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The Influence of Ergonomic Interventions on Employee Stress and Physical Symptoms

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16. Abstract

A recent report by the GAO (1997) indicates that private-sector employers spend as much as $20 billion annually for employee injuries and illnesses due to musculoskeletal disorders (MSDs). While the etiologic mechanisms are poorly understood, there is increasing evidence that psychosocial risk factors related to the job and work environment play a role in the development of work-related MSDs. A longitudinal study was completed to determine the influence of six psychosocial factors and two cost-effective ergonomics interventions on physical discomfort and stress scores reported by employees within a Federal Aviation Administration organization. The results of the study revealed that stress scores decreased significantly across time. However, physical symptom scores did not change across time, nor were they affected by the ergonomic interventions. Two psychosocial factors provided significant and reliable adjustments to stress and physical discomfort scores.

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The Influence of Ergonomic Interventions on Employee Stress and Physical Symptoms

BACKGROUND

A recent report by the United States General Accounting Office (1997) indicates that private-sector employers spend as much as $20 billion annually for employee injuries and illnesses due to musculoskeletal disorders (MSDs). While the etiologic mechanisms are poorly understood, there is increasing evidence that psychosocial factors related to the job and work environment play a role in the development of work-related MSDs, particularly those of the upper extremity and back (National Institute for Occupational Safety and Health, 1997). Consequently, psychosocial factors, such as perceptions of intensified workload, monotonous work, limited job control, low job clarity, lack of job satisfaction, and lack of social support, may represent generalized risk factors for work-related MSDs. The objective of the present research was to explore the influence of these factors on employee ratings of physical discomfort and stress, and to determine if cost-effective ergonomic interventions would affect these ratings.

The research presented here is part of a longitudinal study designed to track and manage organizational changes related to the implementation of the Electronic Document Management System (EDMS) at the Federal Aviation Administration's (FAA's) Civil Aviation Registry (hereafter referred to as the Registry), which is located in Oklahoma City with a staff of 250 employees. The types of jobs at the Registry range from cashiers, who process application fees, to legal instrument examiners, who examine aircraft and airmen application packets to ensure compliance with federal regulations. The Registry's conversion from a manual document system to EDMS in the near future represents a significant organizational change, primarily because employees will be required to learn and master new tools and procedures for completing daily functions and tasks. EDMS will control workflow and the distribution of information with sophisticated software that employees will manipulate using video display terminals (VDTs) and input devices (e.g., keyboard, mouse, etc.). Consequently, when EDMS becomes operational, exposure to VDT work is expected to increase over current exposure rates.

Previous research has demonstrated that increased exposure to VDT work is associated with increased risk of MSDs and elevated levels of physical discomfort, as reported subjectively by employees (Bergqvist, 1995). Furthermore, research assessing psychosocial factors indicates that these factors can contribute individually or in combination to influence both the likelihood of reporting physical discomfort and the perceived level of that discomfort (Bongers, De Winter, Kompier, Hildebrandt, 1993). The current study examined employee ratings of physical discomfort and stress, and psychosocial factors across a 21-month period to determine if these ratings were influenced by two relatively low-cost ergonomic interventions. All employees received one of the interventions; approximately 60% received both. Employees who received both interventions were expected to rate stress and physical discomfort lower than those receiving only one intervention. Although the exact nature of their effect was uncertain, psychosocial factors such as subjective workload, monotonous work, job control, job clarity, job satisfaction, and social support also were expected to uniquely influence stress and physical discomfort scores.

METHOD

Two low-cost ergonomic interventions were developed to forestall anticipated increases in MSD-related illness or injury due to increased exposure rates to VDT work. All employees were included in the first intervention, a 7-hr seminar in July 1997. The seminar was comprised of an introduction to MSD symptoms, an overview of psychosocial risk factors associated with MSDs, ergonomic interventions for the office, and strategies for coping with work-related stress. The second intervention included

145 employees, whose exposure to VDT work was expected to increase with EDMS implementation. Each of these employees received a workstation "checkup" between the period of November 1997 and February 1998. The checkup was designed to assess and adjust the current configuration of workstations so they conformed to a general set of guidelines that were based on the ergonomics research literature. Each checkup consisted of a visit to an employee's workstation, where an 18-item checklist was used to reveal workstation problems associated with MSDs. During the checkup, employees also participated in demonstrations of basic software functions, including how to increase both text and toolbar size, and work with multiple documents. Copies of a "computer fitness brochure" (Great Performance, Inc., 1993) were distributed to all employees who received a checkup. Although every employee was given this brochure at the one-day seminar, 53% of those receiving a checkup recognized the brochure six months later.

Two treatment groups were created based on type of intervention. The "seminar" group received the one-day seminar as an intervention, whereas the "seminar + checkup" group received both the seminar and checkup. The seminar intervention occurred approximately one month after the first administration (May 1997) of the longitudinal survey. Approximately two-thirds of the seminar + checkup intervention had been completed at the time of the second survey administration (December 1997). A third administration of the survey was completed 14 months later, in February 1999. Each survey administration included a modified version of the Nordic Musculoskeletal Questionnaire (Dickinson, Campion, Foster, Newman, O'Rourke & Thomas, 1992), an internally developed 6-item overall job stress scale, and scales that measured the following psychosocial factors: subjective workload (Hart & Straveland, 1988), job control (adapted from Festinger, 1957), and satisfaction, social support, job clarity, and monotonous work (Camman, Fichman, Jenkins, and Klesh, 1983).

Employees used a scale of 1 (not at all) to 5 (to a very great extent) to rate physical discomfort for 12 different body areas, and they rated stress on a scale of 1 (strongly disagree) to 7 (strongly agree). Factor analyses were used to combine the 12 physical discomfort ratings into three unique dimensions, and mean scores were calculated for these dimensions and the stress ratings. Employees also used a scale of 1 to 5 to rate the extent to which they had ever experienced physical discomfort. This rating established a baseline against which all other physical discomfort scores could be assessed. Finally, a scale of 1 to 7 was used to rate 5 psychosocial factors, the sixth factor, subjective workload was assessed with a 1 to 21 scale. A mean score was computed for the baseline physical discomfort scale ratings and for each of the 6 psychosocial scale ratings. A 2 x 3 mixed design was used to examine the effect of the ergonomic interventions (i.e., seminar and seminar + checkup) across time (i.e., May '97, Dec '97 and Feb '99) for each of the outcome measures (i.e., 3 physical discomfort dimension mean scores and a stress mean score). Time was treated as a within-subject variable, and the type of ergonomic intervention served as a between-subject variable. Mean scores of ratings for the baseline physical discomfort and 6 psychosocial factors (viz., subjective workload, monotonous work, job control, job clarity, job satisfaction, and social support) were treated as covariates within the design.

RESULTS

Factor analyses of the physical discomfort ratings produced three unique dimensions that were reliable across the first, second, and third survey administrations, and explained 68%, 68%, and 67% of the variance of the 12 individual ratings included in the respective analyses. The first dimension was labeled Upper Torso and included ratings of the neck, shoulders, and upper and lower back. The second dimension was labeled Upper Extremity and consisted of ratings of the elbows, wrists, and hands. Finally, the third dimension was labeled Lower Extremity and included ratings of the hips, thighs, buttocks, knees, ankles, and feet.

ANCOVA was used to examine the temporal effects of the ergonomic interventions on scores for stress and the Upper Torso, Upper Extremity, and Lower Extremity dimensions. Figure 1 illustrates the results of the ANCOVA for stress scores, which are shown as a function of time and type of ergonomic intervention. The ANCOVA yielded significant main effects for time and type of ergonomic intervention. Although the former main effect revealed that stress scores generally decreased across time, the significant decrement was confined to the period between Dec '97 [M=4.4, SD=0.14] and Feb '99 [M=4.2, SD=0.15;

$F(2,186)=3.01$, $p<.05$, $\eta^2=.031$]. The main effect for type of intervention indicated that employees who participated in the seminar had significantly lower stress scores [M=4.0, SD=0.20] than employees who participated in the seminar and received a workstation checkup [M=4.6, SD=0.12; $F(1,93)=6.8$, $p<.02$, $\eta^2=.068$]. Table 1 shows correlations among covariates and stress scores for May '97, Dec '97, and Feb '99. All covariates were significantly correlated with stress scores. However, only the baseline physical discomfort [$F(1,93)=5.4$, $p<.03$, $\eta^2=.055$] and subjective workload scores [$F(1,93)=29.3$, $p<.01$, $\eta^2=.239$] uniquely adjusted the stress scores.

Figures 2a, 2b, and 2c depict the results of the separate ANCOVAs for Upper Torso, Upper Extremity, and Lower Extremity physical discomfort scores, respectively. These ANCOVAs revealed no significant main effects for type of ergonomic intervention or time, nor did the analyses indicate a significant interaction between these two variables. Correlations among covariates and Upper Torso, Upper Extremity, and Lower Extremity physical discomfort scores are displayed in Table 1. Several covariates uniquely adjusted physical discomfort scores in each of the three ANCOVAs. Although job

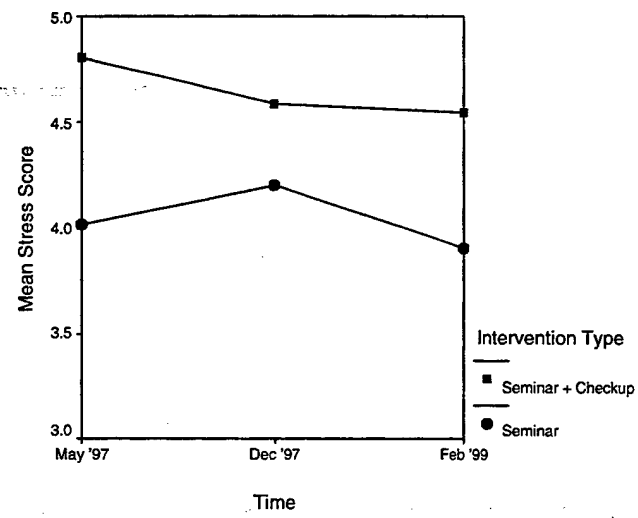

Figure 1. Mean stress scores as a function of time and type of intervention.

Table 1. Correlations among covariates and stress scores, and Upper Torso, Upper Extremity and Lower Extremity physical symptom scores.

	Subjective Workload	Monotonous Work	Job Control	Job Clarity	Job Satisfaction	Social Support	Baseline PS
Stress (May '97)	**.550	**.354	**-.303	*-.172	**-.269	**-.273	**.487
Stress (Dec '97)	**.500	**.262	**-.280	-.142	*-.221	**-.261	**.308
Stress (Feb '99)	**.568	**.264	**-.279	*-.200	**-.299	**-.303	**.472
UT (May '97)	**.409	.121	**-.231	*-.139	-.136	*-.172	**.776
UT (Dec '97)	**.354	.031	-.150	*-.216	-.038	-.128	**.624
UT (Feb '99)	**.410	-.052	-.059	**-.251	*-.175	*-.214	**.549
UE (May '97)	**.382	.136	-.050	*-.154	-.059	-.081	**.692
UE (Dec '97)	**.289	-.047	.045	*-.223	-.120	-.043	**.583
UE (Feb '99)	**.292	-.071	**-.184	*-.219	-.083	-.098	**.482
LE (May '97)	**.288	.102	**-.184	-.118	-.088	-.133	**.596
LE (Dec '97)	.144	-.035	-.106	-.121	-.001	-.066	**.455
LE (Feb '99)	.074	-.164	.092	*-.172	-.095	-.024	**.327
Subjective Workload		**.371	*-.168	-.096	*-.163	**-.274	*.399
Monotonous Work			.059	**.284	**.228	.054	.110
Job Control				**.291	**.394	**.342	**-.233
Job Clarity					**.352	**.310	**-.198
Job Satisfaction						**.476	*-.175
Social Support							*-.153

*Correlation is significant at the 0.05 level (two-tailed).
** Correlation is significant at the 0.01 level (two-tailed).

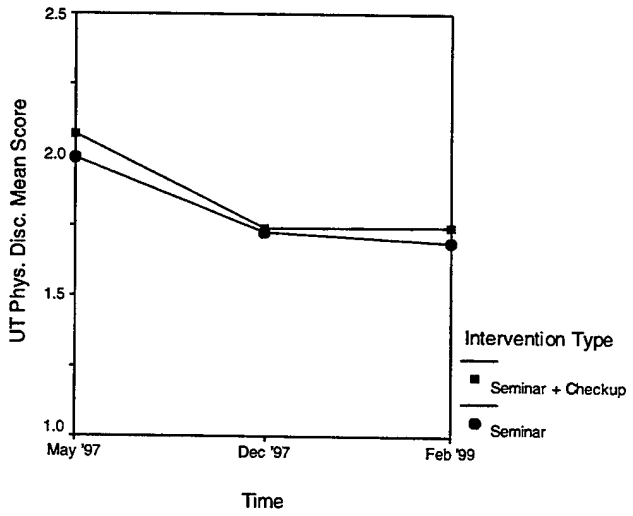

Figure 2a. Mean Upper Torso physical discomfort scores as a function of time and type of intervention.

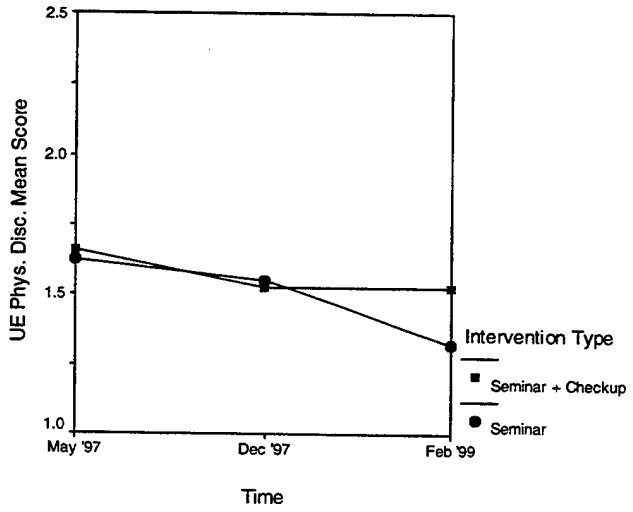

Figure 2b. Mean Upper Extremity physical discomfort score as a function of time and type of intervention.

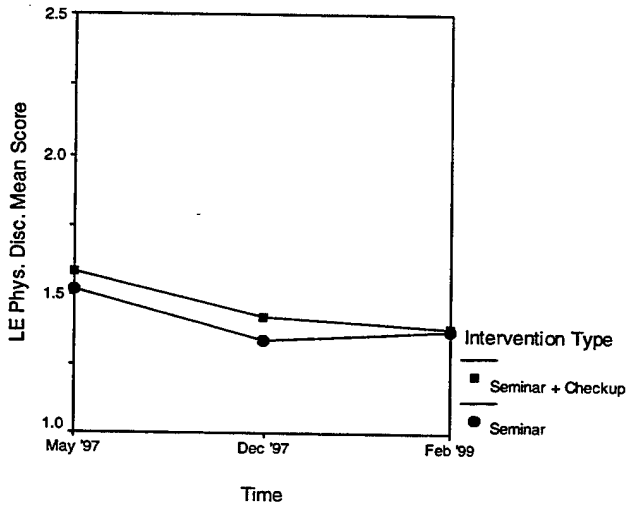

Figure 2c. Mean Lower Extremity physical discomfort score as a function of time and type of intervention.

clarity and Upper Torso physical discomfort scores were significantly correlated, only baseline physical discomfort [$F(1,91)=74.6$, $p<.01$, $\eta^2=.450$] and subjective workload scores [$F(1,91)=10.8$, $p<.01$, $\eta^2=.106$] uniquely adjusted Upper Torso physical discomfort scores. Job clarity scores also correlated significantly with Upper Extremity physical discomfort scores. However, only baseline physical discomfort [$F(1,90)=59.0$, $p<.01$, $\eta^2=.396$], subjective workload [$F(1,90)=3.7$, $p<.05$, $\eta^2=.039$], and job control scores [$F(1,90)=5.6$, $p<.02$, $\eta^2=.059$] provided unique adjustments to Upper Extremity physical discomfort scores. The Lower Extremity physical discomfort scores were uniquely adjusted by baseline physical discomfort scores only [$F(1,92)=45.9$, $p<.01$, $\eta^2=.333$].

DISCUSSION

The pattern of results for employee stress scores indicated that stress decreased across time. The reduction in stress became more pronounced during the period between Dec '97 and Feb '99, and was not a consequence of either of the ergonomic interventions. Although stress scores were significantly higher for employees who received the seminar + checkup relative to those who attended only the seminar, the former group of employees reported significantly higher stress scores throughout the study period. The absence of a significant interaction between intervention type and time indicates that the difference in stress scores remained constant over time. Overall, the level of stress experienced by employees appears to be equivalent to that found in other work settings (e.g., see Paulsen, 1994).

Even though Upper Torso, Upper Extremity, and Lower Extremity physical discomfort scores decreased slightly over time, this change was not significant. Nor was there a significant change in discomfort scores as a result of the two ergonomic interventions. Overall, Figures 2a, 2b, and 2c illustrate that employees reported minimal discomfort throughout the study period. In fact, any effects attributable to the ergonomic interventions may have been undetectable because physical discomfort scores, especially those for the Lower and Upper Extremity dimensions, were near the lowest scale value (i.e., 1.0) throughout the study period. Interestingly, physical discomfort scores did not increase as a consequence of employees becoming more aware of the causes, symptoms, and psychosocial risk factors associated with MSDs. Previous research on this matter is equivocal and employers' reluctance to initiate ergonomics programs is based partly on concerns about increases in reports of physical discomfort, MSDs, and worker compensation costs (Melhorn, 1999).

The baseline physical discomfort scores provided significant and reliable adjustments to stress and the three physical discomfort dimension scores. The correlation coefficients in Table 1 illustrate that the significant relationship between the former and latter scores was moderately positive. This finding is consistent with earlier research and suggests that employees should be screened upon entry into a workforce so that employers have a baseline measure of physical symptoms against which comparisons can be made when important changes occur within an organization. Another covariate, subjective workload, also significantly adjusted employees' stress and physical discomfort scores, with the exception of those for the Lower Extremity dimension. As with prior research examining VDT users (e.g., Sauter et al., 1983), and as can be seen in Table 1, the association between subjective workload and the outcome measures was moderately positive and significant. The effect sizes (i.e., η^2) of the baseline physical discomfort and subjective workload covariates were consistently higher than any of the other effects observed in this research. Hence, subsequent research using employee reports of physical discomfort and stress as outcome measures must not overlook the unique adjustment that these covariates provide to outcome measures.

The longitudinal research reported here provides important baseline information that will be used to assess changes that result from EDMS implementation at the Registry. The research will continue to track employee reports of physical discomfort and stress, along with other data, in an effort to provide trend information that will more fully and reliably assess the effects of the ergonomics interventions and psychosocial factors.

REFERENCES

Bergqvist, U. (1995). Visual display terminal work- A perspective on long-term changes and discomforts. *International Journal of Industrial Ergonomics, 16*, 201-9.

Bongers, P.M., De Winter, C.R., Kompier, M.A.J., and Hildebrandt, V.H. (1993). Psychosocial factors at work and musculoskeletal disease. *Scandinavian Journal of Work, Environment and Health, 20*, 417-26.

Camman, C., Fichman, M., Jenkins, G., and Klesh, J. (1983). Assessing attitudes and perceptions of organizational members. In Seashore, S., Lawler, E., Mirvis, P., and Camman, C. (Eds.), *Assessing Organizational Change: A Guide to Methods, Measures, and Practices.* New York: Wiley & Sons.

Dickinson, C.E., Campion, K., Foster, A.F., Newman, S.J., O'Rourke, A.M.T., and Thomas, P.G. (1992). Questionnaire development: an examination of the Nordic Musculoskeletal Questionnaire. *Applied Ergonomics, 23(3)*, 197-201.

Festinger, L. (1957). *A Theory of Cognitive Dissonance.* Evanston: Row, Peterson.

Great Performance, Inc. (1993). Computer Fitness Brochure. Beaverton, OR: Great Performance, Inc.

Hart, S.G. and Staveland, L. (1988). Development of the NASA task load index (TLX): Results of empirical and theoretical research. In P.A. Hancock and N. Meshkati (Eds.), *Human Mental Workload* (pp. 139-83). Amsterdam: North-Holland.

Melhorn, J.M. (1999). The impact of workplace screening on the occurrence of cumulative trauma disorders and workers' compensation claims. *Journal of Occupational and Environmental Medicine*, 41(2), 84-92.

National Institute for Occupational Safety and Health (1997). Musculoskeletal disorders and workplace factors. Cincinnati, OH: National Institute for Occupational Safety and Health.

Paulsen, B. (1994). A nation out of balance. *Hippocrates*, Oct., 29-32.

Sauter, S.L., Gottlieb, M.S., Jones, K.C., Dodson, V.N., and Rohrer, K. (1983). Job and health implications of VDT use: Initial results of the Wisconsin-NIOSH study. *Communications of the Association of Computing Machinery, 26*, 284-94.

US General Accounting Office (1997). Worker Protection: Private sector ergonomics programs yield positive results. Washington, DC: US General Accounting Office.