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## A field study of supplementary rest breaks for data-entry operators

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Performance.

This study examined the effects of supplementary rest breaks on musculoskeletal discomfort, eyestrain, mood, and performance in data-entry workers. Two rest break schedules were compared in a within-subjects design. Workers alternated between a 'conventional' and a 'supplementary' schedule in 4-week intervals. The conventional schedule contained a 15-min break during the first half of the work shift and a 15-min break during the second half of the shift. The supplementary schedule contained the same two 15-min breaks, and a 5-min break during each hour which otherwise did not contain a break, for a total of 20 extra minutes of break time. Results are based on data from 42 workers. They indicated that discomfort in several areas of the body, and eyestrain, were significantly lower under the supplementary than under the conventional schedule. While symptoms increased from pre- to post-work periods under both schedules, the magnitude of the increases was significantly less under the supplementary schedule. In addition, increases in discomfort of the right forearm, wrist and hand over the course of the work week under the conventional schedule were eliminated under the supplementary schedule. These beneficial effects were obtained without reductions in data-entry performance.

### 1. Introduction

#### 1.1. Data entry

Data entry and other computer-intensive tasks entail prolonged viewing of visual display terminals (VDTs) and repetitive movements of the fingers, hands and wrists while maintaining postures requiring static muscle contractions in the neck, shoulders, back and arms. It has been well documented that these working conditions produce musculoskeletal discomfort, symptoms of eyestrain, and other symptoms of stress such as fatigue and mood disturbances (Dainoff *et al.* 1981, Hunting *et al.* 1981, Smith *et al.* 1981, Sauter *et al.* 1983, Murata *et al.* 1991, Carter and Banister 1994, Schleifer *et al.* 1995, 1996, Anshel 1998). Body parts that are most frequently reported to experience discomfort, and which tend to receive high

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discomfort ratings relative to other body parts, include the neck, shoulders, and back, and to a lesser extent the upper extremities (Hunting *et al.* 1981, Smith *et al.* 1981, Arndt 1983, Grandjean *et al.* 1983, Kukkonen *et al.* 1983, Sauter *et al.* 1984, Zwahlen *et al.* 1984, Bendix *et al.* 1985, Evans 1985, Scalet 1987, Bodek 1990, Sauter *et al.* 1991, Bergqvist *et al.* 1995a,b).

### 1.2. *Ergonomics interventions*

In many cases, efforts to ergonomically optimize workstation design features to reduce musculoskeletal and eye discomfort effects have been beneficial (Sauter *et al.* 1990, 1991). However, workstation redesign does not appear to be sufficient for completely eliminating work-induced discomfort, and in some cases, discomfort has been virtually unaffected by ergonomics interventions. For example, compared to discomfort in the upper and lower extremities, discomfort in the neck and shoulders has been shown to be particularly impervious to ergonomic/workstation improvements (Oxenburgh 1984, Winkel and Oxenburgh 1990, Sauter *et al.* 1991). Neck and shoulder discomfort associated with VDT work has been attributed to prolonged muscle tension from static contractions of the neck and shoulder muscles (Waris 1979, Hagberg 1983). Winkel and Oxenburgh (1990) noted that since constrained shoulder/neck postures are inherently characteristic of VDT work, prolonged static contractions in these muscles are probably not preventable through workstation design changes. They suggested the possibility that neck and shoulder discomfort in VDT work might be relieved only by changes in work organization such as task rotation or increased rest breaks, which allow for periodic interruptions of the VDT task (Winkel and Oxenburgh 1990).

### 1.3. *Discomfort: work duration and rest breaks*

Clearly, a primary determinant of discomfort in VDT workers is the amount of time spent engaged in continuous VDT work. Several studies have demonstrated a positive relation between the amount of exposure to VDT/keyboard work and the severity of discomfort symptoms reported by workers (Smith *et al.* 1981, Bergqvist 1984, Oxenburgh 1984, Bendix *et al.* 1985, Evans 1985, Lueder 1986, Ignatius *et al.* 1993). Similarly, correlational studies have indicated that the risk of musculoskeletal discomfort is increased in VDT workers who have limited rest break opportunities (Bergqvist *et al.* 1995a,b). Controlled studies have demonstrated that musculoskeletal discomfort and muscle tension are reduced immediately following rest breaks (Zwahlen *et al.* 1984, Sundelin *et al.* 1986, Sundelin and Hagberg 1989). Rest breaks, particularly those which include standing and walking, can provide relief from all of the physical sources of strain imposed by VDT work (e.g. intervertebral disc pressure; static muscle fatigue from constrained and awkward postures; dynamic muscle fatigue from repetitive motions; inflammation in tendons, nerves and muscles; reduced blood circulation) (Carter and Banister 1994).

In most work settings, the rest break schedule typically assigned for full-time data entry is one 15-min break during each half of an 8-h work shift. It has been demonstrated, however, that although such conventional breaks reduce discomfort, they are not adequate for preventing cumulative increases in discomfort over time (Zwahlen *et al.* 1984, Schleifer and Amick 1989, Thompson 1990). In a controlled study reported by Sauter and Swanson (1992), it was found that in comparison to a conventional rest break schedule, more marked reductions in discomfort can be achieved by providing frequent, brief breaks distributed throughout the work shift.

In another controlled study, musculoskeletal discomfort was significantly reduced by providing additional break time to supplement workers' spontaneous rest pauses (Henning *et al.* 1993). Musculoskeletal discomfort and eyestrain symptoms were also reduced in field studies employing supplementary rest break interventions for data-entry workers, although the effects of the rest breaks could not be isolated from those of workstation changes that were implemented during the same time periods (Ong 1984, 1990).

#### 1.4. *Performance: work duration and rest breaks*

Prolonged periods of data-entry work are characterized not only by increases in fatigue and discomfort, but also by decrements in performance over time during work periods (Floru *et al.* 1985, Floru and Cail 1987, Henning *et al.* 1989, Gao *et al.* 1990, Galinsky *et al.* 1995). Gao *et al.* (1990) observed performance decrements within 50 to 60 min after initiation of data-entry work, which were associated with decrements in fatigue measures such as critical flicker fusion frequency, reaction time, and hand steadiness. Accordingly, they suggested that a rest break should be given after 40–50 min of VDT work. Floru and Cail (1987) obtained similar time-based decrements in performance as well as in the  $\beta$  index of the electroencephalogram, which was used as a measure of psychophysiological arousal. They demonstrated that arousal and performance decrements can be reversed by providing a rest break after 40 min of data entry. Sauter and Swanson (1992) found that declines in performance during work sessions were disrupted periodically by distributing 'minibreaks' (3 min) and 'microbreaks' (30 s) throughout work sessions. In addition, overall keystroke rates averaged across 2 days of testing were higher when distributed breaks as opposed to conventional breaks were provided (Sauter and Swanson 1992). Ong (1984, 1990) observed improvements in data-entry speed and accuracy measured at 1-year and 2-year intervals followed interventions involving both changes in workstation features and the addition of extra rest breaks. As noted by Ong, the performance improvements may have been mediated by increased alertness and decreased fatigue produced by the extra breaks. It was also recognized that the improvements may have been attributable to the ergonomics interventions. In either case, as Ong pointed out, the findings were compelling in that performance improved even though the extra breaks reduced overall working time.

#### 1.5. *The present study*

In 1993, the National Institute for Occupational Safety and Health (NIOSH) received a request from the Internal Revenue Service (IRS) and the National Treasury Employees Union (NTEU) for assistance in evaluating the health and productivity effects of ergonomics/work organization interventions among data-entry employees. This report describes the first in a series of studies conducted for that purpose. In this study, NIOSH, IRS, and NTEU collaborated in the development and evaluation of a 'supplementary rest break strategy' for workers at a document processing centre during the spring and summer of 1994. The conventional schedule, which contained two 15-min breaks per shift, was compared with an alternative schedule in which the two 15-min breaks were supplemented with 5-min breaks provided periodically throughout the work shift. Performance measures and questionnaire ratings of workers' symptoms were obtained as they alternated between the two schedules at 4-week intervals.

## 2. Method

### 2.1. Participants

A total of 101 data-entry operators provided written voluntary, informed consent to participate in the study. Each of them had been hired as a 'seasonal' employee under an agreement that the job was temporary. The time at which each operator was released from employment was determined by the workload demands of the facility. When workload demands decreased, operators demonstrating the lowest performance levels were released. The present study began on 14 March, 2 weeks after the beginning of the 1994 tax filing/processing season (1 March to 1 July). Most of the attrition of participants over the course of the study (38 participants) was due to release from employment and resignations from employment. In addition, questionnaire data from 21 of the 101 volunteers were too incomplete for statistical analyses. An individual's data set was designated as insufficient if more than four consecutive days of questionnaires were missing from the first 8 weeks of the study, or if more than a total of 8 days of questionnaires were missing from any 4-week period. Approximately half of these instances were due to absence from work, and the remainder were due to non-compliance in filling out questionnaires. The resulting sample of data that was sufficient for analyses included 31 women and 11 men, aged 19 to 50 years, with a mean age of 30 years. Their experience in entering data at the document processing centre ranged from 2 to 68 weeks, with a mean of 8 weeks. Data-entry experience from jobs held at other workplaces prior to the current season ranged from 0 to 30 years, with a mean of 3 years.

### 2.2. The data-entry task

The data-entry task entailed keying mostly numeric data from paper tax forms using a standard keyboard with a right-sided numeric keypad. Workstations, aligned in rows of 11, were uniform, with standard-size video display terminals and document holders placed to the left of the terminals. Chair seat pans and back supports were adjustable. Foot rests were used as needed. Many of the operators listened to music through ear phones while performing the data-entry task.

### 2.3. Rest break schedules

The two rest break schedules evaluated in this study are displayed in figure 1. The 'conventional' rest break schedule consisted of one, 15-min break in the middle of the first half of the work shift and one, 15-min break in the middle of the second half of the work shift. The 'supplementary' rest break schedule consisted of the same 15-min breaks, and also included a 5-min break during each hour of the work shift that otherwise did not contain a break. Thus, for an 8-h shift, the supplementary schedule provided four extra 5-min breaks for a total of 20 extra minutes of break time. A 30-min lunch period was provided under each schedule. Each participant kept a copy of his/her current schedule at the workstation. Participants were encouraged to get up and take at least a short walk away from their workstations during each break.

### 2.4. Rest break timers

Small, hand-built electrical timers were attached to the top of each participant's video display terminal. These timers signalled scheduled breaks, enabling participants to consistently take breaks at the proper times without the need to repeatedly

Time (h)	Breaks—Conventional	Breaks—Supplementary
0.0 Start time		
0.5		
1.0		5-minute break
1.5		
2.0	15-minute break	15-minute break
2.5		
3.0		5-minute break
3.5		
4.0	30-minute lunch	30-minute lunch
4.5		
5.0		
5.5		5-minute break
6.0		
6.5	15-minute break	15-minute break
7.0		
7.5		5-minute break
8.0		
8.5 Quit time		

Figure 1. Rest break schedules.

check the clock or their rest break schedules. Each timer was comprised of a metal box containing circuitry pre-programmed to orchestrate either of the two rest break schedules. The outside of the box contained a toggle switch for setting the rest break schedule (conventional or supplementary), a start button, and a small light bulb. Activation of the start button resulted in illumination of the light bulb during the break times specified by the rest break setting. In the event of any timer malfunctions, or when participants forgot to activate their timers, they were able to rely upon their paper schedules to determine when rest breaks should be taken.

### 2.5. *Experimental design*

A within-subjects/repeated measures design was used. This design allowed all of the participants the opportunity to experience supplementary rest breaks. It also made it possible to compare the effects of conventional and supplementary rest breaks in the same individuals, thereby minimizing error variance.

Data were collected between 14 March and 1 July, 1994. The 16-week period was divided into four, 4-week phases in which participants alternated between the Conventional (C) and Supplementary (S) rest break schedules. Half of the volunteers from each shift (day and night) were assigned at random to experience the C-S-C-S order of rest break schedules, and the other half were assigned at random to experience the opposite (S-C-S-C) order. As a result of attrition (due mostly to work releases), data from just the first two phases of the study were sufficient for analyses. The order of rest break schedules for the resulting sample of participants remained relatively balanced for the two phases, with 19 participants who experienced the C-S order, and 23 participants who experienced the S-C order. The time period covering the two phases (14 March–6 May) encompassed the annual peak period of workload for IRS data-entry operators.

### 2.6. *Questionnaires*

An identification number was assigned privately to each participant. These numbers were used as identifiers on questionnaires in order to ensure confidentiality of data, and to encourage complete honesty in making questionnaire responses.

2.6.1. *Feeling state questionnaire:* Participants were instructed to complete what was termed a 'feeling state' questionnaire four times daily (immediately prior to beginning work, immediately prior to lunch, immediately following lunch, and immediately after the end of their work shift). These rating times permitted the assessment of somatic and effective states before and after each half of the work shift, without interrupting the flow of work. Questionnaire items included levels of discomfort in several body regions (left and right forearm, wrist and hand; left and right elbow; left and right shoulder and upper arm; neck; back; buttocks; legs) as well as levels of eye soreness, visual blurring, headache, cheerfulness, energy, tension and fatigue. The items for cheerfulness, energy, tension and fatigue were derived from the Profile of Mood States (POMS; McNair *et al.* 1971). Each rating was made using a 5-point category rating scale in which the whole numbers 1 to 5 indicated ratings of 'none at all', 'a little', 'moderate', 'quite a bit', and 'extreme', respectively.

Participants were instructed to note on the questionnaire any instances in which their feeling state ratings were clearly influenced by extraneous factors unrelated to their data-entry jobs. Examples of such instances include marked changes in discomfort or mood resulting from non-job factors such as playing sports, gardening, accidents, prescription medications, bereavement, etc. Each instance was marked as a missing value in the data set.

2.6.2. *Rest break questionnaire:* Another questionnaire was used by participants to report the number and duration of actual breaks taken. In order to minimize paperwork, they were asked to complete this questionnaire after each break on only two days per week (Tuesdays and Thursdays). An electronic message board in the work area was used to remind participants to fill out the rest break questionnaire on these days. In order to optimize the accuracy of their responses, they were instructed

to use the clock in the work area to determine the duration of each break, and to record the duration to the nearest minute on the questionnaire immediately after the break. These twice-weekly questionnaires were expected to provide an adequate sample of data for estimating participants' self-reported compliance with the assigned rest break schedules.

**2.6.3. Instructions:** Participants were instructed to follow the assigned rest break schedules as closely as possible. They were also told, however, that it was reasonable to expect that complete compliance to the exact schedules would not always be possible, so they should be sure to accurately fill out their rest break questionnaires. Participants were also instructed to make feeling state questionnaire responses only at designated rating times. They were told that if they realized that they had forgotten to make responses from previous rating times, they should leave them blank rather than try to recall from memory.

### 2.7. Data-entry performance measures

Measures of the study participants' data-entry performance were obtained from agency records.

**2.7.1. Productivity:** One measure of productivity, 'keystrokes per hour', was computed separately for each type of tax form entered by each participant on each work day, and then averaged across tax forms to produce a summary measure for each participant on each day of the study. This measure permitted an objective assessment of one aspect of productivity—data-entry speed—which is independent of other factors such as the length of tax documents and the number of hours worked per day. Another measure of productivity used in this study was the 'total number of documents' entered by each participant on each day of the study. This measure, which is affected by factors such as the length of tax documents entered and the number of hours worked per day, permitted an assessment of 'work output'.

**2.7.2. Accuracy:** Two measures of data-entry accuracy were used for this study. One was the number of errors made per day by each participant. The other was a daily measure of accuracy percentage, which takes into account the number of documents entered per day. It was computed as:

$$\text{Accuracy per day} = \frac{\text{Documents per day} - \text{Documents in error per day}}{\text{Documents per day}}$$

## 3. Results

### 3.1. Reported number and duration of rest breaks

Rest break questionnaires were examined to determine the average number and duration of breaks reported by participants while working under each rest break schedule. The distributions for these measures contained some extreme scores (e.g. breaks lasting 1–2 h, which were possibly used for meetings or training sessions, personal time, etc.). Thus, medians and modes, rather than means, were used to most accurately depict the average number and duration of breaks taken by participants under each schedule. These measures are displayed in table 1.

Table 1. Number and duration of breaks reported by participants under each rest break schedule.

	Median number of breaks reported per day	Modal number of breaks reported per day	Median duration reported per break	Modal duration reported per break	Second most frequent duration reported per break	Median total break duration reported per day	Modal total break duration reported per day
Conventional rest break schedule	3 breaks	2 breaks	15 min	15 min	5 min	35 min	30 min
Supplementary rest break schedule	6 breaks	6 breaks	5 min	5 min	15 min	50 min	50 min

Table 2. *F* statistics for significant main effects of rest break schedule.

Item rated	Neck discomfort	Right forearm, wrist, and hand discomfort	Right shoulder and upper arm discomfort	Right elbow discomfort	Buttocks discomfort	Left shoulder and upper arm discomfort	Right elbow discomfort	Left elbow discomfort	Eye soreness
<i>F</i> (df= 1,40)	20.65	10.20	6.04	6.60	7.70	7.90	11.7	6.64	6.09
<i>p</i> <	0.0002	0.004	0.02	0.01	0.009	0.009	0.002	0.02	0.03

3.1.1. *Conventional schedule:* It can be seen in the table that the modal number of breaks reported per day under the conventional schedule was two, signifying that on most days participants took only two breaks as assigned. However, the median number of breaks reported was three, indicating that participants took an average of one extra break per day under the conventional schedule. Both the median and modal duration per break reported under the conventional schedule were equal to the assigned 15 min, and the modal total duration of breaks reported per day was the assigned 30 min. However, the second most frequent duration reported for breaks was 5 min, and the median total duration of breaks reported per day was 35 min. These results suggest that typically when an extra break was taken under the conventional schedule, it lasted an average of 5 min. Interviews with participants and managers after the study was concluded indicated that this pattern of breaks had been typical under the conventional schedule, prior to the beginning of the study.

3.1.2. *Supplementary schedule:* The data in table 1 indicate that participants complied closely with the supplementary rest break schedule. As assigned under that schedule, they reported taking an average of 6 breaks per day, with the majority of the breaks lasting 5 min and the next most frequently reported breaks lasting 15 min. Both the median and modal total duration of breaks reported per day were equal to the assigned 50 min (i.e. two, 15-min breaks plus four, 5-min breaks).

### 3.2. *Feeling state questionnaire ratings*

As noted previously, participants spent 4 weeks working under either the conventional or supplementary rest break schedule and then switched to the opposite schedule for a further 4 weeks. Data from the first 2 weeks of each 4-week phase were excluded from analyses of the feeling state questionnaire items. This was done to ensure that responses would reflect how the participants felt after they had been experiencing each rest break schedule long enough for its effects to be sufficiently manifested. Exclusion of the first 2 weeks of data from each phase also served to minimize the potential influence of carry-over effects and 'Hawthorne effects'. Mixed Design Multivariate Analyses of Variance (MANOVAs) were performed on participants' ratings for each item of the feeling state questionnaire. Missing ratings were predicted using multiple regression. Only a small percentage of data (approximately 4% of the total, distributed randomly across participants and conditions) was estimated in this way. Each MANOVA examined the effects of four within-subjects factors, including rest break schedule (conventional, supplementary), week (3, 4), day (Monday–Friday), and rating time (before shift, before lunch, after lunch, after shift). The one between-subjects factor was shift (day and evening). Tests for significant outcomes were limited to the main effects of rest break schedule and first-order interactions between rest break schedule and other variables.

A significant main effect of rest break schedule was detected for several questionnaire ratings. These effects are listed with their corresponding *F* statistics in table 2, and are illustrated graphically in figure 2. As shown in figure 2, ratings for these measures indicated significantly lower discomfort levels when participants worked under the supplementary schedule than when they worked under the conventional schedule.

As shown in table 3, results of the analysis also included significant rest break schedule  $\times$  rating time interactions for several questionnaire ratings. The interactions

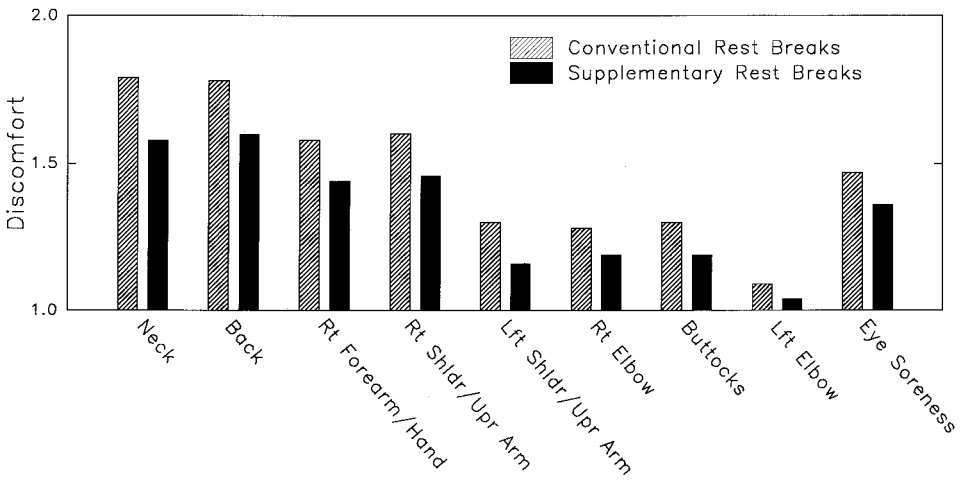


Figure 2. Significant main effects of rest break schedule on ratings of musculoskeletal discomfort and eyestrain (1 = none at all, 2 = a little, 3 = moderate, 4 = quite a bit, and 5 = extreme).

are displayed in figure 3, where mean ratings of musculoskeletal discomfort, eye soreness and visual blurring are plotted as a function of rating time for the two rest break schedules. Under both rest break schedules, ratings increased over the pre-lunch and post-lunch segments of the work shift, with some recovery afforded by the 30-min lunch break. Although musculoskeletal discomfort and visual symptoms increased during work under both schedules, the increases were larger under the conventional as compared to the supplementary schedule.

The remaining effect detected by the analysis consisted of a significant rest break schedule  $\times$  weekday interaction on ratings of discomfort in the right forearm, wrist and hand,  $F(4, 37) = 4.43$ ,  $p < 0.006$ . The interaction is displayed in figure 4, where mean discomfort ratings are plotted as a function of weekday for each rest break schedule. As shown, discomfort in the right forearm, wrist and hand was similar under the two schedules at the beginning of the work week. From Tuesday to Friday, however, discomfort ratings were higher under the conventional schedule than under the supplementary schedule, with slight changes from day-to-day that were relatively parallel under the two conditions. The significant interaction clearly stems from the increase in discomfort after the first day of the work week which occurred under the conventional schedule, but not under the supplementary schedule.

### 3.3. Data-entry productivity

Using records compiled by the data-entry centre, data-entry productivity was examined in the same manner as described for analyses of questionnaire ratings. In addition to the factors included in the MANOVAs for questionnaire ratings, the amount of time spent working at the data-entry centre, measured in weeks, was included in the analyses of productivity data. Dependent variables included the mean keystroke rate and the total number of documents entered by each participant on each day of the 8-week period. Means for these measures were

Table 3. *F* statistics for significant interactions between rest break schedule and rating time.

Item rated	Neck discomfort	Back discomfort	Right forearm, wrist, and hand discomfort	Right shoulder and upper arm discomfort	left shoulder and upper arm discomfort	Right elbow discomfort	Buttocks discomfort	Legs discomfort	Left elbow discomfort	Eye soreness	Visual blurring
<i>F</i> (df= 1,38)	6.69	3.22	3.76	3.78	3.66	6.38	5.38	4.71	2.97	4.23	2.98
<i>p</i> <	0.002	0.04	0.03	0.02	0.03	0.002	0.004	0.008	0.05	0.02	0.05

computed across participants and averaged for the 4-week period spent working under each rest break schedule. The mean number of keystrokes per hour was somewhat higher under the supplementary (8591) as compared to the conventional (7931) rest break schedule. The mean number of documents entered per day was somewhat lower under the supplementary (273) as compared to the conventional (286) rest break schedule. Results of the MANOVAs, however, indicated that the effect of rest break schedule was not significant for either measure,  $F(1, 40) = 0.43, p > 0.05$  for keystrokes per hour and  $F(1, 40) = 1.46, p > 0.05$  for documents per day.

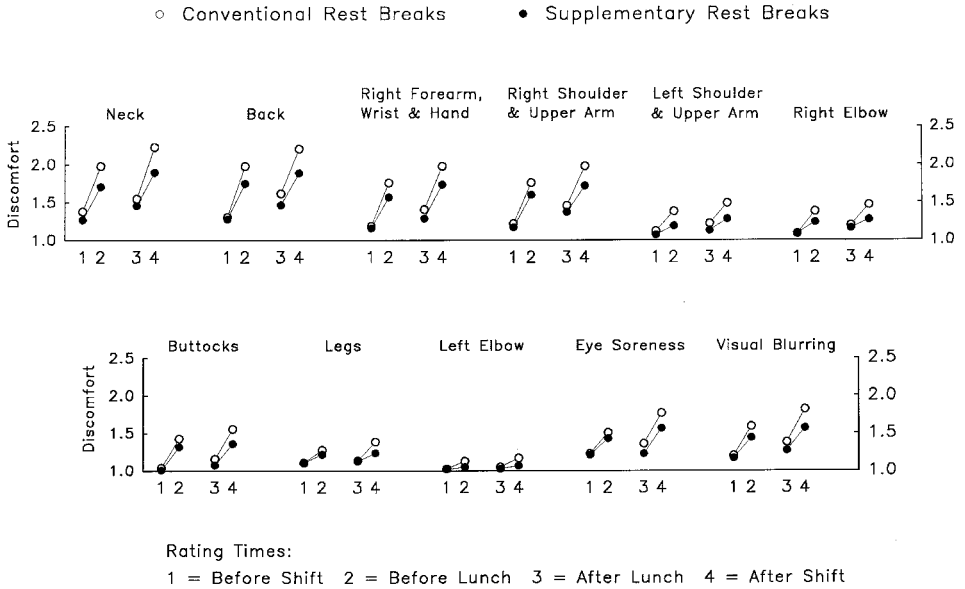


Figure 3. Significant rest break schedule  $\times$  rating time interactions on ratings of musculoskeletal discomfort and eyestrain (1= none at all, 2= a little, 3= moderate, 4= quite a bit, and 5= extreme).

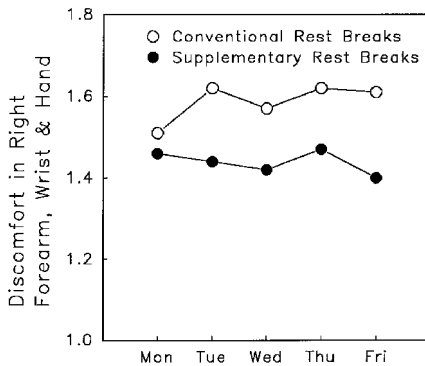


Figure 4. Significant rest break schedule  $\times$  weekday interaction on right hand/arm discomfort (1= none at all, 2= a little, 3= moderate, 4= quite a bit, and 5= extreme).

The only significant effects revealed by the analyses of productivity data were the main effects of day,  $F(4, 37) = 4.01$ ,  $p < 0.008$ , and week,  $F(3, 38) = 19.79$ ,  $p < 0.0001$ , on keystrokes per hour. As shown in table 4, mean keystroke rate increased from day-to-day during the work weeks, and also increased from week-to-week as the study progressed. These effects, most likely attributable to practice, were not influenced by changes in rest break schedule.

### 3.4. Data-entry accuracy

Records of data-entry accuracy during the first 4 weeks of the study were not available. Remaining available data indicated that participants' accuracy was essentially equal under the conventional and supplementary rest break schedules. Specifically, the mean number of errors per day was 14.5 under the conventional schedule, and 13.5 under the supplementary schedule. The mean level of accuracy per day, based upon the number of documents entered per day and the number of documents containing  $\geq 1$  error per day, was identical (97%) under the two schedules.

## 4. Discussion

### 4.1. Discomfort levels and effect sizes

In the present study, body regions that received the highest discomfort ratings included the neck and back as well as the right shoulder and upper extremities. This pattern of discomfort is characteristic of VDT work (Arndt 1983), particularly for a right-handed data-entry task (Ong 1984, Sauter *et al.* 1991).

The scale used by participants to rate their levels of discomfort and other feeling states contained five intensity levels. In general, ratings encompassed the full range of intensities, typically indicating no discomfort at the beginning of the work shift and then increasing from the beginning to the end of each work period, sometimes to the highest level of 'extreme discomfort'. Nevertheless, as expected, overall mean ratings of discomfort were relatively low, and mean changes in ratings produced by statistically significant rest break effects and interactions were small. These outcomes are consistent with prior research (Winkel and Oxenburgh 1990, Waersted *et al.* 1991, Sauter and Swanson 1992, Henning *et al.* 1993, Swanson and Sauter 1993, Schleifer *et al.* 1995, 1996, Henning *et al.* 1997). However, the importance of what appear to be modest effects should not be under-emphasized. Theories of cumulative trauma propose that chronic disorders result from the cumulative effects of repeated 'microtraumas' manifested as small-to-moderate increments in discomfort during work (Hagberg 1987, Putz-Anderson 1988, Carter and Banister 1994).

Table 4. Significant (a) day-to-day, and (b) week-to-week increases in data-entry speed.

Weekday	Monday	Tuesday	Wednesday	Thursday	Friday
Keystrokes/hour	8162	8206	8247	8323	8367

Week	1	2	3	4
Keystrokes/hour	7926	8166	8427	8525

#### 4.2. *The impact of supplementary breaks on symptom ratings*

The results of this study indicate that providing 5-min hourly breaks to supplement conventional 15-min mid-work-period breaks effectively reduced musculoskeletal discomfort in data-entry operators. Accumulation of discomfort in several body parts was significantly attenuated by providing frequent opportunities to recover from the fatigue imposed by static postures and repetitive motions during periods of work. It is particularly noteworthy that supplementary rest breaks reduced discomfort in the neck and shoulders, as these body parts have not appeared to benefit in previous studies utilizing workstation design interventions (Oxenburgh 1984, Winkel and Oxenburgh 1990, Sauter *et al.* 1991). The present findings confirm the prediction of Winkel and Oxenburgh that a supplementary rest break strategy could serve as an appropriate and effective approach for reducing neck and shoulder discomfort in VDT work.

It was also found that small day-to-day increases in discomfort in the right forearm, wrist and hand during the work weeks under the conventional schedule were significantly offset by providing supplementary rest breaks. Taken together, the outcomes for musculoskeletal discomfort ratings in the present study add to a growing body of evidence indicating that musculoskeletal discomfort produced during VDT work is alleviated by rest breaks (Zwahlen *et al.* 1984, Sundelin *et al.* 1986, Sundelin and Hagberg 1989), and that the alleviatory effects can be enhanced by providing supplementary breaks (Sauter and Swanson 1992, Henning *et al.* 1993).

In addition to their positive effects on ratings of musculoskeletal discomfort, supplementary rest breaks also led to decreased levels of eye soreness and visual blurring. Similar findings were reported by Ong (1984, 1990), who observed that symptoms of eyestrain in data-entry operators were abated following rest break interventions, although the effects could have been at least partially due to workstation changes implemented during the same periods of time. Thus, to our knowledge the present report describes the first controlled study to demonstrate beneficial effects of supplementary rest breaks on eye comfort and function.

#### 4.3. *Performance*

Taken together, the few studies that have examined the effects of supplementary rest breaks have obtained inconsistent results for performance. Unlike the results of Ong (1984, 1990) and Sauter and Swanson (1992), who found that overall improvements in data-entry performance occurred with supplementary rest breaks, no performance effects were detected by Henning *et al.* (1993) nor in the present study. Since the present data consisted of daily summary measures, it was not possible to determine if performance decrements occurred during work sessions, or if any such decrements were offset by additional rest breaks as in the studies by Floru and Cail (1987) and by Sauter and Swanson (1992).

The finding that neither the mean data-entry speed nor the mean document output were significantly influenced by the addition of supplementary rest breaks in this study appears to be somewhat puzzling. One would expect that if the speed of data-entry under the two schedules were equal, then total document output would be lower under the supplementary schedule, since study participants spent less total time performing the data-entry task under that schedule. Inspection of the data indicates that the mean keystroke rate was actually higher (although not

significantly) under the supplementary schedule than under the conventional schedule. It is possible that were it not for that increment in keystroke rate, total document output may have been significantly reduced under the supplementary schedule.

In light of the foregoing considerations, it is important to emphasize that the supplementary rest break schedule did not have any negative impact on worker performance. Furthermore, interviews with worksite managers indicated that no disruption of work processes were associated with the supplementary rest break schedule nor with the study in general, and all of the productivity goals ('program completion dates') were met on schedule throughout the duration of the study.

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