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The effects of ergonomics training on the knowledge, attitudes, and practices of teleworkers

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Abstract

Problem: The rapid growth of teleworking has raised several social and legal issues regarding an employer's responsibility for the safety of an employee's home office. In this paper, researchers discuss the need for safety training for teleworkers and the effectiveness of a home office ergonomics training program. **Method:** Study participants ($N = 50$) were randomly assigned into a treatment or control group. The treatment group completed the ergonomics training and a pre- and posttest. The control group completed the pre- and posttests without training. **Results:** The study demonstrated the need for teleworker ergonomics training. More than 85% of participants had not received teleworker training before, and 44% had experienced pain or discomfort while teleworking. Participants who completed the training significantly improved their scores on knowledge, attitude, and practices subtests. In a follow-up survey, participants indicated that they had made ergonomic changes to their offices based on the training. Several participants indicated that the pain or discomfort that they had been experiencing was eliminated or reduced as a result of the training.

Keywords: Ergonomics; Training; Teleworkers

1. Introduction

1.1. The growth of teleworking

Teleworking, also known as telecommuting, means using information technology and telecommunications to replace work-related travel. With teleworking, employees work full- or part-time at home or at a local telework center. Communication is accomplished by phone, fax, modem, and teleconferencing.

Teleworking is changing the way millions of Americans communicate, commute, and work. Over the last several years, both private industry and the federal government have joined together to encourage these changes, many of which have proven to be beneficial to the economy, to the environment, and to families. In 2001, there were an estimated 28 million Americans who teleworked one day a week or more (Davis & Polonko, 2001).

The National Performance Review (Gore, 1993) and former President Clinton's Climate Change Action Plan (Clinton & Gore, 1993) identified teleworking as one method to help the U.S. achieve environmental goals, to conserve national resources, and to enhance the quality of work life. In his memorandum dated July 11, 1994, former President Clinton wrote, "The executive branch must implement flexible work arrangements to create a family-friendly workplace. The head of each executive department or agency is hereby directed to establish a program to encourage and support the expansion of flexible family-friendly work arrangements, including: job sharing; career part-time employment; alternative work schedules; and telecommuting and satellite work locations." In 1996, the President's Management Council approved the National Telecommuting Initiative Action Plan, launching a 3-year initiative to significantly increase the number of federal telecommuters (Lieber & Wohl, 1996). In December 1999, U.S. Representative Frank Wolf of Virginia announced details of a federal telework program that could dramatically increase the number of teleworkers nationwide. According to Representative Wolf, "the congestion and mobility crisis is perhaps the greatest single threat to continued prosperity and most

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certainly our quality of life and the family unit. Telecommuting is the information age's answer to reducing traffic congestion, nurturing environmental stewardship, and strengthening the family'' (International Telework Association and Council, 1999).

The rapid growth of teleworking has raised several social and legal issues regarding an employer's responsibility for an employee's home office. On November 15, 1999, the Occupational Safety and Health Administration (OSHA) sent a letter to a Texas employer stating that he was responsible for federal safety and health violations that occur in his employee's home office. The letter suggested that employers could be liable for any unfavorable incidents met by an employee who chose to work at home, such as unsafe stairs, improper lighting, and inadequate ventilation in home offices. This policy interpretation created a national uproar, causing some firms to cancel or postpone giving teleworking rights to their employees.

In January 2000, the U.S. Department of Labor withdrew the advisory letter and asked the National Economic Council to convene an interagency working group to examine the broad social and economic effects of teleworking. On February 25, 2000, OSHA issued a new compliance directive to formalize agency policy on home-based work. According to the new policy, OSHA will not inspect home offices for violations of federal safety and health rules and employers are not expected to conduct home office inspections. The only exception to this policy is for a home where factory-type manufacturing occurs.

The purpose of the Occupational Safety and Health Act of 1970 is to assure as far as possible every working man and woman in the nation safe and healthful working conditions. The question remains—who is responsible for the workplace safety and health of teleworkers in the virtual workplace? Many still believe the responsibility lies with the employer. ''Taking the OSHA statement as a faithful interpretation of the rules, managers should demonstrate best efforts and thorough safety planning for all alternative workspaces, including home offices,'' says John Girard, an analyst with the Gartner Group in Stamford Connecticut (Zbar, 2000). Despite the Labor Department's retraction of the OSHA letter, Girard suspects OSHA will revisit the issue of home office safety within the next 5 years, as teleworking increases.

1.2. The risk of musculoskeletal disorders

Musculoskeletal disorders (MSDs) are injuries and disorders of the muscles, nerves, tendons, ligaments, joints, cartilage, and spinal disks. Examples of MSDs include carpal tunnel syndrome, tendonitis, sciatica, herniated disc and lower back pain. MSDs are one of the most significant problems in the workplace today. Work-related MSDs account for more than one-third of all occupational injuries and illnesses that are serious enough to result in days away from work. Each year more than 620,000 employees suffer lost-workday because of MSDs. These MSD injuries cost businesses $15 to $20 billion in workers' compensation costs each year. Indirect costs may run as high as $45 to $60 billion. Carpal tunnel syndrome, one form of MSD, results in more days away from work than any other workplace injury (OSHA, 1999).

According to a study by the International Telework Association and Council (Davis & Polonko, 2001), the primary home telework activity is using a computer (87%). The relationship between computer-use and the development of musculoskeletal disorders (MSDs) is well-documented (Bergqvist, Wolgast, Nilsson, & Voss, 1995a, 1995b; Demure et al., 2000; Faucett & Rempel, 1994; Ferreira, Conceicao, & Saldiva, 1997; Hales et al., 1994; Marcus & Gerr, 1996; Ong, 1994; Yu & Wong, 1996). The very technology that is powering the *Information Age* is also leaving many of its workers with this painful malady.

Workplace factors that increase the risk for computer-related MSDs include: improper workstation design; incorrect monitor, mouse, and keyboard placement; poor posture; incorrect chair height; improper office lighting; and intense typing without resting periods (Aaras, Horgen, Bjorset, Ro, & Thoresen, 1998; Demure et al., 2000; Keir, Bach, & Rempel, 1999; McHugh & Schaller, 1997; Ong, 1994). In a corporate or government workplace, many of these risk factors are controlled. The company purchases and sets up the computer workstations. Corporate safety officers inspect for ergonomics hazards. Lighting is engineered and designed for office use. Rest periods are common, as other workers are nearby and interruptions are likely. However, in the home office these risk factors may not be so easily controlled. Studies have shown that teleworkers typically set up their own offices without assistance (Center for Office Technology, 1999). Teleworkers may place their computers on coffee tables or old desks, creating numerous ergonomic hazards. Without training, teleworkers are unaware of workplace factors that increase their risk of developing MSDs.

A poll of the nation's leading technology and business executives in February 2000 found that only 9% of respondents had set safety guidelines for employees who work at home, with 80% having no guidelines and 11% unsure if their companies had set guidelines (Chief Information Officer, 2000). ''This is a critical issue to everyone who works from home,'' says Debra A. Dinnocenzo, President of the teleworking consultant firm AlLearnatives. ''Utilizing basic home office safety guidelines can prevent injury, productivity losses, and property damage, all of which have significant payoff to the individual home office worker, whether or not OSHA mandates it'' (Zbar, 2000).

Research has shown that ergonomics training and environmental intervention decrease the incidence of musculoskeletal disorders. Businesses that have implemented

1. Introduction to Ergonomics
Participants will be able to:
Define ergonomics.
Identify the benefits of ergonomics training.
Main Topics:
a. What is ergonomics?
b. Why is ergonomics important?

2. Understanding MSDs
Participants will be able to:
Define musculoskeletal disorder (MSD).
Identify the symptoms of MSDs.
Identify the risk factors that contribute to the development of MSDs.
Understand the importance of early detection and reporting of MSDs.
Main Topics:
a. What are musculoskeletal disorders (MSDs)?
b. Types of MSDs
c. Symptoms of MSDs
d. Risk factors
e. Medical evaluation
f. Early detection and reporting of MSDs
g. Preventing MSDs

3. Principles of Ergonomics
Participants will be able to:
Identify and define the 6 principles of ergonomics.
Main Topics:
a. Have good posture
b. Move, exercise, stretch, and rest
c. Provide appropriate lighting
d. Minimize pressure points
e. Reduce excessive force
f. Keep everything in easy reach

4. Evaluating Your Home Office
Participants will be able to:
Identify how to configure their office area to reduce discomfort and increase productivity.
Identify ergonomic features of office equipment.
Main Topics:
a. Setting up your desk
b. Adjusting your chair
c. Adjusting your monitor
d. Using a document holder
e. Using a telephone
f. Using a laptop computer

5. Stretching Exercises
Participants will be able to:
Understand the importance of stretching and moving.
Identify exercises to reduce the risk of developing an MSD.
Topics:
a. Importance of breaks, stretching and moving
b. Exercises to reduce your risk

Fig. 1. Ergonomics for teleworkers curriculum outline.

ergonomics programs report significant decreases in accidents, injuries, illnesses, and health care costs over time, along with increases in productivity, quality of work, and worker morale (Cook & Pinelli, 1995; Cumulative Trauma Disorder News, 1995a, 1995b). While the effectiveness of ergonomics intervention is well documented in the corporate environment, there is little research available on the effectiveness of ergonomics training in the home office setting.

The purpose of this research was to evaluate the short-term effects of an ergonomics training program on the knowledge, attitudes, and practices of a group of teleworkers.

2. Methods

2.1. The training program

Researchers developed a 45-minute computer-based training module on home office ergonomics. Researchers developed learning objectives and a detailed curriculum guide for the ergonomics module (see Fig. 1). The main topics were: Introduction to Ergonomics, Understanding Musculoskeletal Disorders, the Principles of Ergonomics, Evaluating Your Home Office, and Ergonomic Stretching Exercises.

Using the *Ergonomics for Teleworkers* curriculum guide, the researchers developed a detailed storyboard. The storyboard included graphics/animations, screen title/text, narration, interaction, and navigation for each screen. Experts in ergonomics, teleworking, computer-based training, instructional design, and program evaluation reviewed the storyboard for accuracy, content, and instructional design.

2.2. The computer software

The *Ergonomics for Teleworkers* program combines text, graphics, color illustrations, animation, and sound to provide a fully interactive, media rich learning environment. The program has 66 separate screens, with 61 colored illustrations. Each of the five main topics has between 3 and 23 screens. Each screen contains interaction, animation, or a color illustration designed to keep the learner focused. The program includes screen to screen navigation so that participants could move forward, pause, repeat a topic, or quit the lesson. See Fig. 2 for a sample screen.

Ergonomics for Teleworkers was developed using *Macromedia Author*ware *6.0*. *Adobe Premiere 6.0* software was used to render video clips and save them in a Microsoft AVI format. Audio narration clips were recorded using *Cool Edit*

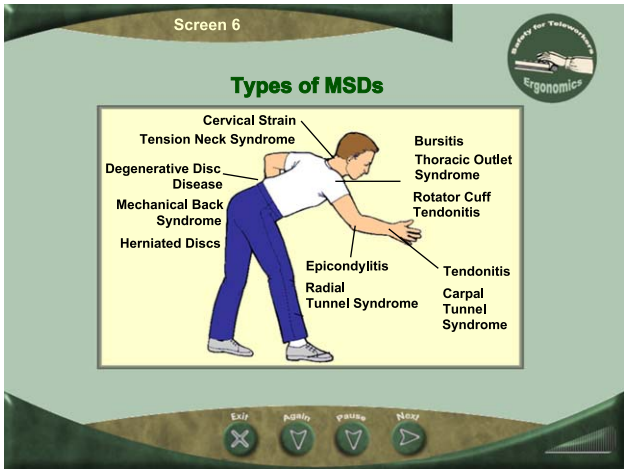

Fig. 2. Sample screen from "ergonomics for teleworkers."

2000 and saved in a WAV format. Illustrations were stored in .jpg format.

2.3. The measurement tools

The researchers developed 64 criterion-referenced items designed to assess the participants' knowledge, attitudes, and ergonomic safety practices at pre- and posttest. Each item was a statement about ergonomics to which participants were asked to respond: agree, disagree, or don't know. Examples include: "If I design my office using ergonomics, I can get more done" (attitude item-agree); "I include neck and wrist exercises in my daily work plan" (practices item-agree); "My mouse should be at the same height as my keyboard" (knowledge item-agree); "If I use ergonomics to design my office, I will be less tired" (attitude item-agree); "I type with my wrists bent slightly upwards" (practices item-disagree); and "My computer desk should face a window for best lighting" (knowledge item-disagree).

Content experts reviewed the test items for content accuracy and clarity. A small group from the target population (n = 10) were recruited to try out the test items. Researchers used a split-half reliability analysis to eliminate items in which low scorers outperformed high scorers. They also eliminated items that the content experts found confusing or those on which they disagreed on the answers. Items were selected to include from two to nine items for each learning objective and to include a balanced number of knowledge, attitude, and practice items. The final instrument consisted of 26 items: 10 knowledge items, 6 attitude items, and 10 practices items.

The evaluation team also developed an informed consent statement for participants to read and complete before participating in the training. The informed consent included information about the purpose of the study, risks/benefits to participants, and contact information for questions. The consent letter stated that participation was voluntary, that they could choose not to participate at any time, and that they could choose not to answer any of the questions. In order to match pre- and posttest results, researchers asked participants to identify themselves by name on the pre- and posttest.

Participants provided the following demographic information on the pretest: name, date, job title, gender, ethnicity, age, and educational level. Participants also provided information about their teleworking status: days per month; years teleworking; previous teleworker training; previous ergonomics training; teleworking location; who purchased teleworking equipment; reasons for teleworking; percentage of day spent writing reports, working on the computer, reading documents, or using the telephone; type of Internet connection; and whether participants had experienced discomfort, soreness, or pain while teleworking.

The posttest included the same 26 items about ergonomics that appeared on the pretest with one change. The 10 practice items were changed from the pretest version to indicate participants intended practices. For example, the pretest item "I have evaluated my home office for ergonomic hazards," was changed on the posttest version to read, "I plan to evaluate my home office for ergonomic hazards."

A participant evaluation form was adapted from one developed for a similar study (Harrington & Walker, 2001). Researchers administered the participant evaluation anonymously. The form included 13 statements designed to elicit the participants' opinions about the usefulness of the program and the content. The first eight items were written as statements, such as, "The training program was useful to me as a teleworker." For each item, participants were asked to select a response from three options: agree, disagree, no opinion. Items 9 to 12 were open-ended questions: "What did you like most about the training?" "What did you dislike about the training?" "How can we make the program more useful or interesting?" and "What changes do you plan to make as a result of this training?" Item 13 asked participants to check topics from a list of other safety areas that would be of interest to them.

2.4. The program try-out

Prior to the study, researchers tested the training with a small sample of teleworkers (N = 10). These 10 teleworkers attended a training session at the General Services Administration using computers provided by the researchers. Participants were observed while they completed the training. The average time to complete the training was 50 minutes. Information from the tryout was used to revise the training.

Total scores for the pre- and posttest were calculated as well as the scores of three subtests: knowledge, attitudes, and practices. A paired sample t-test was used to determine whether differences from pre- to posttest were significant. The average pretest score was 13.7 (52.7%), the average

posttest score was 24 (92.3%). The mean increase was 10.3 items (39.6%). The t value of 8.63 (df = 9) was significant at $p = .0005$. Pre- to posttest increases on the knowledge ($t = 4.99$, $p = .001$), attitudes ($t = 3.07$, $p = .05$), and practices ($t = 6.10$, $p = .0005$) subtests were also significant.

2.5. The study

The design for the study was a Two Group Comparison Study with Random Assignment to Groups. The 102 teleworkers who completed the pretest were randomly assigned to one of two conditions: Treatment Group or Control Group. Participants in the Treatment Group completed the pretest, the ergonomics training program, posttest, and course evaluation. Participants in the Control Group completed the pretest, and then without completing the training completed the posttest four to five weeks later.

The research questions were:

1. Did the computer-based training significantly affect the participants' knowledge, attitudes, and practices related to ergonomics?
2. Did the computer-based training program significantly affect the participants' knowledge, attitudes, and practices related to ergonomics as compared to the Control Group?
3. Did the participants like the computer-based format for training?

2.6. Participant recruitment and pretest data collection

For the purpose of this study, a *teleworker* was defined as a person who works in his or her home or in a telecommuting center one or more days a month. A teleworker may work for a business, academic institution, or government agency, or be self-employed.

To recruit participants for this study, researchers sent an e-mail message to 331 teleworkers who were members of a federal teleworker e-mail list. These 331 individuals included teleworkers/employees from the federal government, private industry, and academic institutions.

The target population for this study consisted of the 102 teleworkers who volunteered to participate by completing the consent form and pretest at the website established by researchers for that purpose. The recruitment e-mail described the purpose of the project, risk/benefits, tasks to be completed, and gave them a contact person. Of the 102 participants, the majority (91) worked for federal agencies and 11 were teleworkers from private industry or academic institutions.

2.7. Setting of the study

The data collection took place at the website that researchers created for the study. The website contained links for the pretest, posttest, and course evaluation. Participants completed all tests online in their home offices or remote worksites. These data were stored in a secure Internet Service Provider (ISP) database.

The *Ergonomics for Teleworkers* training program was stored on a CD-ROM, which was mailed to participants. Study participants completed the CD-ROM training on their computers in their home offices or remote worksites. Participants were given 3 weeks to complete the training.

2.8. The data analysis

At pretest and posttest, participant responses to test items were stored in the secure website database. The researchers imported participant data into an Excel spreadsheet. Items were coded in the spreadsheet and scored as correct or incorrect. In each case, Don't Know or "no response" was scored as incorrect. The total number of correct responses by each participant was calculated. Subtest scores were calculated for knowledge (10 items), attitude (6 items), and practice items (10 items). Each item was also assigned to one of the five module objectives. Mean pretest and posttest scores were calculated for the Treatment Group, the Control Group, and the sample as a whole. Mean scores were calculated for each of the subtests.

Responses on the Participant Evaluation Forms were analyzed. For items 1–8 and 13 on the evaluation instrument, a mean for each item was calculated and converted to a percentage. Items 9–12 were placed into tables and reviewed to determine what changes should be made to improve the module.

Data were analyzed using *SPSS Version 10*. In each case, the level of significance required to reject the null hypotheses was established at $p < .05$.

3. Results

3.1. Demographics of the study population

One-hundred and two teleworkers completed an online pretest. Researchers randomly assigned these teleworkers to the Treatment Group or Control Group. Treatment Group participants were asked to complete the training and posttest. Of those assigned to the Treatment Group, 28 teleworkers completed the posttest and were included in the study. Control Group participants were asked to complete the posttest (before completing the training). Of those assigned to the Control Group, 22 completed the posttest and were included in the study.

The attrition rate from pre- to posttest was 51% (of the 102 participants who took the pretest, 50 participated in the study). Two contributing factors for the high attrition rate were the short timeframe for completion and the timing of the study. Participants were given three weeks to complete the training during the month of June. Reasons cited for not

completing the training included: too busy or on vacation (6); not yet teleworking (5); used a Macintosh system only (3); too short a timeframe (3).

The 50 study participants included teleworkers from 10 federal agencies (n = 42), and 4 private companies (n = 8). Participants teleworked in 11 states and the District of Columbia. The states included: Maryland, Texas, Virginia, North Carolina, Tennessee, Nebraska, Illinois, New York, Michigan, Florida, and Pennsylvania,

The participants consisted of 28 (56%) males and 22 (44%) females. Thirty-eight were white (78%) and the others were members of different minority groups (22%). The dominant minority group was black (n = 8); there was one Asian and two Hispanics. One person did not indicate ethnic group. All of the participants had completed some college courses. Forty-one people had a bachelor's degree; of those, 29 had completed some graduate level work.

Forty-nine of the study participants (98%) teleworked from home. They teleworked an average of 8 days per month and had been teleworking for an average of 3.5 years. Twenty-one participants (42%) had a room or area of their home used exclusively for teleworking. Twenty-nine participants (58%) purchased their own home office equipment, while 12 (24%) indicated that some of their equipment was purchased by their employer and 8 (16%) indicated that their employer purchased all of their equipment. Forty-three participants (86%) had not received teleworker training and 40 (80%) had never completed ergonomics training. Participants spent an average of 64% of their time using a computer, 16% reading documents that are not on the computer, 10% on the phone, and 8% writing reports or other documents using a pen or pencil.

Participants cited the following reasons for teleworking: 34 (68%) "reduces time spent going to and coming from work;" 6 (12%) "my employer requires it;" 5 (10%) "I can be at home when children come home from school;" 17 (34%) "I prefer working by myself at home;" 24 (48%) "flexible hours;" 1 (2%) "I have a health problem or disability that makes traveling to and from work difficult;" and 1 (2%) "I can smoke in my home office."

Researchers performed a Chi-square analysis to determine whether there were significant differences between the two groups (Treatment and Control) related to gender, ethnicity, education, and previous training. Differences were not significant. See Table 1.

Table 1
Characteristics of the sample population (N = 50)

Variables	Total N = 50 (100%)	Treatment Group n = 28 (56%)	Control Group n = 22 (44%)	Chi square $X^{2\ (df)}$
Sex				3.498 (1) n.s.
Male	21 (42%)	15 (54%)	6 (27%)	
Female	29 (58%)	13 (46%)	16 (73%)	
Ethnicity				.035 (1) n.s.
Minority	11 (24%)	6 (22%)	5 (23%)	
White	38 (76%)	21 (78%)	17 (77%)	
Education				.257 (2) n.s.
HS Graduate and some college	9 (18%)	5 (18%)	4 (18%)	
College Graduate	12 (24%)	6 (21%)	6 (27%)	
Graduate School	29 (58%)	17 (61%)	12 (55%)	
Previous Ergonomics Training				.183 (1) n.s.
Yes	10 (20%)	5 (18%)	5 (23%)	
No	40 (80%)	23 (82%)	17 (77%)	
Previous Teleworker Training				.004 (1) n.s.
Yes	7 (14%)	4 (14%)	3 (14%)	
No	43 (86%)	24 (86%)	19 (86%)	

Researchers used a t-test to determine whether differences were significant for age and time spent teleworking. The mean age for the total group (n = 46) was M = 44, SD = 9.6. For the Treatment Group (n = 28), M = 45, SD = 8.81; for the Control Group (n = 18), M = 43, SD = 10.7, t = .80 (44 df). The mean years of teleworking for the total group was M = 4, SD = 4.28. For the Treatment Group (n = 27), M = 4; SD = 4.74; for the Control Group (n = 22), M = 4; SD = 3.75, t = .01 (47 df). The mean days per month of teleworking for the total group was M = 8, SD = 8.87. For the Treatment Group (n = 27), M = 8; SD = 9.69; for the Control Group (n = 22), M = 7; SD = 7.92, t = .45 (47 df). In each case, the differences were not significant.

Researchers performed a correlation analyses using Pearson Product Movement to determine if any of the demographic variables were related to either pretest or posttest scores. Only ethnicity was found to be related to pretest scores (r = .305, df = 50; p = .031.) The mean score on the pretest for Caucasians was 14.86 and 12.08 for minorities. Using a one way ANOVA, the difference was shown to be significant (F = 4.912, p = .031). Posttest scores were not related to any of the tested variables including the pretest. These findings indicate that minority participants had less knowledge than Caucasian participants initially, but by the end of the training these differences disappeared.

3.2. Estimates of instrument reliability

Reliability of the test instrument was investigated to allow researchers to improve the instrument for future research. Researchers calculated a Cronbach alpha as a measure of internal stability. At pretest, the alpha (with 50 cases and 26 items) was .66. At posttest, alpha = .87. None of the items had zero variance. Pretest Item 5, "I think my risk of developing a musculoskeletal disorder increases if I sit for long periods of time," was negatively correlated with the item total score. (Participants who scored higher on the test as a whole got this item wrong more often than those who scored lower on the test.) At posttest, responses to this item were positively correlated to the total score. Item 20 at posttest was negatively

correlated with the total score. (I plan to adjust my computer monitor's brightness and contrast so the screen is easier to see.) Those items will be examined and may be revised for future research. The reliability of the instrument, however, appears to be within the acceptable limits for this type of test (Crocker & Algina, 1986).

3.3. Pre- posttest differences for treatment groups

The means and standard deviations for the pre- and posttest scores were calculated for the total group and each group for the total test and for each subtest (See Table 2). A Paired Samples Test was used to calculate a *t*-score for each of the comparisons. For the Treatment Group, differences between the pre- and posttest mean scores were significant for the total score (t = 12.14, df = 27, p = .0005), for the knowledge subtest (t = 8.36, df = 27, p = .0005), for the attitudes subtest (t = 7.29, df = 27, p = .0005) and for the practices subtest (t = 9.68, df = 27, p = .0005). Differences between mean scores for the Control Group were not significant for the total score or for any of the subtests.

3.4. Item differences from pre- to posttest

In order to evaluate participant learning on specific items, researchers performed a *t*-test for pre- to posttest scores on each of the 26 items. Participants in the Treatment Group improved significantly on all of the items except for Item 2. (If I use a laptop computer, attaching a regular keyboard is usually a good idea.) However, the mean posttest score was higher than the mean pretest score.

3.5. Training effect on knowledge, attitudes and practices related to ergonomics

A repeated measures analysis was performed to determine the difference between the Treatment and Control Groups at posttest. Researchers used scores measured at two points in time (pre- and posttest) as the dependent variables (See Table 3). The one within subjects variable was time and the one between subjects variable was group (Treatment vs. Control). The main effect of time and the interaction of time by group were both significant. The main effect of time indicates that posttest scores were higher than pretest scores. The significant interaction of time by group suggests that the improvement from pre- to posttest was not uniform across groups. See Table 2 above for means and standard deviations for Treatment and Control Groups, which shows that Treatment Group mean scores were significantly higher than Control Group scores.

Table 2
Mean differences between groups, time, and tests

Group	Total			Knowledge		Attitude		Practices	
	Time	*M*	SD	*M*	SD	*M*	SD	*M*	SD
Treatment (n = 28)	Pre	14.0	4.4	5.3	1.9	4.0	1.3	4.7	2.4
	Post	23.7	1.9	8.9	1.2	5.6	.5	9.2	.9
Control (n = 22)	Pre	14.5	3.4	5.2	2.0	4.2	1.4	5.0	2.3
	Post	14.8	3.5	4.1	1.5	4.1	1.5	5.2	2.3

Table 3
Tests of within-subjects contrasts

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
TIME (pre- and posttest)	614.401	1	614.401	89.628	.0005
TIME*GROUP (treatment vs. control)	549.121	1	549.121	80.105	.0005
Error (TIME)	329.039	48	6.855		

3.6. Participant discomfort

Twenty-two participants (44%) indicated on the pretest that they had experienced discomfort while teleworking. People who teleworked more days per month reported a greater incidence of work-related discomfort (r = .347, 48 df, p = .016). The most common complaints were sore/tired eyes, sore back, neck pain, and sore wrists.

3.7. Participant evaluation

Participants in the Treatment Group (n = 28) and the program tryout at the General Services Administration (GSA; n = 10) were invited to complete an anonymous online course evaluation immediately following the training. Thirty-four participants (89.5%) completed an evaluation. The study participants completed the course evaluation at their remote worksites and the GSA participants completed the evaluation in a conference room at GSA. Not every participant completed an evaluation. For each item, participants were asked to read a statement about the training and respond: agree, disagree, or no opinion. For the purposes of this analysis, the responses "disagree" and "no opinion" were grouped together as negative responses to the program (except for Item #3 for which the opposite was true). The participants were positive toward the training. The responses are presented in Table 4.

3.8. Participants' anticipated changes

Participants were also invited to respond to four open-ended questions on the course evaluation. Twenty-seven participants (71%) responded to the questions. The first question was "What did you like most about the training?" The most common responses were: "flexibility and ability to work at my own pace" (n = 6), "the simplicity and ease of the program" (n = 7), and "it was informative" (n = 6). The second question asked participants "What did you dislike about the training?" The most common responses were "there was no back button"

Table 4
Program evaluation results for items 1 to 8

Evaluation Items	*n*	Positive Response	Negative Response
1. The training program was useful to me as a teleworker.	34	34 (100%)	0 (0%)
2. The information in this program was interesting to me personally.	34	33 (97%)	1 (3%)
3. The program was too long.	34	28 (82%)	6 (18%)
4. I learned a great deal from this program.	34	27 (79%)	7 (21%)
5. I would recommend this program to others.	34	33 (97%)	1 (3%)
6. The computer was easy to use for training.	34	33 (97%)	1 (3%)
7. I enjoyed the computer-based training more than instructor-led training.	34	20 (59%)	14 (41%)
8. I want to use the computer for future training classes.	34	29 (85%)	5 (15%)

($n = 6$), "too slow" ($n = 3$), "too long" ($n = 3$), and "too much clicking on the next button" ($n = 2$). The third question asked participants "How can we make the program more useful and more interesting?" The most common response was "I wouldn't change anything" ($n = 5$). Other responses included: "take more breaks and stretch more," "add more interactive sections," "make it less redundant," and "show more examples of workstations that are ergonomically correct that people adapt for their homes." The last question asked participants what changes they plan to make as a result of the training. A summary of participant responses to this question are shown in Fig. 3.

Participants were also asked to check topics from a list of other safety training topics that would be of interest to them as teleworkers. Fifteen participants (44%) checked electrical safety, 13 (38%) checked fire safety, and 19 (56%) checked radon.

3.9. Participant follow-up survey

Researchers sent a follow-up e-mail to participants in the Treatment Group ($n = 28$) one month after they completed the posttest. Participants were asked to respond to the question: "What changes have you made to your office or work habits since completing the training?" Seventeen participants (61%) responded to the follow-up e-mail. Participants indicated that the training had reduced or eliminated work-related pain to their backs, eyes, fingers, or shoulders. Responses are summarized in Fig. 4.

4. Conclusion

4.1. Discussion

This study demonstrates the need for safety training for teleworkers. At pretest, seven participants (14%) indicated that they had received teleworker training. Of these seven participants, the majority indicated that the teleworker training was related to managing teleworkers rather than

What changes do you plan to make as a result of this training?

- I plan to purchase a new chair. (5 responses)
- I plan to adjust my chair and workstation. (3 responses)
- I will be more aware of my posture. (3 responses)
- Moved my monitor slightly closer to about arm's length. Will use my computer glasses, instead of my progressive all the time.
- I plan to adjust my chair and document holder at home as well as purchase a footrest.
- I plan to make some changes at home regarding the position of my computer in the room.
- I will use the speakerphone more, clean my screen more often, put heavy books in arm's reach, etc.
- Try to apply what I learned about ergonomics
- I plan to move my mouse and monitor, and move heavy items that I use frequently. Also, take frequent breaks.
- I'm very guilty of keeping a dirty computer screen, and I'll change that. I'm going to mention what I learned to my husband, who wears tri-focal glasses and works for long periods of time on the computer.
- I will give thought to posture and reaching (especially). I will also share the need for ergonomic thinking with my staff.
- I will be ergonomically aware each time I use the computer and adjust my surroundings accordingly.
- Very few, but will look into a headset for my telephone.
- Align monitor directly in front of keyboard. Ensure my wrists are more in line with forearms. Focus more on my posture while sitting in my chair. Move around more frequently during the day.
- Make sure my posture, desktop, etc. and phone are properly positioned, make sure I avoid eyestrain through improper lighting or glare, make sure to do periodic exercises and take frequent breaks.

Fig. 3. Participant planned changes.

What changes have you made to your office or work habits since completing the training?

- Adjusted chair (6 responses)
- Walk around and stretch more frequently (4 responses)
- Increased awareness of posture (4 responses)
- Adjusted keyboard height (3 responses)
- Moved computer screen to avoid window glare (3 responses)
- Started using a footrest (3 responses)
- Adjusted monitor height (2 responses)
- Adjusted mouse location (2 responses)
- Purchased a new chair
- Plan to purchase a new computer desk and keyboard stand
- Plan to purchase a new chair
- Purchased a table lamp with a light that is easier on my eyes
- Purchased an extended key pad so the keyboard and mouse are at the same height
- Purchased wrist pads
- Adjusted chair armrests
- Ordered larger monitor
- Purchased telephone headset
- Started using a document holder
- Purchased a new mouse
- Purchased a new phone cradle
- Plan to purchase a new keyboard for a laptop
- Changed from using progressive lenses back to contact lenses and computer glasses

Fig. 4. Summary of responses to follow-up survey.

preventing injuries. Only one participant specifically indicated that he had received training related to safety or ergonomics. Twenty-two participants (44%) indicated on the pretest that they had experienced discomfort while teleworking. The most common complaints were sore/tired eyes, sore back, neck pain, and sore wrists. People who teleworked more days per month reported a greater incidence of work-related discomfort ($r = .347$, 48 df, $p = .016$). At pretest, nearly three-quarters of the participants (74%) indicated that they had never evaluated their home offices for ergonomic hazards. At posttest, 100% of Treatment Group participants indicated that they planned to evaluate their home offices for ergonomic hazards.

This study also demonstrates the potential for training to improve teleworkers' ergonomic knowledge, attitudes, and practices. The Treatment Group significantly increased overall scores between pre- and posttest, and also for scores on each subtest (knowledge, attitudes, practices). In the follow-up survey, participants indicated that they had made changes to their offices based on the training. Several participants indicated that pain or discomfort that they had been experiencing was eliminated or reduced as a result of the training.

The findings also suggest that computer-based training is an effective training technique for teleworkers. All participants who completed a participant evaluation form ($n = 34$) thought that the training program was useful to them as teleworkers. Ninety-seven percent of the participants who completed an evaluation form said they would recommend the program to other teleworkers, that the information in the program was interesting to them personally, and that the computers were easy to use for training. Eighty-five percent said they would like to use a computer for future training courses. In addition, participants made positive comments in the course evaluation regarding using computer-based training, including the ability to progress through the materials at their own pace, the ability to complete the training at their convenience, and the ability to complete the training in their home offices.

4.2. Limitations of the study

This study consisted primarily of federal teleworkers recruited from a single federal e-mail list, without consideration of geographic region or employment status (federal, non-federal, or self-employed). In a future large-scale study, researchers will recruit a sample more representative of the teleworker population.

Additional studies need to examine the benefits of safety training for teleworkers in other areas. Study participants indicated that electrical safety, radon, and fire safety are areas of interest.

The computer-based training materials used in this study were stored on a CD-ROM. In the future, the training will also be accessible on a website. This will eliminate the need to ship a CD-ROM to each teleworker. Developers can revise web-based courses whenever the content is out-of-date. Technology is constantly improving and allowing more rapid transfer of complex data, such as graphics, video, and sound, from website to learner. These methods of training will help to meet an ever-growing need for skills and information for teleworkers.

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