

Reducing Musculoskeletal Discomfort: Effects of an Office Ergonomics Workplace and Training Intervention

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Effects of an office ergonomics workplace and training intervention on workers' knowledge and self-reported musculoskeletal pain and discomfort were investigated. An instructional systems design process was used to develop an office ergonomics training program and the evaluation tools used to measure the effectiveness of the training program on workers' office ergonomics knowledge and skills. It was hypothesized that the training and workplace intervention would allow the worker to more effectively use their workplace through increased office ergonomics knowledge and skills. Following the intervention, there was a significant increase in workers' office ergonomics knowledge and awareness. Self-reported work-related musculoskeletal disorders significantly decreased for the group who had a workplace change and received ergonomic training relative to a workplace change-only group and a no intervention control group.

musculoskeletal office ergonomics intervention

1. INTRODUCTION

Recently, the occurrence of work-related musculoskeletal disorders (WMSDs) in computer workers has received growing attention. With over 45,000,000 computers in workplaces in the USA, concerns have been raised over the

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potential for an escalation in the incidence of computer-related WMSDs as dependence on computer use increases. Computer work is identified as a risk factor for WMSDs in the working age population (e.g., Bernard, Sauter, Fine, Peterson, & Hales, 1994). Research suggests that ergonomics training and workstation design can prevent or reduce musculoskeletal injuries in an office environment (e.g., Bayeh & Smith, 1999; Robertson & O'Neill, 1999; Sauter, Schleifer, & Knutson, 1991). Office ergonomics interventions contribute to enhanced worker health and well-being as well as to organizational effectiveness. When a successful office ergonomics intervention program is implemented, one of the many results is an increased ability for the worker to change their work environment, leading to enhanced individual effectiveness and the prevention of WMSDs and injuries (e.g., Aarås, Horge, Bjorset, Ro, & Walsoe, 2001; O'Neill, 1999; Sauter, Dainoff, & Smith, 1990).

The importance of ergonomic training programs has been demonstrated by several researchers and practitioners (e.g., Brission, Montreuil, & Punnett, 1999; Green & Briggs, 1989; Verbeek, 1991). Whereas engineering controls such as workstation re-design or the use of adjustable furniture are frequently suggested (Verbeek, 1991), administrative controls such as training must also be used so that employees and management understand the need to change work habits when using office technology. Additionally, training can assist in ensuring that both managers and employees fully understand and participate in the ergonomics program (Kukkonen, Luopajarvi, & Riihimaki, 1983). Training helps employees to understand workstation setup and the use of proper postures to avoid work-related musculoskeletal discomforts (Brisson, et. al, 1999; Kukkonen, et al., 1983). Without training, the presence of other administrative and engineering controls results in limited success. For example, Green and Briggs (1989) found that the availability of adjustable furniture alone did not prevent the onset of overuse injury. Workers who suffered injuries were using the same equipment as non-sufferers, but expressed greater discomfort with the new furniture. Sufferers adopted more awkward postures than non-sufferers, which could be attributed to inadequate knowledge.

The purpose of this study was to investigate the effects of an office ergonomics workplace and training intervention on workers' knowledge and self-reported musculoskeletal pain and discomfort. An instructional systems design process was used to develop an office ergonomics training program and the evaluation tools used to measure the effectiveness of the training program on workers' office ergonomics knowledge and skills. It was hypothesized that the training and workplace design together would allow the worker

to effectively use their workplace through increased office ergonomics knowledge and skills. Moreover, these intervention effects would be expected to translate into behavioral changes, for example, re-arranging workspaces, adjusting furniture and accessories, changing computing work habits, thus leading to a reduction in musculoskeletal discomfort. Two hypotheses were tested in this study: Hypothesis 1: Self-reported pain and musculoskeletal discomfort will be reduced as a function of workspace flexibility; Hypothesis 2: The greatest reduction in self-reported pain and musculoskeletal discomfort will occur as a result of both workspace flexibility and ergonomic training.

2. MATERIALS AND METHODS

2.1. Setting and Participants

A new flexible office work environment was created for approximately 750 employees within a large corporate office building (housing about 1,750 employees), for a U.S. management-consulting firm. About 500 employees engaged in identical work, but remaining in a mix of traditional office workspaces on other floors of the building, served as the control group. These employees were classified as knowledge workers who used a computer for more than 4 hrs a day. One thousand, one hundred, and thirty-five participants took part in the study. The sample demographics regarding job level consisted of partner (4%), associate partner (4%), manager (29%), consultant/specialist (37%), analyst (24%), and assistant (1%).

2.2. Study Design

A quasi-experimental field study design, using an “interrupted time series with a non-equivalent, no treatment control group,” was employed (Campbell & Stanley, 1979). The experimental interventions consisted of (a) a new flexible office space with adjustable workstations and a flexible overall facility layout, and (b) office ergonomics training regarding the use of the space that supports employee control over how the overall space is used. There were three treatment conditions: (a) control group consisting of employees who did not receive a new workspace or training; (b) workstation-only employees who received the new experimental, flexible workspace; and (c) workstation and training employees who received the new workspace and office ergonomics

training. Employees were randomly selected to participate in the training, however participation was limited to employees on two out of the four building floors to minimize unwanted cross contamination or voluntary sharing of the training materials and ergonomic knowledge with other employees. Data were collected simultaneously, from all three groups, once prior to any workplace change, and once following the interventions.

2.3. Office Workplace Intervention

The goals of the workplace intervention project were to (a) create a new concept for work environments that enables higher worker effectiveness; (b) provide ergonomically designed workspaces that enhance employee's health and well-being, and support employees' needs; (c) increase communication and collaboration between individuals, groups, and departments; and (d) create operational efficiencies through business process effectiveness. Specifically, the ergonomic design effort involved a corporate ergonomist, a facility manager, and an architectural firm. Supporting individual workers' ergonomic needs was identified as an essential design criterion and was accomplished by providing flexible, moveable, and adjustable furniture and workstation components.

The overall architectural design of the former workplace consisted of long hallways, with private offices on the perimeters, with large "bull-pen" cubicles for individual workstations. Natural lighting was limited, with small group areas located in the core of floors. Individual workstations were L-shaped, with non-adjustable storage, and minimally adjustable chairs. The new workplace was architecturally designed to create a sense of openness and to provide natural lighting throughout the workspace. Auditory and visual privacy was addressed by installing white noise and moveable partitions. The layout of individual workstations was a soft U-shape with supporting hanging panels of adjustable storage and paper management tools. Highly adjustable chairs were also provided.

2.4. Office Ergonomics Training Intervention

To create the office ergonomic training we used an instructional model based on a systems approach. This model consists of five processes: (a) analysis, (b) design, (c) development, (d) implementation, and (e) evaluation (Knirk & Gustafson, 1986). In the analysis phase we collaborated with, and inter-

viewed, the company's corporate safety and facilities managers to identify existing related office health and ergonomics training programs and determined if workers had been previously trained. However, it was found that no ergonomic training had been offered at the company. Also, we identified the corporate ergonomics process of managing ergonomic issues and the follow-up steps to an employee's request regarding office ergonomics needs. This allowed us to establish a baseline of prior knowledge of the study participants, to determine the training objectives, and to identify the corporate ergonomic policies and practices.

With the results of the training needs analysis, we customized the design of the training program to support the organizational culture, and the existing health and ergonomics programs and policies. The goals of the training were defined as (a) to understand office ergonomic principles, (b) to perform ergonomic self-evaluation of workspace, (c) to adjust and rearrange one's own workspace, and (d) to understand how to utilize the various workspaces designed to support individual and group work. Ten instructional objectives were specified including recognizing work-related musculoskeletal disorders and risk factors, understanding the importance of varying work postures, knowing how to rearrange the workstation to maximize the comfort zone, recognizing and understanding visual issues in the office environment and reducing visual discomfort, understanding computing habits (rest breaks) and knowing how to change work-rest patterns, knowing how to use the various workspaces for individual and group work, being aware of the company's existing health and ergonomic programs, and knowing how to obtain ergonomic accessories through the company's programs. Overall, the training was designed to incorporate active adult learning models that allow for a high level of interaction among the trainers and trainees. Several media were used to deliver the training. Developed training materials included a facilitators handbook and a computer ergonomic guidelines (Ergo-Guidelines) handout with recommendations and solutions. Designed e-mail messages provided feedback to the trainees on the results of the knowledge tests, which also served as reminders of office ergonomics principles. These messages were sent to the trainees at 1 and 3 months after the training.

The training and evaluation materials (including the pre- and post-knowledge tests) were piloted and appropriate revisions were made. One facilitator delivered the training at the company site and the training lasted for 1 hr and 45 min. An introduction to the training was given by the Senior Manager of Facility Services. A total of 61 employees were trained, including several senior managers, managers, analysts, consultants, and executive

administrators. Each trainee brought their own office chair and learned how to appropriately make adjustments. Group exercises and break-outs were included in which trainees conducted ergonomic assessments of several computer workspaces and provided recommendations. Debriefing following these group exercises was led by the facilitator and allowed trainees to share experiences related to the computer workspace.

Training effectiveness was evaluated based on a five level training evaluation framework (Kirkpatrick, 1979; Knirk & Gustafson, 1986): (a) baseline assessment, prior to training; (b) trainee reaction; (c) learning; (d) performance (behavioral changes); and (e) organizational results (productivity). Results of the first three training evaluation levels (trainee's reaction to the workshop (usefulness, value, and relevance), pre- and post-training knowledge tests, and their self-reported behavioral changes and the effect on WMSDs) will be presented here. The behavioral changes were self-reported intended behaviors that the trainees provided on the post-training knowledge test: Trainees reported what workstation changes they planned to make when they returned to their work environment.

2.5. Instruments and Measures

Two methods of data collection were employed: (a) work environment electronic surveys, and (b) ergonomic knowledge tests. The work environment survey contains 10 sections to measure office environment design issues, office ergonomics, and work-related musculoskeletal pain and discomfort. The scales used were adapted from previous office environment studies (Brill, Margulis, Konar, & BOSTI, 1985; O'Neill, 1999) where earlier factor analyses revealed these variables. Musculoskeletal symptoms were determined based on the standardized Nordic questionnaire using a 5-point Likert-type scale (Corlett, Wilson, & Manenica, 1986). Results for specific Work Environment survey items as a function of Time 1 and Time 2 will be presented.

3. RESULTS

3.1. Response Rates

One thousand, six hundred, and seventy-three surveys were distributed for each trial. Six hundred and eighteen completed surveys were returned during Time 1 (37% completion rate); 517 were returned during Time 2 (31% com-

pletion rate). As not all participants completed both pre- and post-surveys, only matched samples (pre and post) were used for the WMSDs analyses for each experimental group and the control group. The pre- and post-sample size was 94 for the control group, 494 for the workstation-only group; and 45 for the workstation and training. Sixty-one workers attended the office ergonomics training, however 15 workers in this group were later laid off.

3.1. Intervention Effects: Ergonomics Training and Workplace

Participants found the training to be beneficial in understanding office ergonomics as reported on the post-training evaluation questionnaire by either strongly agreeing (74%) or agreeing (26%). Trainees' reported strong agreement (74% strongly agreed, 30% agreed) that they will be able to apply this information to their job.

Results of the pre- and post-knowledge test revealed a significant 32% increase in overall office ergonomics knowledge ($t = 21.3, p < .01$; see Figure 1). Significant increases were also observed in the categories of (a) improvement of body posture ($t = 11.9, p < .01$); (b) the use of an ergonomic workstation, chair features, and ergonomic accessories ($t = 9.9, p < .01$), and (c) awareness of the company ergonomic practices and company resources ($t = 12.4, p < .01$).

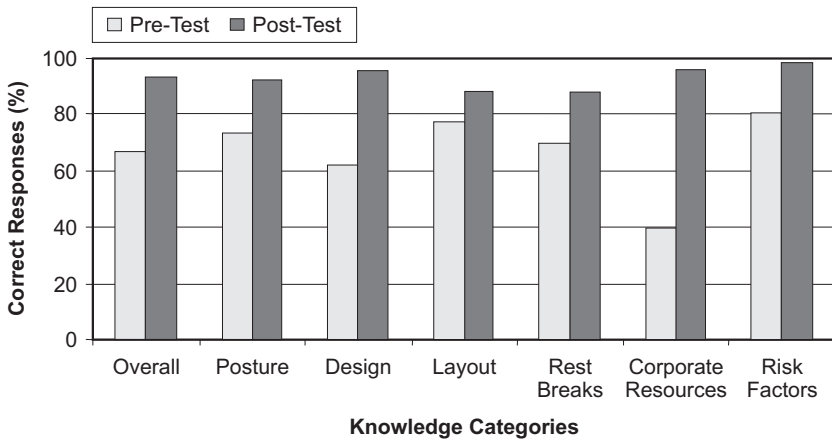


Figure 1. Pre and post office ergonomics knowledge test results: percentage of correct responses overall and for six ergonomic knowledge categories (n = 61).

Pertaining to self-reported intended behaviors, over 93% of the trainees responded to the open-ended question “What immediate changes are you

going to make to your computer workstation as a result of this office ergonomics training?" Of those that responded, 45% indicated at least two or more changes with changes to the chair, appropriate workstation adjustments, and monitor placement the most frequently provided responses.

3.4. Musculoskeletal Discomfort

Table 1 shows the frequency of the employees who reported experiencing work-related discomfort (*yes* vs. *no*) in the last 3 months for Time 1 and Time 2. The reduction in work related discomfort for Time 1 to Time 2 was not significant for either the control or workstation groups (5% and 27%, respectively). In contrast, the workstation and training groups reported a significant reduction in overall musculoskeletal discomfort ($\chi^2 = 7.76, p < .01$).

TABLE 1. Frequency and Means (SD) of Employees Reporting Work-Related Discomfort and Percentage Reduction of Discomfort Between Time 1 and Time 2 for Each Experimental Condition

Reported Discomfort and Reduction	Control Group		Workspace-Only Group		Workspace and Training Group	
	Time 1	Time 2	Time 1	Time 2	Time 1	Time 2
Number of employees who reported experiencing work-related discomfort in the last 3 months	40	38	183	134	26	14*
<i>M</i> (<i>SD</i>)	1.57 (0.5)	1.57 (0.5)	1.63 (0.48)	1.68 (0.47)	1.26 (0.44)	1.59 (0.5)
Reduction between Time 1 and Time 2 (%)	5		27		46	

Notes. * $(\chi^2 = 7.76, p < .01)$.

A 2 (Time: Pre vs. Post) \times 3 (Treatment: control, workstation-only, workstation and training), within subjects MANOVA, adjusting for unbalanced cell size, was conducted using the general linear model in SYSTAT. Significant main effects of treatment ($F(2, 505) = 5.34, p < .01$) and Time ($F(2, 500) = 5.32, p < .05$) were observed. The dependent measure was rated discomfort collapsed over body parts. A significant interaction of treatment \times time ($F(2, 488) = 4.07, p < .05$) was revealed indicating a difference over time for the workstation and training only group ($t = 7.89, p < .05$) but not for

TABLE 2. Means and SD for Self-Reported Discomfort in Eight Body Areas Across Time 1 and Time 2 and Percentage of Decrease of Self-Reported Discomfort for Each Experimental Condition

Reported Discomfort and Reduction	Control Group		Workspace-Only Group		Workspace and Training Group		Decrease (%)
	<i>M (SD)</i>		<i>M (SD)</i>		<i>M (SD) (% Decrease)</i>		
	Time 1	Time 2	Time 1	Time 2	Time 1	Time 2	
Neck	2.74 (1.4)	2.90 (1.50)	2.59 (1.4)	2.48 (1.3)	3.65 (1.7)	2.76 (1.60)	
Upper back	1.98 (1.2)	2.51 (1.57)	2.24 (1.4)	2.20 (1.4)	3.00 (1.5)	3.00 (1.80)	
Lower back	2.46 (1.3)	2.95 (1.40)	2.65 (1.5)	2.43 (1.4)	3.50 (1.6)	2.47 (1.20)*	29
Shoulders	2.47 (1.4)	2.70 (1.50)	2.55 (1.5)	2.28 (1.4)	3.75 (1.5)	1.66 (1.10)	
Elbows	1.52 (1.1)	1.68 (1.20)	1.54 (1.1)	1.49 (1.0)	2.46 (1.5)	1.60 (0.99)*	35
Wrist/hand	2.38 (1.3)	2.46 (1.30)	2.32 (1.4)	2.27 (1.4)	3.36 (1.6)	2.94 (1.50)	
Fingers	1.57 (1.1)	1.87 (1.40)	1.51 (1.0)	1.62 (1.2)	2.83 (1.9)	1.67 (1.10)*	41
Legs	1.86 (1.4)	2.29 (1.30)	1.76 (1.1)	1.66 (1.1)	2.75 (1.8)	1.27 (0.70)*	33

Notes. * $p < .05$, paired t tests.

the other groups ($p > .05$). In separate ANOVAs, as a function of body part, there were significant main effects of treatment for neck ($F = 4.34, p < .01$); upper back ($F = 4.76, p < .01$); shoulders ($F = 8.56, p < .01$); elbows ($F = 3.50, p < .05$); wrist/hand ($F = 5.96, p < .01$); fingers ($F = 5.27, p < .01$); legs ($F = 3.56, p < .05$). Table 2 presents means of the self-reported discomfort for the eight body areas for each treatment group across Time 1 and Time 2. A significant main effect was found across time for legs ($F = 5.32, p < .05$). A significant difference for legs between the control group and the workstation-only group and between the workstation-only and the workstation and training group over time using a Tukey's post-hoc test was found ($p < .01$; $p < .01$, respectively). Significant treatment \times time interactions were observed for the lower back ($F(2, 500) = 4.09, p < .05$); elbows ($F(2, 477) = 6.85, p < .05$); fingers ($F(2, 475) = 4.93, p < .05$); and legs ($F(2, 483) = 7.89, p < .05$). No significant differences were observed for any body part for the control group and the workstation-only group regarding self-reported musculoskeletal discomfort. However, there were significant decreases in reported discomfort in the lower back, elbows, fingers, and legs for the workstation and training group ($p < .05$).

4. DISCUSSION AND CONCLUSIONS

The trainees reported that the office ergonomics training was beneficial and that they could apply the information to their work environment. Additionally, there was an observed increase in office ergonomics knowledge and skills of the participants from pre to post knowledge test. Participants exhibited a large, significant increase in knowledge in the categories of body postures, ergonomic design features, and corporate resources. The knowledge gained in terms of understanding proper use of their work environment to achieve a neutral posture and improve working postures, corresponds with the self-reported intended changes. Through training, these employees were encouraged to use corporate resources to achieve an ergonomic fit with their new workstations. Participants gained a high sense of knowledge and awareness of where to go and who to contact concerning the use of their company's corporate resources pertaining to ergonomic and facility adjustments and changes.

The pre-training results concerning the knowledge category of risk factors appear to indicate these office workers showed a high level of awareness of risks factors associated with office work before attending the workshop. This

is not surprising considering the general public's awareness of ergonomics and computer work. In contrast, the strongest gains in knowledge were in the areas of working posture, understanding the design features of the workspace, and awareness of the company's corporate resources. Only moderate knowledge gains were noted in workstation layout, which pertains to setting up the workstation to support one's comfort zone of work. Again, this may be due to general awareness and knowledge of computer ergonomics.

The findings that the workstation and training group exhibited significant decreases in overall discomfort as well as for the lower back, elbows, fingers, and legs compared to the workstation only and control group suggest that training provides employees with the knowledge necessary to use their workstation in a more ergonomic and healthy way. The observation that the workstation only group reported a greater decrease in overall discomfort relative to the control group suggests that providing ergonomic furniture alone is beneficial however, without coupling training, strong overall health benefits are not observed. These results are consistent with the earlier findings of Green and Briggs (1989), Verbeek (1991), and Kukkonen et al. (1983). However, the current results need to be considered keeping several limitations in mind: Given the nature of field studies and associated quasi-experimental research designs, the degree to which threats to internal and external validity can be addressed is limited. Also, there was only one data collection period before the intervention and group sizes were unequal. Training was only administered to a small group due to time constraints and resources.

Overall, it appears that due to the knowledge gained following the office ergonomics training and workplace design change, workers were able to appropriately change and adjust their workstation and chair setup as well as use the workplace facility more ergonomically and effectively. These results suggest that the provision of ergonomic skills, in the form of training, allows individuals to make appropriate workstation changes, thus reducing musculoskeletal risks and discomfort associated with computer work.

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