Behavior Change

Reducing Risk Factors for Cumulative Trauma Disorders (CTDs): The Impact of Preventive Ergonomic Training on Knowledge, Intentions, and Practices Related to Computer Use

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PURPOSE

Cumulative trauma disorders (CTDs) related to computer use are among the fastest-growing and most costly health and safety problems in the workplace. As the number of workers using keyboards and visual display terminals (VDTs) on the job has increased to more than 70 million, data from the Bureau of Labor Statistics indicates that the number of occupational illnesses due to repeated trauma rose from 23,000 in 1981 to 281,800 in 1992, a more than tenfold increase.[1] This rise is thought to be the result of several factors, including heightened awareness by both employees and employers, advances in diagnosis and improved accuracy of reporting, and the ever-accelerating pace of work, especially the increasing use of computers for performing job tasks. Employees affected by CTDs often experience substantial pain and functional impairment, while employers are affected by loss of productivity and increased costs in the form of higher medical expenses and disability payments for injured workers.[2] In 1992 the total annual costs for CTDs of the upper extremity alone were estimated to exceed $563 million in the United States.[3]

Researchers have identified key work-related risk factors for the development of CTDs. These include (a) repetitive motions, (b) forceful exertions, (c) awkward joint posture, (d) direct pressure, (e) vibration, (f) extreme temperatures, and (g) prolonged constrained posture.[4] If two or more risk factors appear at the same time, as often occurs with computer use, the combination markedly increases the possibility of developing CTDs.[5] Based on the increasing injury rate, growing anecdotal evidence, and numerous studies, it can be inferred that many people lack knowledge both of these risk factors and of the recommendations for minimizing potential trauma.[6]

Employee education/training is frequently cited as a primary way to prevent CTDs in the workplace.[4,6] Implicit in the educational training principle is the assumption that knowledge of proper ergonomic arrangement and usage practices will lead to positive actions and a consequent impact on risk factors. Although this principle has been effectively demonstrated with back injury prevention training interventions,[7] a review conducted by the authors of 205 articles on the topics of ergonomics or CTD injuries revealed none that has specifically examined the effectiveness of ergonomics educational training as a preventive measure to alter computer-related risk behaviors.[6]

The purpose of this pilot research project was to examine the impact and effectiveness of educational interventions by measuring the effects of ergonomic training programs both on participants' immediate- and long-term knowledge of ergonomic principles and on actual computer-related work practices. This study was designed as a pilot project to test hypotheses about the effectiveness of ergonomic training.

METHODS

Design

Three comparable groups located in three separate buildings within a single corporation on a campus in Northern California were selected as study groups and were randomly assigned as one of three intervention sites: (1) Treatment Site A: Instructor-Directed Intervention; (2) Treatment Site B: Self-Directed Intervention; or (3) Control Site C: No Intervention. Baseline data were obtained in September 1994 before the interventions, using two assessments: (1) a knowledge test, and (2) a survey of

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work habits and equipment use practices. Immediately after the interventions, subjects at both treatment sites were asked to complete the same knowledge test. Final assessments at all three sites using the same knowledge test and survey as the pre-intervention instruments were also conducted 15 months after the interventions. Additionally, to evaluate participant satisfaction and perceived value of training, one focus group session was conducted with participants from each of Sites A and B at 8 months after the interventions, and a follow-up participant evaluation survey was administered to both treatment groups after the completion of all phases of the study, 18 months after the interventions.

Sample

The study was conducted at Amdahl Corporation, a Sunnyvale, California, company having three separate buildings with a high percentage of "high-risk" computer users. These were defined as employees who routinely work at a computer for a total of 4 hours or more during a 12-hour period, a definition based on generally accepted ergonomic guidelines[4,6] and specifically identified in the 1993 California Code of Regulations Ergonomics Draft.[8] The three sites were comparable both in number of employees and type of work performed. Additionally, within each site participants were randomly selected from among the total eligible high-risk pool. Employees with preexisting disabilities were identified and eliminated from the data pool, but were allowed to participate for educational reasons. Approximately 50 employees at each site began the study, but due to company layoffs and transfers, approximately one-half completed the 15-month study.

Measures

The knowledge test consisted of 22 multiple-choice questions concerning (a) knowledge of risk factors, (b) correct computer equipment and accessory placement (monitor, keyboard, mouse, chair, and document holder), (c) recommended equipment adjustments (correct heights, depths, distances, and supports), and (d) usage behaviors ("ergonomic" work practices, breaks, and exercises). Questions were developed for the Stanford Computer Injury Prevention Educational Intervention (SCI-PEI) based on ergonomic recommendations and guidelines from the federal Occupational Safety and Health Administration (OSHA), the National Safety Council (NSC), and the California Occupational Safety and Health Administration (Cal-OSHA). Reliability was tested for internal consistency (alpha = .68), which though somewhat low was considered acceptable. Face validity of the measure was tested by two researchers with advanced degrees in health education related areas.

The usage survey questionnaire consisted of 27 items concerning personal computer use habits and "ergonomic" work practices, also based on recommendations from OSHA, NSC, and Cal-OSHA, including equipment use (monitor, keyboard, mouse, chair, and accessories), adjustments made, stretches and breaks practiced, intention to make changes in equipment or work practices, and actual changes made. Face validity of the survey was tested by the same researchers, but reliability was not tested.

The follow-up participant evaluation form consisted of six multiple-choice questions concerning participant satisfaction, perceived value, and evaluation of the intervention.

Intervention

Site A participants (instructor-directed intervention) attended a 60-minute ergonomics educational seminar led by an in-house instructor trained by the Stanford staff. Sessions were offered on company time at three different time periods to accommodate employee schedule needs. Seminar content consisted of the following segments designed to impact computer-related risk factors and usage practices: (1) an instructor-led presentation of Introduction to Office Ergonomics and CTD Risk Factors; (2) two 15-minute videos (both based on recommendations from OSHA, NSC, and Cal-OSHA) presenting specific information on the topics of Recommended Adjustments to Workstation Equipment and Accessories and Recommended Breaks and Exercises; and (3) a concluding discussion during which the instructor summarized information and responded to individual questions. Two related pamphlets reviewing the video-presented topics were distributed for follow-up reference.

Site B participants (self-directed intervention) attended one of three 45-minute seminars using the same video and print materials as Site A participants, but without instructor-led segments.

Analysis

Differences in knowledge scores and the number of positive computer use habits between the two assessment phases within each group were examined with paired *t*-tests. Differences in knowledge between the two treatment sites at the post-intervention phase, and in knowledge and the number of positive habits among the three sites at the final follow-up phase, were examined with analyses of variance (ANOVA), where the effects of knowledge test scores and the number of positive habits at the pre-intervention phase were controlled for as covariants. Comparisons between any two groups on the difference in degree of changes were made using the Scheffe procedure.

Differences in improvement of intent and actual changes toward proper computer equipment use among groups were examined using chi-square tests.

RESULTS

Random assignment of subjects was confirmed since there were no significant differences in total knowledge scores and habits among the three groups on baseline assessments.

Results of changes in knowledge are presented in Table 1. Both intervention groups demonstrated statistically significant improvement in knowledge of correct computer equipment placement and recommended usage practices at the post-intervention phase. Differences in knowledge scores between pre-intervention and 15-month follow-up

Table 1

Changes in Knowledge and Positive Habits

	Pre-intervention Mean (SD)	Post-intervention Mean (SD)	Follow-up Mean (SD)	*t*
		Knowledge Test Scores		
Group A*	11.9 (3.11)	16.0 (4.30)		−4.94 ($p < 0.001$)
	11.9 (3.11)		15.8 (3.42)	−4.95 ($p < 0.001$)
Group B†	10.7 (4.39)	14.3 (3.40)		−5.10 ($p < 0.001$)
	10.7 (4.39)		13.7 (3.33)	−5.04 ($p < 0.001$)
Group C‡	10.8 (3.28)	—	11.1 (3.36)	−1.73 (ns)
		Number of Positive Habits§		
Group A*	2.9 (1.40)	—	4.3 (2.28)	−4.65 ($p < 0.001$)
Group B†	2.0 (1.65)	—	3.5 (1.68)	−4.72 ($p < 0.001$)
Group C‡	1.5 (1.38)	—	1.5 (1.28)	0.00 (ns)

* n = 28.
† n = 22.
‡ n = 17.
§ Positive habit choices included the following: attempt to maintain good posture and body alignment; vary work tasks; take regular overall breaks; take regular vision breaks; do exercises for neck and shoulders; do exercises for wrists and hands; do exercises for back; warm up/stretch before work; have attempted to break bad usage habits.

Table 2

Intention to Change and Actual Workstation Change

	Group A	Group B	Group C
	Intention to Change*		
Positive†	17 (65.4)	14 (63.6)	5 (33.3)
No change/Negative‡	9 (34.6)	8 (36.4)	10 (66.7)
	Actual Changes§		
Positive†	15 (55.6)	11 (50.0)	0 (0.0)
No change/Negative‡	12 (44.4)	11 (50.0)	17 (100.0)

n (%)
* Categories included: I have never thought of making ergonomic adjustments/modifications; I have considered doing so; I have plannec to do so; I have actually done so within the past six months; I had actually done so prior to the past six months.
† Positive change is defined as movement from a lower to a higher level between pre-intervention and follow-up surveys.
‡ No change/negative change is defined as no change in level or movement from a higher to a lower level between pre-intervention and follow-up surveys.
§ Categories included: No adjustments/changes made in equipment or equipment positioning prior to the present time; yes, a few (1–4) adjustments/changes made; yes, many (five or more) adjustments/changes made.

for both groups remained significant. As expected, Group C, the control group, did not show any significant change in knowledge. Differences in the knowledge score at the follow-up phase among the three groups were statistically significant after controlling for the effects of knowledge scores at the pre-interventions ($F = 7.25$, df = 2, 64, $p < .01$). There were statistically significant differences in the degree of change from pre-intervention to follow-up between Group A and Group C ($p < .05$) and between Group B and Group C ($p < .05$), but not between Group A and Group B.

Both intervention groups also demonstrated statistically significant changes in reported "ergonomic" use/habits (Table 1). As expected, Group C did not show any improvement. There was a significant difference in use/habit improvement among the three groups ($F = 6.715$, df = 2, 64, $p < .01$). Statistically significant differences in the improvement were found between Group A and Group C ($p < .05$) and between Group B and Group C ($p < .05$), but no significant difference was found between Group A and Group B.

An analysis of "intent to change" pre- and post intervention (Table 2) was not statistically significant ($\chi^2 = 4.57$, df = 2, ns), but indicated that a higher percentage of participants showed a positive movement (i.e., from a lesser to a higher level of intent) for both Groups A (65.4%) and B (63.6%) than for Group C (33.3%). Analysis of reported specific ergonomic changes made also indicated positive movement for both Group A (55.6%) and Group B (50.0%), with both groups having at least 50% change from a lower category (i.e., "none" or "a few") into a higher category (i.e., "a few" or "many"). Group C reported no changes made.

Results of mid-study focus group sessions indicated that participants from both types of training groups were highly satisfied with their respective programs and felt that participation had been beneficial. It is interesting to note that analysis of focus group responses indicated that a majority (15 of 18 from Group A and 10 of 16 from Group B) had physical symptoms before the study that had not been officially reported (all reported claims had been eliminated from participation). A high percentage of these respondents felt that participation in the interventions had been helpful in ameliorating discomfort; for example, to the question, "Did participation in the educational session improve comfort/help?", nearly all those responding (12 of 15 from Group A and 9 of 10 from Group B) replied affirmatively, with respondents citing a variety of specific improvements or reduction of symptoms resulting from participation.

Results of the follow-up evaluation survey confirmed positive participant perception of value, improvement in comfort, and reported behavior change, with fully 100% (17 of 17) of Group A and 90% (10 of 11) of Group B respondents evaluating their seminar as "valuable," "very valuable," or "extremely valuable," and 88% (15 of 17) of Group A and 81% (9 of 11) of Group B indicating that they "felt their comfort was improved specifically as a result of participation." Every participant in both groups reported making ergonomic changes as a result of the seminars, either in workstation adjustments or in use/habits, and a significant majority (73% of Group A and 63% of Group B) reported making changes in both categories.

DISCUSSION

Summary

Results of this study indicate that both ergonomic training programs increased user knowledge of correct computer equipment placement and use in both the short and long term. Additionally, training resulted in greater numbers of self-reported correct workstation adjustments and positive use/habits.

Results of mid-session focus groups and follow-up evaluation surveys indicated that virtually all participants were satisfied with the type of training program received, reported that participation in training had led to improvement in individual comfort, and reported making specific changes in workstation arrangement, personal usage/habits, or both.

Significance

As the numbers of computer-related injuries and associated costs have climbed, attention has turned to the need for preventive measures. A working environment "free from recognized hazards" is required by Section 5 of the federal OSHA General Duty Clause, and, apart from legal requirements, many employers also are motivated by sincere concern for the well-being of employees, organizational morale, and the desire to lower actual and potential costs.[9] This study demonstrates that ergonomic training interventions can be effective as a preventive health promotion measure to increase employees' knowledge of CTD risk factors and possible solutions, resulting in changed intentions, altered risk behavior, and self-reported benefits. It follows that employees who make changes toward safe work areas and practices reduce risk factors and should have fewer injuries. Additionally, since the use of self-report quality of life measures in studies of workers has been supported,[10] the results of this study are encouraging, indicating that the comfort of workers who use computers can be positively affected by changes in workstation arrangement and practices stimulated by ergonomic training. Although educational interventions may actually increase costs in the short term (e.g., costs of training materials, purchases of recommended equipment, possible increase in short-term workers' compensation claims), they may subsequently yield longer-term savings through early detection and prevention of CTDs.

Limitations

Given the pilot project nature of this research, several limitations would need to be addressed in larger, randomized trials: (1) Because the number of participants in this pilot project was limited, the small sample size precluded assessment of the cost-effectiveness of interventions, especially the impact on workers' compensation claims. Clearly, a randomized trial involving substantially larger numbers of workers with a longer follow-up time of up to 2 years would be highly desirable, both to minimize the effects of attrition as well as to allow assessment of the impact of interventions on workers' compensation claims and costs. (2) Workers were employed by a major computer company, Amdahl, and perhaps had somewhat higher baseline knowledge of appropriate computer use. Still, there were significant positive changes. It remains to be seen how much these positive findings can be generalized into other computer-intensive but possibly lower baseline-knowledge settings, such as banks, utilities, telecommunications, and airlines. (3) During the study, Amdahl experienced significant reorganization, resulting in attrition of study participants. Although attrition was consistent among the three study groups, the sample size reduction could have biased the findings if those participants leaving the study were different from those remaining in their ability to learn from the training. Finally, (4) in the era of managed care, it would be valuable to expand the study of training impact to include a cost-benefit analysis of a more rigorous study design, including stronger measures that eliminate weak or unknown psychometric properties and the inclusion of equipment-related costs and workers' compensation and insurance data. Future studies are required with longer time frames and larger sample sizes to fully study the impact of ergonomic training on both knowledge and practices and also on injuries and costs.

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