defined workers at risk for CTDs as those working at a computer workstation 4 or more hours in a workday. Nurses' threshold for developing these injuries may be lower because of the already high physical demands of their work. OSHA has stated that, while it is difficult to determine the length of computer usage time related to risk of injury, workers who maintain static posture and use repetitive motions will also have problems if work variation and breaks are not used.[13]

Nurses have additional ergonomic concerns. Many nurses are now working at computer workstations in clinical environments that were not originally designed to accommodate computer use.[14] Some clinical settings have been retrofitted[14] and have improper counter heights, old equipment, inadequate workspace, improper lighting, and limited capacity for redesign.

WORKSTATION RESEARCH AND LITERATURE

Table 1 summarizes literature about general workstation design, as well as ergonomic recommendations for equipment placement and usage. The literature reviewed comes from professional nursing management, research, occupational health, ergonomics, and informatics journal articles. Classifications of ergonomic literature include: theoretical articles, research studies investigating the effects of equipment and design on the user, and government Web sites that provide policy information and ergonomic recommendations. Search terms used included: ergonomics, nurse injury, CTD, repetitive stress injury, carpal tunnel syndrome, computer workstation, workstation analysis, human factors, human–computer interaction, and ergonomic guidelines.

Literature was analyzed by searching for research studies that pertained to nurse clinical workstations, investigating the individual components of computer workstations, and exploring Bureau of Labor Statistics (BLS) and OSHA websites and publications about current ergonomic guidelines and policies. The research and literature described in Table 1 were chosen because they were the most recent, and contained information necessary for the assessment and design of computer workstations. Several articles that contained redundant information about repetitive stress injury, keyboard specifications, visual display terminals, and outdated medical office design information were not included.

Study findings in Table 1 emphasize the need to have adjustable workstation equipment, although exact specifications vary from study to study. Recommended viewing distances for monitors range from 16 to 48 inches.[4,7-8,15-17] Doheny et al[4] recommended using a flat keyboard, whereas other studies recommended 0° to 15° keyboard slopes.[2,17] Some studies suggest a relationship between perceptions of occupational stress and psychosomatic symptoms.[12,18,19] Literature about chair design emphasizes the need for lumbar support, 90° leg angles, and the need for the computer user's legs to reach the floor.[4,7,8] The number of injuries related to mouse use has risen, as computer users have become more dependent on mouse computer input devices.[20] Some sources advise that the mouse and trackball be placed on the left side of the user (regardless of handedness) to reduce neck and shoulder stress (especially when frequently using the number keys on the right side of the keyboard).[4,7] Computer keying forces of less than 48 g are also suggested.[21]

These specifications may be applicable to nurse computer workstations because the computer equipment used in the office worker studies is comparable to equipment used by nurses. Data on postural factors, ergonomic training, length of time spent working at a computer, type of equipment design and placement, employee workstation and environment perceptions, and presence of MSD and upper extremity user symptoms are also included in Table 1.

Consideration of the entire surrounding environment can also promote healthier nurse–computer interactions. This includes such factors as lighting, aesthetics, design of furniture, and computer positioning.[4,22] Staggers and Parks[23] described some of the physical features that make up the nursing context, that is, lighting or noise in the nursing environment. They also discussed the bidirectional nature of nurse computer interaction, such as how screen glare affects nurse action. OSHA lists simple measures to reduce screen glare, such as putting up curtains, providing light diffusers or adjustable desk lights.[24] Such small modifications can make computing more comfortable for the nurse and increase work efficiency.

Table 1

Ergonomic Workstation Literature Review

	Primary Author, Year		
	Gerr, 2002[36]	**Marcus, 2002[21]**	**Zecevic, 2000[2]**
Study/literature details	Sample—632 newly hired computer users working >15 hours/week on the computer. Over half had upper extremity symptoms after one year. Women were more likely to have symptoms and disorders than men. Past history increased risk of present MSD. Neck and shoulder symptoms more prevalent than head and arms symptoms. 2.5% examined upon follow-up phase of study had carpal tunnel syndrome.	Sample—632 newly hired computer users working >15 hours/week on the computer. Specific postural risk factors in computer workstations are associated with neck/shoulder and head/arm MSD and symptoms.	Sample—16 without CTD diagnosis who worked on computer over 5 hours/day. Fixed keyboard design has potential to reduce the risk of CTDs by influencing the time that the wrist spends in different positions. Individual typing skills are also significant.
Recommendations			
Screen/monitor		Head tilt angle <3°.	
Keyboard		>121° inner elbow angle of keyboard, "J" key >4.8″ from edge of desk and should be <1.4″ above desk surface, keying force <48 g.	A fixed keyboard with a slope of 10° should be used.
Desk/chair		Need armrests.	
Mouse/trackball		Wrist ulnar deviation angle <5°. Inner elbow angles should be 137°–148°.	
Additional factors		Telephone shoulder rest pads should not be used.	
	Martin, 1999[15]	**Jaschinski, 1999[16]**	**Kietrys, 1998[37]**
Study/literature details	Sample—45,000 office workers in 125 state agencies in Oregon. Ergonomics programs have contributed to fewer claims, lower claim costs, and lost worktime.	Sample—38 subjects from a telephone directory-assistance office in Germany. VDU screen positions should be adjusted to make comfortable for the user.	Sample—27 people that spent at least 3 hours/day using computer. No difference in cervical flexion when VDT height changed from 38.6" to 43.7".
Recommendations			
Screen/monitor	Position screen 16–29" from the eyes, adjust height to fit user. Reduce glare with curtains and/or glare screens.	Users prefer viewing distances of 36″ with vertical gaze inclinations of −10°.	VDT screen height does not have a significant effect upon cervical spine flexion. Do not elevate screen positions (this does not relieve postural stress).
Keyboard	Use adjustable keyboard trays.		
Desk/chair	Leave room on surface to complete work. Use adjustable chairs with five legs and castors, and adjustment controls.		
Mouse/trackball	Place at same angle as keyboard. Use extender platforms, bridges, or covers if using a keyboard tray with mouse. Use non-dominant hand if used frequently.		
Additional factors	Take breaks every 30 minutes to 1 hour, lasting 15 seconds to 3 minutes.		

(continues)

Table 1

Ergonomic Workstation Literature Review *(Continued)*

	Primary Author, Year		
	Hess, 1997[12]	**McHugh, 1997[7]**	**Doheny, 1995[4]**
Study/literature details	Sample—621 state agency employees. Perceived stress significantly associated with perceived RSI symptoms. Computer use ≥4 hours/day had significant amount of symptoms. Fewer symptoms when at-risk users perceived ergonomically correct workstations.	This literature review describes ergonomic risk factors for nurse-computer workstations, and gives specifications for workstation design.	This literature review provides information about repetitive injuries, how to reduce risks by improving work posture and workstation equipment, and provides questions that can guide the computer user about how to improve workstation design
Recommendations			
Screen/monitor		Bottom of monitor 20° below the line of sight and 13–18″ away from the eyes.	Monitor should be arm's length from user's body. Top of screen at eye level, positioned to reduce glare.
Keyboard		At elbow height, 28–30″ from the floor. Should have 90° elbow angle while using light keying force.	90° forearm angle. Should not be elevated in the rear. Keep right end of keyboard 6" from center of the body when typing.
Desk/chair		Desk—28–30″ high and adjustable, with leg room and work space. Chair—adjustable, lumbar support, allow feet flat on floor. Thighs parallel to floor or with 5–10° upward slope.	Desk—High enough to allow leg and arm positioning. Chair—Height should allow feet to rest on the floor, should have lumbar support, and swivel/rolling chairs should not be too movable.
Mouse/trackball		Move to left side of the keyboard (even if right-handed).	Move to left side of keyboard (even if right-handed). Trackball preferred, but should have buttons that do not require force to push down.
Additional factors		Use uplighting, shades, or tinted glass if outside light too strong.	Take breaks every 1–2 hours.

	Nelson, 1995[18]	**Ala, 1994[8]**	**Library of Congress, 1992[17]**	**Pickett, 1991[19]**
Study/literature details	Sample—646 employees in Washington from Department of Labor and Industries. Although low presence of air contaminants, CNS, respiratory symptoms, and skin symptoms were frequent, more than 50% found workstation too hot or cold, 48% found workstation noisy, 53% were satisfied with their workstation.	Sample—5 technology and chemist laboratory visual display terminal users. Correlation between the number of staff and number of years worked at job.	Ergonomics report	Sample—79 data entry clerks in Ontario. Poor lighting contributed to eyestrain and headache. Duration of employment not associated with stress or physical health complaints. Highly significant associations between levels of occupational stress and physical complaints were found.

(continues)

Table 1

Ergonomic Workstation Literature Review *(Continued)*

	Nelson, 1995[18]	Ala, 1994[8]	Library of Congress, 1992[17]	Pickett, 1991[19]
Recommendations				
Screen/monitor		Adjustable monitor with a tilt, positioned 20° below eye level, eye-screen distance 24–28″. Should allow user to have a neutral neck position.	Have top of screen at or below eye level and eye-screen distance between 18″ and 30″. Minimize glare with curtains, anti-glare screen, or by reducing overhead lighting.	
Keyboard		Adjustable keyboard, should be where the thumb joints are when the elbows are at a 90° and the arms and hands are parallel to the floor.	Keyboard height 23.5–30.5″ from the floor with a 0–15° slope. Upper arm and forearm should form a right angle, with hands placed on the keyboard and wrist rest used.	
Desk/chair		Chair—Medium high level with a back rest. User's feet should be flat on the floor, with legs at 90° angle.	Chair—Adjustable height of 15–21″ from the floor with adjustable seat back. User's feet should reach the floor.	
Mouse/trackball				
Additional factors		Users have a VDT color usage preference.		

Involvement of computer users in the selection and assessment of their workstation equipment is an important component of workspace design, can improve user satisfaction, and reduce fatigue and stress.[25] A study of home health nurses' experiences with a wireless system prompted the modification of computing equipment by their employers. When nurses relayed their concerns about how heavy their wireless computers were, and they received computers that were one-third the weight for their home visits.[26] We do not know how this approach affected nurse injury; however, studies have suggested a relationship between administrative and engineering controls (such as reducing heavy loads) and worker injuries.[15,27]

For example, the institution of an office ergonomics program resulted in a 21% decrease in time lost because of occupational injuries over a 3-year period. Office worker injury costs were diminished by half, as well.[15] This program included researching the problems, training in ergonomic principles, encouraging managerial and staff support, involving appropriate health and safety professionals, and developing a task force responsible for equipment specification, scheduling, and defining roles and responsibilities. Assessors were chosen to evaluate compliance with ergonomic standards, measure employees and equipment, educate staff, and provide adjustable office equipment.

There are many limitations of the research in this area. Very few articles are available about clinical workstations. Most of the literature is about seated workstations and their equipment components. Literature about ergonomic design of Personal Digital Assistants (PDAs) is not yet available. General laptop guidelines have been introduced,[28] but do not focus on the clinical environment. Articles have been written for occupational health nurses to assist with performing ergonomic analyses of work settings, but they do not address the ergonomic needs of nurses themselves.[15] Most research studies have taken place in small laboratory settings, with small samples of office workers at their worksites, and may not be generalizable to a clinical population. Only one study was found that investigated nurse upper extremity CTD.[29] In this study, nurses and other hospital workers using the computer fewer than 4 hours daily had a 32% prevalence of upper extremity CTD, 60% of which was considered to be carpal tunnel syndrome related to excessive repetitive movements, and workstation design requiring awkward postures.[29] Because this study was cross-sectional in design and had only a 40% response rate, conclusions should be interpreted with caution.

POLICY ISSUES

In November 2000, OSHA proposed ergonomic standards to protect over 102 million workers from repetitive motion injuries in the workplace. These standards went into effect in January 2001, but were repealed by President Bush in March 2001 (Senate Joint Resolution 6). The OSHA standards encouraged MSD reporting for injuries sustained from heavy lifting or repetitive tasks such as typing on keyboards, and ensured that injured employees be seen by a healthcare professional and receive proper treatment. Ergonomic programs, risk assessment, training, and outcome evaluation were to be implemented and would likely have had a beneficial effect upon nurse injury.[30]

The new 2002 OSHA ergonomics guidelines that have been promulgated[31] are strictly voluntary, and therefore have been criticized by the American Nurses Association as being ineffective in protecting nurses from injury.[32] Although ergonomic programs that combine workstation assessments, appropriate equipment, furniture, and managerial support have been shown to reduce injury,[15] it is unlikely that most organizations will provide such programs voluntarily.

OSHA recently accepted public comments on new ergonomics guidelines directed toward nursing homes. These guidelines focus on management practices, performing worksite analyses, and providing control methods to prevent healthcare worker injury, but do not cover ergonomic risk factors associated with clinical computer workstations.[33]

Employee work breaks of adequate length and frequency have been found to be beneficial.[8] There are currently no federal laws that mandate break length and frequency. Although individual state laws and regulations vary in regard to employee break provisions, some states require 15-minute breaks or alternative work every 2 hours for video display terminal users.[8]

Breaks of different lengths and frequencies are recommended in the literature for computer work, which makes it difficult to apply to clinical work practices. One article suggests 10-minute breaks at work for each hour spent on the computer[7]; another recommends breaks of 15 seconds to 3 minutes in length, taken every 30 to 60 minutes.[15] The National Institute of Occupational Safety and Health (NIOSH) suggests 10-minute breaks every 2 hours for operators who have moderate visual demands, and 15 minutes per hour for workers with repetitive work or high visual demands.[5] Breaks can be effective in reducing CTDs and other MSDs because they allow the muscles to rest or recover, although current guidelines do not specify break recommendations for computing nurses in particular.

RECOMMENDATIONS

For Employers

Ergonomic programs that include administrative and engineering controls can help to ensure safe nurse–computer interactions in the clinical setting. The following information can be used when instituting an ergonomic program.

NIOSH provides administrative and engineering controls that can reduce worker injury.[34] These include: gathering evidence of worker injuries from OSHA logs, symptom data from staff, and turnover and absenteeism rates; assessing workflow so that awkward movements, forceful exertion, and repetitive motion are eliminated; designing the job and surroundings to fit the workers' capabilities; training staff how to properly use and adjust equipment; and taking frequent small breaks while computing, in addition to regular breaks.

Workstation and worker assessments should be done before purchasing computer workstation equipment. Periodically, all components of the office workstation should be reassessed including video display terminals (VDT), chairs, and peripheral equipment, such as the keyboard, computer mouse, trackball, etc., in order to improve worker productivity and safety. Any new equipment should also meet computer users' ergonomic needs. A participatory approach among staff nurses and other healthcare personnel can help to determine staff nurses' ergonomic needs and make necessary modifications.[25]

Information is available on how to perform worker/workstation assessments,[5,15,25] including a "Workstation Checklist," available on the OSHA Web site: http://www.osha.gov/SLTC/computerworkstations_ecat/checklisthtml.[35] This Web site can help to quickly analyze ergonomic workstation design by assessing how the computer monitor, keyboard/input device, chair, and other workstation components fit the specific worker. Specifications from Table 1 cover similar workstation components as the OSHA checklist and can also be used when evaluating clinical workstations.

The effectiveness of any ergonomic interventions can be evaluated by comparing staff injury rates and job turnover and absenteeism rates to those before the program was instituted.[34] Qualitative analysis may also reveal valuable information about the program effectiveness and any barriers to success.

Future Research and Literature Needs

Future research could investigate ergonomic applications to nurse computer workstations in particular. This research should focus on the length of time nurses

spend computing at seated and standing workstations, the risk of sustaining repetitive stress or cumulative trauma disorders from exposures that are part of nursing work, appropriate rest periods for nurses using computers, and whether break lengths should vary according to nurse specialty, equipment used, and individual body characteristics. Researchers could investigate each component of the nurse workstation to determine the best ergonomic specifications for worker safety. The relationship between nurse computer user involvement in the selection and assessment of workstation equipment and injury could also be studied.

Other beneficial and rapidly evolving tools in the clinical setting should be researched. Height, lighting, input devices, and other ergonomic considerations of standing nursing workstations should be studied. There is a lack of information about laptop computer design specifications regarding weight, input devices, monitors, carrying cases, and other laptop accessories. PDA ergonomic research can also investigate the relationship between users and lighting, color, visual strain, and CTD. More literature based on new research should be written describing findings and recommendations regarding ergonomic nurse–computer interactions.

CONCLUSIONS

This article addressed the ergonomic considerations of computer workstations. Published specifications that are relevant to nursing workstations were included. Research studies have shown a positive relationship between improved workstation design and physical safety and productivity of the combined human–computer system; however, more work must be done to address nurse–computer interactions. Safer work environments can be attained by considering the enclosed specifications to clinical computer workstations, making ergonomic adjustments in the clinical setting, conducting and disseminating research, writing about ergonomic nurse–computer interaction, and taking an active role in policy development.

Acknowledgment

The authors thank Susan K. Newbold, MS, RNBC, FAAN, for her thoughtful review of this manuscript.

REFERENCES

1. Bureau of Labor Statistics. Table D. Number (in 1,000s) of work-related musculoskeletal disorders involving time away from work and median days away from work by occupation, 1999. Available at: http://www.bls.gov/iif/oshwc/osh/case/osnr0012.pdf. Accessed September 7, 2002.
2. Zecevic A, Miller DI, Harburn K. An evaluation of the ergonomics of three computer keyboards. *Ergonomics*. 2000;43(1):55–72.
3. Bureau of Labor Statistics. The part of body affected, occupational injuries, and illnesses involving days away from work, 1999. Available at: http://www.bls.gov/iif/oshwc/osh/case/osch0021.pdf. Accessed September 7, 2002.
4. Doheny M, Linden P, Sedlak C. Reducing orthopaedic hazards of the computer work environment. *Orthopaedic Nurs*. 1995;14(1):7–16.
5. Occupational Safety and Health Administration. *Working Safely with Video Display Terminals*. OSHA, Washington, DC;1997:18–20.
6. American Federation of Labor–Congress of Industrial Organizations. Workers need protection from 'ergonomic' hazards. Available at: http://www.aflcio.org/safety/ergo-why.cfm. Accessed April 1, 2003.
7. McHugh ML, Schaller P. Ergonomic nursing workstation design to prevent cumulative trauma disorders. *Comput Nurs*. 1997;15(5):245–252.
8. Ala M, Ala M, Bagot G. Ergonomics in the laboratory environment. *Nursing Manag*. 1994; 25(7):50–52.
9. Occupational Safety and Health Administration. Ergonomics: guidelines for nursing homes. November 18, 2002. Available at: www.osha.gov/ergonomics/guidelines/nursinghome/index.html. Accessed April 1, 2003.
10. National Center for Nursing Research. Nursing Informatics: Enhancing patient care. NIH Publication 93-2419, pp. 3–9; 1993. Bethesda, MD: U.S. Department of Health and Human Services.
11. National Institute of Nursing Research (NINR). Applying patient care ergonomics to the patient–nurse-machine interaction. NCNR and NNRA Priority Expert Panel E. Chapt.5, Vol. 4; 1993. Available at: http://www.nih.gov/ninr/research/vol4/Chapter5.html. Accessed October 21, 2001.
12. Hess D. Employee perceived stress: relationship to the development of repetitive strain injury symptoms. *AAOHN J*. 1997;45(3):115–23.
13. Occupational Safety and Health Administration. Ergonomic Report Excerpt from 1992 Ergonomic Report tw921209. Computer Layout and Design. Potential Hazards and Possible Solutions. Available at: http://www.osha.gov/SLTC/ergonomics/ergonomicreports_pub/tw921209.html. Accessed March 15, 2002.
14. Hebda T, Czar P, Mascara C. *Handbook of Informatics for Nurses and Health Care Professionals*. 2nd ed. Upper Saddle River, NJ: Prentice Hall; 2001.
15. Martin C, Andrew-Tuthill DM. Office ergonomics. measurements for success. *AAOHN J*. 1999; 47(10):479–491, 492–493.
16. Jaschinski W, Heuer H, Kylian H. A procedure to determine the individually comfortable position of visual displays relative to the eyes. *Ergonomics*. 1999;42(4):535–549.
17. Library of Congress. Collections Services VDT Ergonomics Committee. Ergonomics and VDT USE.1992. Available at: gopher://marvel.loc.gov:70/00/employee/health/ergonomics/broadside. Accessed October 18, 2001.
18. Nelson NA, Kaufman JD, Burt J, Karr C. Health symptoms and the work environment in four nonproblem United States office buildings. *Scand J Work Environ Health*. 1995;21(1):51–59.
19. Pickett CW, Lees RE. A cross-sectional study of health complaints among 79 data entry operators using video display terminals. *J Soc Occup Med*. 1991;41(3):113–116.
20. Kahan, NJ, Griffin V. Motion Based Ergonomics Keyboard Retraining II-"Mousing." *The RSI network*. 1999; issue 41. Available at: http://www.ctdrn.org/rsinet/archive/rsinet41.pdf. Accessed October 28, 2001.
21. Marcus M, Gerr F, Monteilh C, Ortiz DJ, Gentry E, Cohen S, Edwards A, Ensor C, Kleinbaum D. A prospective study of computer users: II. Postural risk factors for musculoskeletal symptoms and disorders. *Am J Indust Med*. 2002;41:236–249.
22. Armstrong ML. Ergonomic considerations in computer implementation: a primer. *Comp Nurs*. 1984;2(4):121–124.
23. Staggers N, Parks PL. Description and initial applications of the Staggers and Parks nurse–computer interaction framework. *Comp Nurs*. 1993;11(6):282–290.

24. Occupational Safety and Health Administration. Working safely with video display terminals (OSHA Bulletin 3092). 1997. Available at: http://www.osha.gov/Publications/osha3092.pdf. Accessed April 1, 2003.
25. Greenberg LA. Planning a nurse station for clinical function. 2000. Available at: http://www.hermanmiller.com/us/pdf/healthcare/wp-nursesstation1000.pdf. Accessed December 26, 2002.
26. Wilson R, Fulmer T. Home health nurses' initial experiences with wireless, pen-based computing. *Publ Health Nurs*. 1998;15(3): 225–232.
27. United States General Accounting Office. Report to congressional requesters. Worker protection. Private sector ergonomics programs yield positive results. 1997. Available at: http://www.gao.gov/archive/1997/he97163.pdf. Accessed December 26, 2002.
28. Griffin V, Kahan NJ. Guidelines for laptop computer users. *The RSI Network*. 1999; issue 40. Available at: http://www.ctdrn.org/rsinet/archive/rsinet40.pdf. Accessed October 28, 2001.
29. Punnett L, Robins JM, Wegman DH, Keyserling WM. Soft tissue disorders in the upper limbs of female garment workers. *Scand J Work Environ Health*. 1985;11(6):417–425.
30. Malone RE. Ergonomics, policy, and the ED nurse. *J Emerg Nurs*. 2000;26(5):514–515.
31. Occupational Safety and Health Administration. Effective Ergonomics: Strategy for Success. A Four-Pronged, Comprehensive Approach. April 5, 2002. Available at: http://www.osha.gov/ergonomics/ergofact02.html. Accessed April 12, 2002.
32. American Nurses Association. Press Release. Statement by Mary E. Foley, ANA president. American Nurses Association Denounces OSHA Ergonomics Plan. April 8, 2002. Available at: http://nursingworld.org/pressrel/2002/pr0410.htm. Accessed September 6, 2002.
33. Occupational Safety and Health Administration. OSHA Trade News Release. 2002. Available at: http://www.osha.gov/media/oshnews/aug02/trade-20020829.html. Accessed September 6, 2002.
34. National Institute for Occupational Safety and Health. Elements of ergonomics programs. A primer based on workplace evaluations of musculoskeletal disorders. Step 5: Developing controls. 1997. Available at: http://www.cdc.gov/niosh/epstep5.html. Accessed December 26, 2002.
35. Occupational Safety and Health Administration. Computer Workstations: Workstation Checklist. 2002. Available at: http://www.osha.gov/SLTC/ computerworkstations_ecat/checklist.html. Accessed September 15, 2002.
36. Gerr F, Marcus M, Ensor C, Kleinbaum D, Cohen S, Edwards A, Gentry E, Ortiz DJ, Monteilh C. A prospective study of computer users: I. study design and incidence of musculoskeletal symptoms and disorders. *Am J Indust Med*. 2002;41:221–235.
37. Kietrys DM, McClure PW, Fitzgerald GK. The relationship between head and neck posture and VDT screen height in keyboard operators. *Phys Ther*. 1998;78(4):395–403.