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Mood Disturbances and Musculoskeletal Discomfort: Effects of Electronic Performance Monitoring Under Different Levels of VDT Data-Entry Performance

Lawrence M. Schleifer

University of Maryland
USA

**Traci L. Galinsky
Christopher S. Pan**

National Institute for Occupational Safety and Health
USA

The effects of electronic performance monitoring (EPM) work management on mood disturbances and musculoskeletal discomfort were evaluated under three levels of data-entry task performance. EPM work management (i.e., performance monitoring and feedback) was used to induce compliance with data-entry performance standards of greater than or equal to 200 keystrokes per minute and less than or equal to six errors per minute. Forty-seven female office workers who had difficulty maintaining the data-entry speed standard were assigned at random to EPM work management or no EPM work management. Participants in both work management conditions were divided into three keystroke performance groups (low, moderate, high). Self-ratings of mood disturbance and musculoskeletal discomfort were recorded at periodic intervals over three consecutive workdays. Regardless of the level of data-entry performance, the increase in perceived time pressure across the workdays was greater under

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This research was initiated by Lawrence M. Schleifer during his tenure as a Research Psychologist in the Division of Biomedical and Behavioral Science, National Institute for Occupational Safety and Health, Cincinnati, OH.

Correspondence and requests for reprints should be sent to Lawrence M. Schleifer, Department of Health Education, University of Maryland, College Park, MD 20742-2611.

EPM work management than under no EPM work management. Among workers who consistently failed to meet the performance standards (i.e., low and moderate performance), the increases in mood disturbances and musculoskeletal discomfort across the workdays were greater under EPM work management than under no EPM work management. These stress effects were more evident when keystroke rates were relatively close to the standard (moderate performance) than when they were far below the standard (low performance). The results suggest that EPM work management should be employed with performance standards that balance production requirements against the worker's skills and abilities.

INTRODUCTION

A review of the literature on electronic performance monitoring (EPM) suggests that there is a theoretical basis (Amick & Smith, 1992; Carayon, 1993; Schleifer & Shell, 1992; Smith, Carayon, & Miezio, 1986) and increasing empirical evidence (Aiello, & Shao, 1993; Carayon et al., 1993; DiTecco, Cwitco, Arsenault, & Andre, 1992; Schleifer, Galinsky, & Pan, 1995; Schleifer, Sauter, Hales, & Peterson, 1992; Smith et al., 1986; Smith, Carayon, Sanders, Lim, & LeGrande, 1992) indicating that this approach to work management (i.e., goal setting and performance monitoring and feedback) is associated with psychological stress and musculoskeletal discomfort. EPM work management can cause these deleterious effects by increasing work pressure and reducing task control which, in turn, produces an imbalance between task demands and the worker's resources to adapt.

Goal setting and performance feedback are established work management methods for enhancing productivity (Ilgen, Fisher, & Taylor, 1979; Locke, Shaw, Saari, & Latham, 1981). In this sense, the use of computer technology to monitor and give feedback on employee performance and promote compliance with performance goals is not a new development. What is new, however, is the use of EPM work management in office settings to monitor employee performance on a second-by-second, keystroke-by-keystroke basis so that corrective action, performance feedback, award of incentive pay, or disciplinary measures can be implemented at any time (Smith, 1988).

There also is increasing concern regarding the manner in which EPM work management has been implemented (Smith et al., 1986; Westin, 1986). In some workplaces, EPM work management is perceived as an unfair labor practice when it is used to measure individual, as opposed to group, performance. Workers have particularly taken exception to the use of monitoring to enforce compliance with performance standards that impose excessive work load demands. EPM work management also can make the work process more impersonal by replacing a human supervisor with an electronic supervisor. In addition, the overemphasis on production may encourage workers to compete instead of cooperate with one another.

Schleifer and Shell (1992) suggested that EPM work management is most likely to produce an imbalance between task demands and a worker's resources

to adapt when it is used to enforce compliance with performance standards that are unrealistic, unfair, or otherwise very difficult to meet. Under these conditions, workers may experience stress through excessive workload demands, negative computer and supervisor feedback, and threat of job loss. Smith et al. (1986) also observed that EPM work management can be a source of fear and anxiety when it is used to exert excessive management control and to coerce workers to meet unrealistically high work standards.

According to the Office of Technology Assessment (OTA, 1987), the "fairness" of EPM work management systems has significant implications for worker health and the quality of working life. In this regard, an important factor in the perceived "fairness" of EPM work management is the establishment of reasonable performance standards. OTA (1987) noted that:

Fair standards must be realistic, taking into account system downtime, slow response time, and varying levels of complexity of different tasks. When standards are not realistic, or when they are not perceived as fair by employees and managers, they can easily lead to a decline in morale, increased turnover rate, and ultimately a decrease in productivity. (p. 41)

The present report examines the effects of EPM work management versus no EPM work management on mood disturbances and musculoskeletal discomfort at three levels of data-entry performance (i.e., low, moderate, and high). Key-stroke rate data were used to divide the workers in each work management condition into a low-performance group, moderate-performance group, and a high-performance group. Under EPM work management, performance monitoring and feedback was used to enforce compliance with predetermined performance standards of greater than or equal to 200 keystrokes per minute and less than or equal to six errors per minute. This approach provided for evaluations of EPM work management effects on mood disturbances and musculoskeletal discomfort among workers who exceeded the data-entry speed standard (high performance), among workers who just missed the standard (moderate performance), and among workers who fell far below the standard (low performance). It also provided for an indication of whether stress effects among workers who fell below the data-entry standard (i.e., low and moderate performance) varied with the magnitude of the shortfall in performance relative to the standard.

METHOD

Participants

Forty-eight, right-handed women with clerical work experience were recruited from an employment agency. One of the participants was unable to complete the study. Thus, the results are based on data from 47 participants (M age = 24, range = 19–38). Participants were compensated at a rate of \$7.55 per hour. All

were in good general health, with normal or corrected-to-normal visual acuity and no musculoskeletal complaints.

To generate high work-load demands under EPM work management, participation in the study was restricted to participants who did not meet a performance screening standard of 200 keystrokes per minute during a 20-min numeric data-entry task.

Apparatus

The study was conducted in the Work Stress Laboratory of the National Institute for Occupational Safety and Health. Two IBM-PCATs (5170) were used at each workstation to deliver the data-entry task and collect experimental data. Each workstation was also equipped with an IBM 3163 VDT, an ergonomic table and chair, wrist supports, contrast enhancement filters, and a copyholder. Overhead fluorescent lighting fixtures were fitted with parabolic lenses. The ambient illumination level at each workstation was held constant at 500 Lux. Ergonomic adjustments to the workstations were made on an individual basis to maximize physical comfort for each participant.

Task

The data-entry task required participants to enter numbers from bogus IRS 1040-EZ tax forms using the numeric keypad of an IBM 3163 VDT. Each form contained 11 fields of seven printed digits that were obtained from a table of random numbers. Participants entered the appropriate numeric information from each field on the printed tax form in a continuous sequence, pressing the "enter" key after each field was completed. As each participant entered data, she was able to use the backspace key to delete any errors committed within the current field, and replace them with the correct numeric information. The data-entry program was designed to prohibit backspacing to any location prior to the current field. Thus, even if an error was detected in a previous field, it was not possible to correct it. All participants performed the task exclusively with the right hand.

Task Conditions

Participants were assigned at random to perform the numeric data-entry task under EPM work management or no EPM work management.

EPM Work Management. In this condition, keystroke and error rates were monitored electronically and performance feedback was periodically provided via each participant's VDT in order to enforce compliance with data-entry performance standards. The keystroke rate performance standard was designated as "a fair day's work pace;" that is, "the work pace at which an average, well-trained

employee can work without undue fatigue while producing an acceptable quality of work" (Nolan, 1983). Using Methods-Time Measurement procedures (Maynard, Stegemerten, & Schwab, 1948), the fair day's work pace for the data-entry task was determined to be 200 keystrokes per minute (k/min).¹ A requirement of no more than six errors per minute (e/min) was chosen as the error standard for an acceptable quality of work (97% accuracy rate). Following each work period, feedback specifying keystroke and error rates for that period was presented on each EPM participant's video display. If the participant's keystroke rate was below 200 k/min, if the participant's error rate was greater than 6 e/min, or both, the feedback data were accompanied by the negative performance feedback message: "You have not met the minimum performance standard; your performance for this work period is unsatisfactory." If the participant's keystroke rate was 200 k/min or higher, and the error rate was less than or equal to 6 e/min, the feedback data were accompanied by the positive performance feedback message: "You have met the minimum performance standard; your performance for this work period is satisfactory."

No EPM Work Management. In this condition, no work standards were imposed, and no performance feedback was provided to participants. Participants were instructed to perform the data-entry task at their usual work pace and level of accuracy.

Mood Disturbance and Musculoskeletal Discomfort Measures

Self-ratings of mood disturbances and musculoskeletal discomfort were obtained using measures administered via the VDTs. Mood disturbance measures included irritation, perceived time pressure, tension, workload dissatisfaction, boredom, and fatigue (see Caplan, Cobb, French, Van Harrison, & Pinneau, 1975 and Schleifer & Amick, 1989, for detailed descriptions of these scales). Musculoskeletal discomfort measures included ratings of discomfort, pain, stiffness, or soreness in the lower back, neck, left shoulder, right shoulder, left elbow, right elbow, left hand, and right hand.

Participants indicated the degree to which they were experiencing mood disturbances and musculoskeletal discomfort using a category rating scale ranging from 1 (*hardly at all*) to 5 (*a great deal*).

Procedure

Participants assigned to the same condition were tested simultaneously in groups of three or less. Testing occurred over the course of three consecutive

¹Richard Shell, an expert in Methods-Time Measurement, computed the fair day's work pace standard for the data-entry task.

days. Each day included six 40-min work periods (three in the morning and three in the afternoon). Mood disturbance and musculoskeletal discomfort ratings were obtained from participants at the end of each work period. Participants received a 45-min lunch break, a 10-min break in the morning (prior to the third work period), and a 10-min break in the afternoon (prior to the sixth work period).

On the first day (baseline), no EPM work management (i.e., no work standard or performance feedback) was invoked for either group of participants. Participants in both groups were simply instructed to perform the data-entry task at their usual work pace and level of accuracy. Participants were unaware of the condition (EPM or no EPM) to which they were assigned until the end of the first day. On the second and third days, EPM work management was in effect for the experimental group only; participants in the no EPM work management (control) group were instructed to continue working at their usual pace and level of accuracy.

Performance Groups

The data analyses were directed toward comparing the stress effects of EPM work management among participants who met or exceeded the data-entry speed standard with those who fell somewhat below the standard and with those who fell far below the standard. Performance data from the last day of testing (Day 3) were used to make these comparisons because participants achieved their highest data-entry speeds on the last day. Participants were rank ordered according to their mean data-entry speeds in EPM work management on Day 3 and then were divided into three performance groups of approximately equal size (low: $n = 9$; moderate: $n = 7$; high: $n = 8$). Similarly, participants were ranked ordered according to their mean data-entry speeds in no EPM work management and then were divided into three performance groups of approximately equal size (low: $n = 9$; moderate: $n = 7$; high: $n = 7$). Mean, minimum, and maximum data-entry speeds in each performance group in each condition are displayed in Table 1. As shown, mean data-entry speeds of all EPM participants in the high performance group exceeded the speed standard of greater than or equal to 200 keystrokes per minute. By contrast, mean data-entry speeds of EPM participants in the moderate and low performance groups were somewhat below, and far below the standard, respectively.

Data Analyses

To provide for the most meaningful comparisons between the EPM and no EPM conditions, the data analyses focused only on the baseline day (Day 1) and last day (Day 3) of the study. The second day of the study (Day 2) was not included in the data analyses to minimize the impact of "novelty effects" that may occur as the participants adapted to EPM work management. A General Linear Models

Table 1. Mean Keystrokes Per Minute in the Low-, Moderate-, and High-Performance Groups Under EPM and No EPM Conditions on Day 3

Condition	Performance Group	M	Range
EPM	Low (<i>n</i> = 9)	153	126–166
	Moderate (<i>n</i> = 7)	184	170–200
	High (<i>n</i> = 8)	215	203–223
No EPM	Low (<i>n</i> = 9)	142	120–158
	Moderate (<i>n</i> = 7)	181	169–188
	High (<i>n</i> = 8)	196	190–203

Note. EPM = electronic performance monitoring.

procedure (SAS Institute, 1987) was used to perform analyses of variance on repeated measures using planned contrasts for each of the three performance groups (low, moderate, and high). These analyses were carried out to determine whether the magnitude of changes in mood disturbances and musculoskeletal discomfort from Day 1 to Day 3 differed significantly between EPM work management and no EPM work management for each of the three performance groups (i.e., low, moderate, and high).

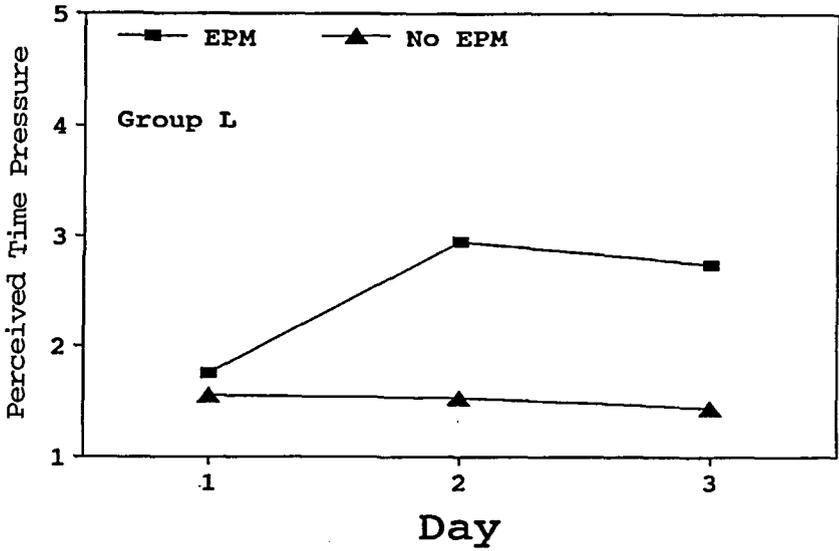
Mood Disturbances

Figures 1 through 7 present the mean ratings of perceived time pressure, workload dissatisfaction, irritation, and tension for performance groups reflecting significant differences across the three workdays for EPM work management and no EPM work management.

Analyses of variance on repeated measures using planned contrasts indicated that increases in mood disturbances from Day 1 to Day 3 were larger for EPM work management than for no EPM work management in the low-performance group: perceived time pressure, $F(1, 16) = 9.66, p < .01$; workload dissatisfaction, $F(1, 16) = 8.74, p < .01$; in the moderate-performance group: perceived time pressure, $F(1, 12) = 29.36, p < .001$; irritation, $F(1, 12) = 7.70, p < .05$; tension, $F(1, 12) = 4.64, p = .052$; workload dissatisfaction, $F(1, 12) = 10.50, p < .01$; and in the high-performance group: perceived time pressure, $F(1, 13) = 4.81, p < .05$. There were no significant differences between EPM work management and no EPM work management for the other measures of mood disturbances in the various performance groups.

Musculoskeletal Discomfort

Figures 8 and 9 present the mean ratings of right-hand discomfort and right-shoulder discomfort across the 3 workdays for the Moderate performance group under EPM work management and no EPM work management. Planned con-



Figures 1-7. Mean ratings of mood disturbances across the workdays under EPM and no EPM work management conditions for select performance groups.

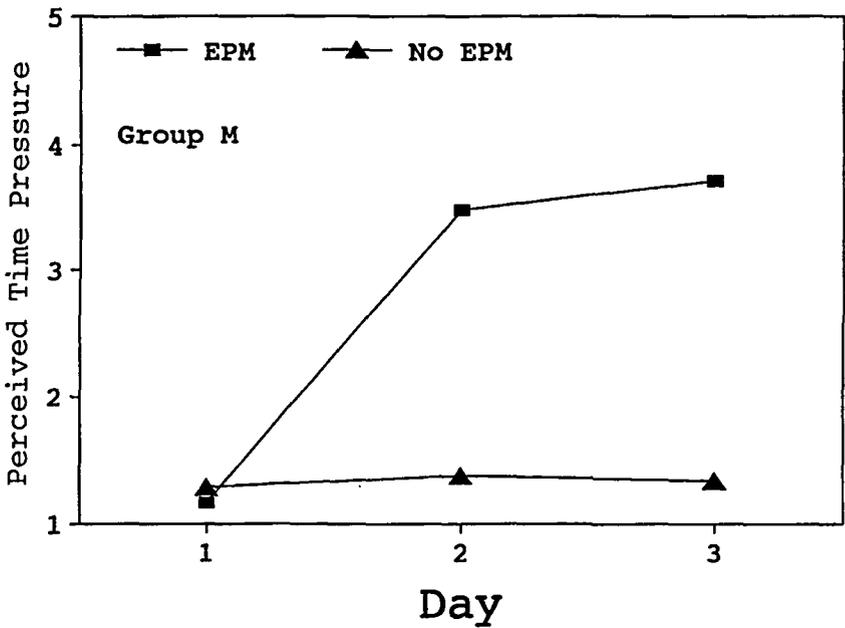


Figure 2.

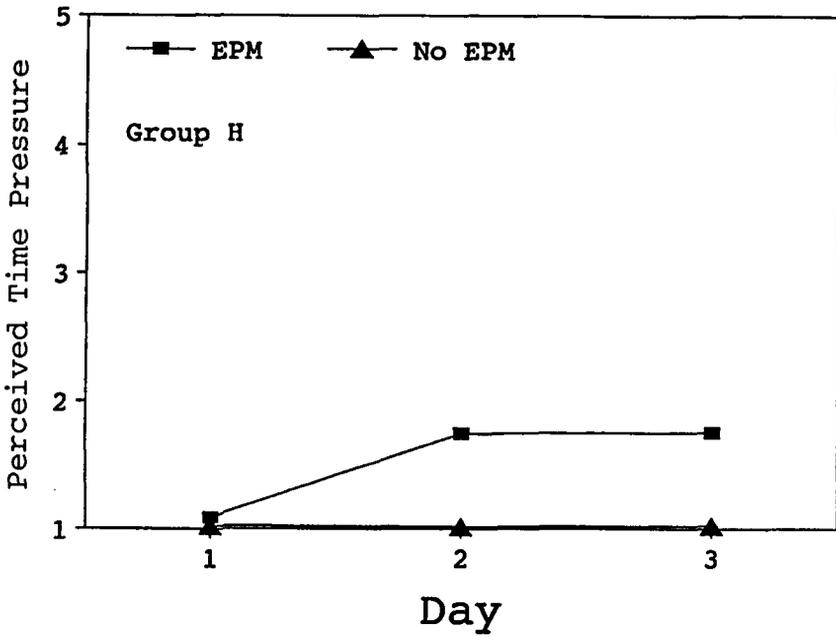


Figure 3.

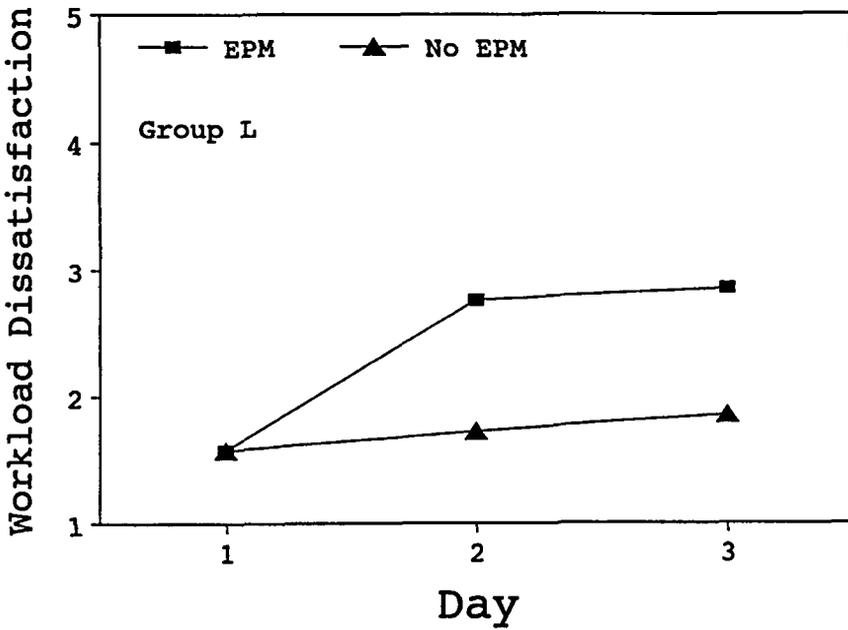


Figure 4.

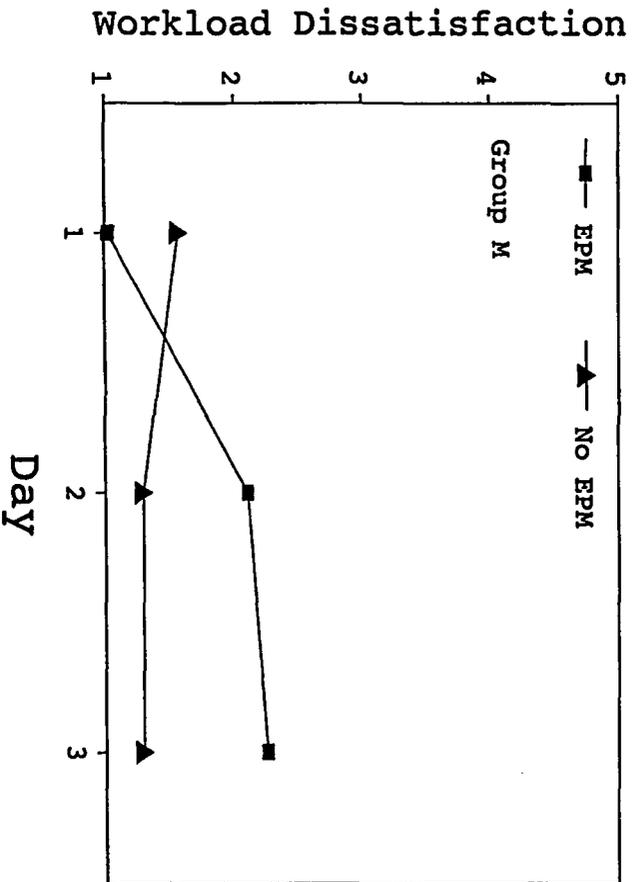


Figure 5.

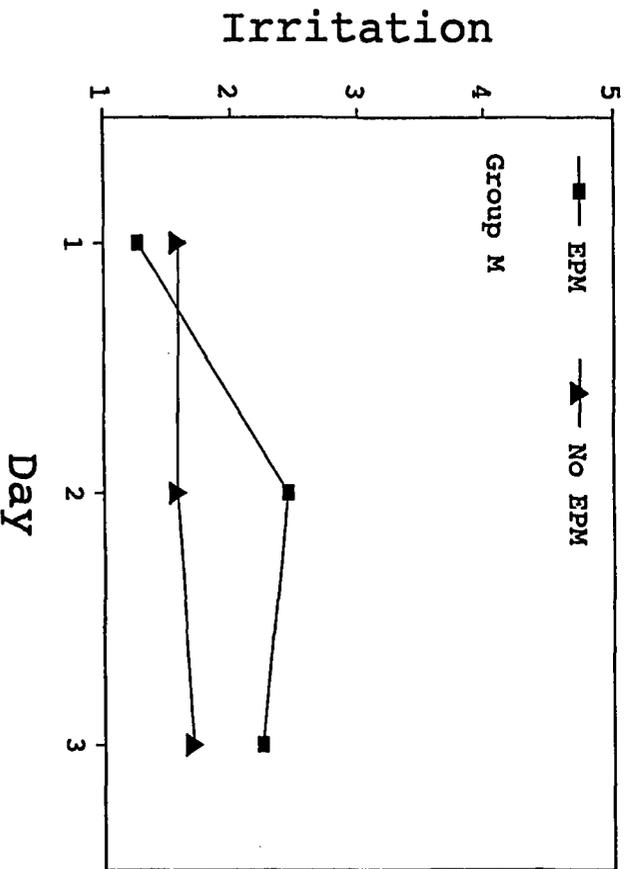


Figure 6.

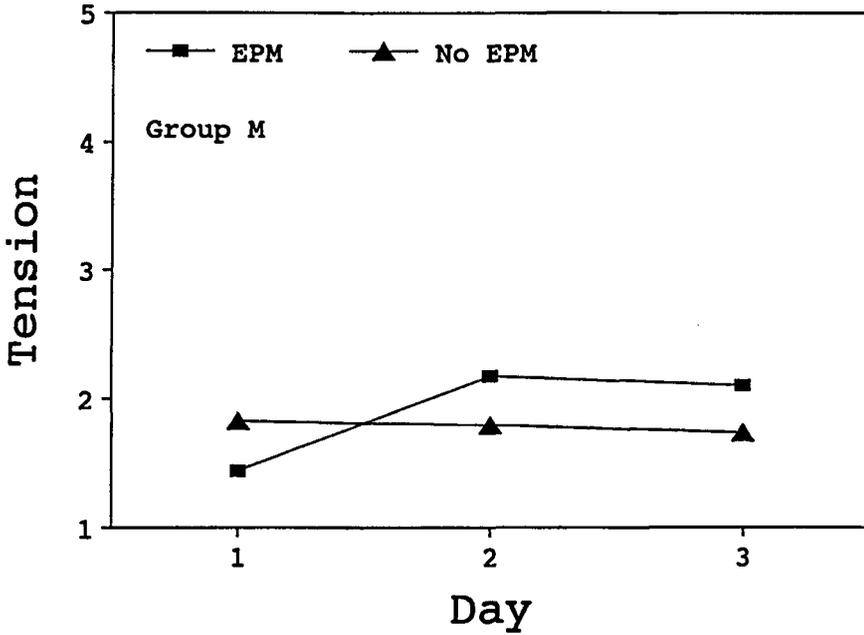
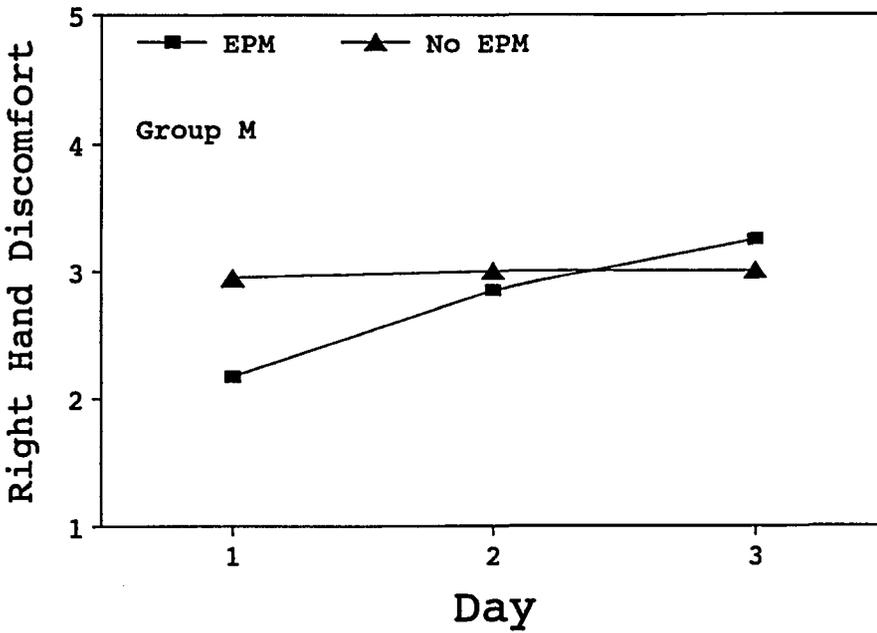


Figure 7.



Figures 8 and 9. Mean ratings of musculoskeletal discomfort across the workdays under EPM and no EPM work management conditions for select performance groups.

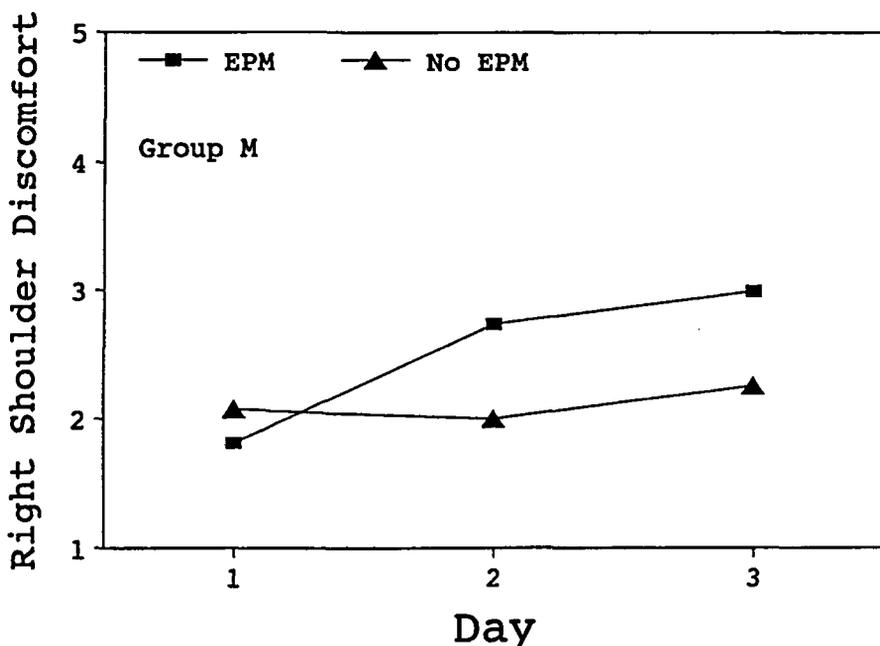


Figure 9.

trasts indicated that in the moderate-performance group, increases in right-hand discomfort and right-shoulder discomfort from Day 1 to Day 3 were significantly greater for EPM work management than for no EPM work management: right shoulder, $F(1, 12) = 6.58, p < .05$; right hand, $F(1, 12) = 11.07, p < .01$. There were no significant differences between EPM work management and no EPM work management for the other measures of musculoskeletal discomfort in the moderate-performance group. In addition, there were no musculoskeletal discomfort effects in the low- or high-performance groups.

DISCUSSION

Perceived time pressure was the only mood disturbance that increased significantly in response to EPM work management in all three performance groups. Thus, it is likely that workers who have difficulty meeting or maintaining performance standards will experience time pressure under EPM work management, regardless of their specific level of data-entry performance. However, inspection of Figures 1 through 3 indicates that the magnitude of perceived time pressure effects tended to be greater among workers who did not meet the performance standard (i.e., low- and moderate-performance groups) than among participants who met the performance standard (i.e., high-performance group).

The other mood disturbance effects occurred only in the low- and moderate-performance groups. Workload dissatisfaction was higher under EPM work management in the low-performance group, and tension, irritation, and workload dissatisfaction were higher under EPM work management in the moderate-performance group. Thus, under EPM work management, mood disturbances were more evident among participants who did not meet the minimum key-stroke production standard of 200 k/min by the third day of testing ($M_{Low} = 153$; $M_{Moderate} = 184$) than among participants who did tend to meet the minimum keystroke production standard ($M_{High} = 215$).

This pattern of results suggests that it was not electronic monitoring per se which was emotionally stressful to participants. Rather, it appears that the mood disturbance effects of EPM work management were mediated by the negative performance feedback which occurred predominantly in the low- and moderate-performance groups as a result of not meeting the data-entry performance standard.

Tension and irritation effects were present among participants in the moderate-performance group, but were absent among participants in the low-performance group, even though the shortfall in data-entry performance relative to the standard was much greater in the low-performance group than in the high-performance group. In addition, the magnitude of the perceived time pressure effects was higher in the moderate-performance group than the low-performance group. These results are counterintuitive, as they suggests that small performance deficiencies generate more mood disturbances than large performance deficiencies.

A possible explanation for such an outcome is that participants in the moderate-performance group under EPM work management were continually frustrated by the negative feedback they received following each work period, which indicated that their performance was almost, but not quite, acceptable. By contrast, participants in the low-performance group tended to receive negative feedback which indicated that their performance was substantially lower than the standard. This may have led the participants in this performance group to conclude that the standard represented an unrealistic goal, and that failure to meet the goal should not be as frustrating. Thus, in this study, falling short of an EPM-regulated work standard by a relatively small margin was perceived as being more stressful than missing the mark by a wide margin.

Further research should be pursued to determine whether these results would prevail under conditions in which low performance has additional negative consequences, such as pay cuts or threats of job loss. It is possible that under such circumstances, time urgency stress and workload dissatisfaction would be accompanied by other mood disturbances, such as tension and irritation.

With respect to musculoskeletal discomfort, higher increases in right-hand and right-shoulder discomfort under EPM work management were evident only in the moderate-performance group. Thus, in this study, musculoskeletal discomfort effects under EPM work management occurred only when the shortfall in performance was relatively close to the standard (i.e., moderate-performance group). Participants who either exceeded the standard (i.e., high-performance

group) or fell far below the work standard (i.e., low-performance group) did not experience increased musculoskeletal discomfort under EPM.

There were no musculoskeletal discomfort effects under EPM work management in the high-performance group, despite the fact that the mean keystroke production rates in this group ($M_{High} = 215$) were considerably higher than the mean keystroke production rates in the moderate-performance group ($M_{Moderate} = 184$). It is also interesting to note that under EPM work management in the moderate-performance group, increases in right-hand discomfort and right-shoulder discomfort corresponded with increases in irritation, perceived time pressure, and tension. Taken together, these findings suggest that psychological stress reactions to negative performance feedback in the moderate-performance group may have been more important in promoting musculoskeletal discomfort under EPM work management than the physical work load of the task (i.e., the rate of keystroke repetition).

CONCLUSIONS

The results of this study indicate that the psychological and musculoskeletal stress effects of EPM work management vary with data-entry performance level. Workers who fell below an EPM-enforced performance standard experienced more mood disturbance and musculoskeletal discomfort effects than workers who exceeded the performance standard. Moreover, the stress effects of EPM work management were more evident when the shortfall in performance was relatively small than when performance was far below the standard.

Right-hand and right-shoulder discomfort were associated with irritation, tension, and time pressure, but were independent of keystroke production rates. These findings suggest that, at least for repetitive data-entry tasks, the psychological effects of negative performance feedback under EPM work management may be more important than the actual physical task demands imposed by the performance standard. Such a possibility merits further investigation, as it may lend empirical support to the hypothesis that psychological stress can be a contributing factor in the etiology of musculoskeletal disorders. In this regard, it would be useful to replicate this study under actual workplace conditions, as opposed to the simulated conditions in the laboratory, in which mood disturbance and musculoskeletal effects are, perhaps, amplified by the real consequences of not meeting performance standards.

With respect to the practical implications of the study findings, it appears that EPM work management should be employed with performance standards that do not exceed workers' resources or capacities. Employers should take steps to ensure that the workers perceive the performance standards to be fair; that is, there should be a balance between the employers' production requirements and the employees' skills and abilities. This will help to minimize the possibility of repeated negative performance feedback as a result of failure to meet EPM

enforced standards and the associated adverse mood and musculoskeletal effects.

This study represents one of the first efforts to evaluate the stress effects of EPM work management under controlled conditions. The findings presented in this article are consistent with the premise advanced by Schleifer and Shell (1992) that stress is most likely to occur when this approach to work management is used to enforce compliance with performance standards that workers have difficulty meeting (Schleifer & Shell, 1992).

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