

Supplementary Breaks and Stretching Exercises for Data Entry Operators: A Follow-Up Field Study

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Background This study expanded previous NIOSH-IRS research examining the effects of rest breaks and stretching exercises on symptoms and performance in data-entry workers.

Methods All workers spent 4 weeks with conventional breaks (two 15 min breaks per day) and 4 weeks with supplementary breaks (two 15 min breaks plus four 5 min breaks per day). One-half were assigned at random to a group instructed to perform brief stretching exercises during breaks. The remainder comprised the “no stretching” (control) group.

Results 51 workers (stretch group $n = 21$; no stretch group $n = 30$) completed the study symptom questionnaires. Discomfort and eyestrain were significantly lower with supplementary breaks, and supplementary breaks attenuated accumulation of discomfort and eyestrain during work sessions. Data-entry speed was significantly faster with supplementary breaks so that work output was maintained, despite replacing 20 min of work time with break time. In the stretch group, workers reported stretching during only 25% of conventional breaks and 39% of supplementary breaks, and no significant effects of stretching on discomfort or performance were observed.

Conclusions These results provide further converging evidence that supplementary breaks reliably minimize discomfort and eyestrain without impairing productivity. Low compliance in performing stretches prevented valid assessment of stretching effects. Further research on stretching exercises and exercise compliance is warranted. *Am. J. Ind. Med.* 50:519–527, 2007. Published 2007 Wiley-Liss, Inc.[†]

KEY WORDS: rest breaks; computers; stretching exercises; musculoskeletal discomfort; eyestrain; fatigue; productivity

INTRODUCTION

Computer-Intensive Work

Extensive use of computers increases the risk of developing several types of symptoms, including musculoske-

letal discomfort, fatigue, eyestrain, and mood disturbances [Carter and Banister, 1994; Schleifer et al., 1996; Anshel, 1998; Lim et al., 1998; Nainzadeh et al., 1999]. Growing concerns regarding disabling upper-extremity injuries from computer-intensive work have been well-publicized [USA Today, 2001], however, symptoms in the neck, shoulders, back and eyes are more prevalent. Matias et al. [1998] cited an 8–38% incidence and predicted a 40% probability of wrist injuries in computer workers. Nainzadeh et al. [1999] reported an 80% prevalence of tension neck syndrome in computer (office) workers. Visual symptoms occur in 50–90% of computer workers [Anshel, 1998; Lim et al., 1998]. The prevalence and severity of symptoms are significantly correlated with the amount of time spent performing computer tasks [Bergqvist, 1984; Rossignol et al., 1987; Burt et al., 1990; Bergqvist and Knave, 1994; Faucett, 1994; Punnet and Bergqvist, 1997; Matias and Salvendy, 1998; Matias et al., 1998].

The conclusions in this report are those of the authors and do not necessarily represent the views of the National Institute for Occupational Safety and Health or the Internal Revenue Service.

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Rest Breaks

Restriction of rest break opportunities during computer work has been identified as a significant risk factor for musculoskeletal symptoms and injuries [Bergqvist et al., 1995a,b; Ferreira et al., 1997]. By contrast, muscle tension and discomfort are reduced [Zwahlen et al., 1984; Sundelin et al., 1986; Sundelin and Hagberg, 1989], and psychophysiological arousal is increased [Floru and Cail, 1987], immediately following rest breaks. Research addressing rest break frequency has evaluated various schedules with breaks ranging from 10 s “micro-breaks” every 6 min to 15 min breaks every 2 hr. Most of these evaluations have demonstrated that rest break-induced reductions in discomfort, eyestrain, fatigue and mood disturbances can be augmented by increasing the frequency of rest breaks [Sauter and Swanson, 1992; Henning et al., 1993; Boucsein and Thum, 1997; Galinsky et al., 2000; McLean et al., 2001; Balci and Aghazadeh, 2003, 2004]. In some studies, increases in rest break frequency have produced improvements in computer workers’ keying speed and/or accuracy [Floru and Cail, 1987; Sauter and Swanson, 1992; Kopardekar and Mital, 1994; Balci and Aghazadeh, 2003, 2004]. In other studies performance was not significantly affected by increased rest break frequency [Henning et al., 1997; Galinsky et al., 2000; McLean et al., 2001; van den Heuvel et al., 2003]. The latter results are noteworthy, however, in that increased break frequency did not impair productivity, in spite of the reductions in work time necessitated by the extra breaks.

Stretching Exercises

In addition to frequent rest breaks, exercise has also been recommended as an intervention for computer workers. It has been noted that brief stretching exercises are more likely to be accepted in Western workplaces, as compared to “group calisthenics” such as those that have been used in some Japanese workplaces [Carter and Banister, 1994]. Potential physiological benefits of stretching exercises include reduced intervertebral disc pressure, increased blood circulation, reduced lactic acid in muscles, and increased psychophysiological arousal and alertness [Thompson, 1990; Carter and Banister, 1994]. It is reasonable to expect that such effects could lead to reductions in perceived discomfort and improvements in performance.

Results of studies examining effects of stretching exercises for computer workers have been inconsistent and somewhat difficult to interpret due to methodological issues. Thompson [1990] reported a case study in which data-entry operators were provided training and paid work time to do stretching exercises, and were encouraged to do the stretches periodically throughout each day, both at work

and at home. Reductions in the number of worker’s compensation claims and increased data-entry productivity were observed in the year following introduction of the stretching program, although statistical tests to confirm significance were not reported. Fenety and Walker [2002] found significant short-term reductions in musculoskeletal discomfort and postural immobility after implementing a 5-day program in which computer workers were prompted to do brief stretching exercises every 30 min during work. Feuerstein et al. [2004] implemented an intervention for office personnel with work-related upper extremity symptoms which included workstation adjustments and information on stretching exercises. Compared to pre-intervention measures, they found significant decreases in symptoms and functional limitations at both 3-month and 12-month post-intervention follow-ups. While these three studies have encouraging implications for the benefits of stretching exercises, alternative explanations for the observed improvements are possible. Since control groups could not be utilized, it is not possible to rule out positive effects due to other factors, such as the workstation adjustments in the Feuerstein et al. study, or other unidentifiable changes that may have occurred during the intervention periods.

Using a brief testing protocol lasting 150 min, Balci and Aghazadeh [2004] measured perceived discomfort, electromyographic changes in muscle load, and performance under three different schedules of breaks, all of which involved stretching exercises. They found that musculoskeletal discomfort, eyestrain, and shoulder (trapezius) tension were significantly lower, and performance was significantly higher, when “micro” stretching breaks occurred every 15 min as compared to when longer, less frequent stretching breaks were provided. Since the breaks in all three schedules contained stretching exercises, it was not possible to compare the effects of stretching breaks to the effects of rest breaks without stretches. Thus, the positive effects may have been attributable to the rest breaks themselves rather than to the stretching activities which occurred during the breaks.

Swanson and Sauter [1993] conducted a 2-day laboratory study to compare discomfort, mood, and performance of data-entry operators under two frequent rest break conditions—one containing breaks without exercises and one containing breaks which included stretching exercises. Neither discomfort nor mood nor overall performance differed significantly between the two conditions, however, keystroke decrements during work periods were significantly less pronounced when the breaks included stretching exercises.

Henning et al. [1997] conducted field studies of computer workers at two sites for a 9-week period to examine the effects of frequent breaks, both with and without stretching exercises. At one of the worksites, neither break

frequency nor stretching exercises significantly affected discomfort, mood or performance. At the other worksite, discomfort in the eyes, legs and feet were significantly lower, and productivity was significantly higher, when the breaks included stretching exercises. Due to sample size limitations in this study, however, a within subjects design without controls for time/order effects was used, with the stretching exercise period following the no stretching exercise period for all participants. Thus, it is possible that the observed comfort and performance improvements would have occurred over time even without the implementation of stretching exercises.

Van den Heuvel et al. [2003] conducted an 8-week field study to compare symptoms, sick leave, and performance among three groups of symptomatic workers—a control group, an intervention group prompted to take frequent breaks, and an intervention group prompted to take frequent breaks which included stretching exercises. Productivity was significantly higher in the intervention groups as compared to the control group, but no significant differences in productivity were observed between the “frequent breaks” and the “frequent stretch breaks” groups. No significant effects on workers’ ratings of symptom frequency, symptom severity, nor sick leave were found. However, in both intervention groups, significantly more workers reported feeling that they had recovered from their disorders than in the control group. A similar outcome was reported by Silverstein et al. [1988], who found that a high percentage of assembly workers reported feeling better after participating in an exercise program, despite a lack of significant reductions in actual symptom ratings.

A Follow-Up Study

The subject of the current article is a study that was conducted as a replication and an extension of a previous field study of supplementary rest breaks for data-entry operators at the Internal Revenue Service (IRS) [Galinsky et al., 2000]. The original study took place during an 8-week period at the IRS Service Center in Austin, Texas, and the study reported here took place the following year during an 8-week period at the IRS Service Center in Cincinnati, Ohio. In the first study, supplementary breaks produced small but significant reductions in discomfort and eyestrain, and productivity levels were maintained in spite of the extra breaks. The first purpose of the follow-up study was to assess the robustness of those positive effects by evaluating supplementary rest breaks at a separate, geographically distant IRS service center. The second purpose of the follow-up study was to determine if symptoms and performance would differ significantly for workers performing stretching exercises during breaks as compared to workers taking breaks without stretching exercises.

METHODS

Study Participants

Participants were seasonal employees hired on a temporary basis to process income tax forms at the Cincinnati IRS Service Center. The study sample was recruited from one area of the center containing workstations for 101 individuals, 90 of whom volunteered to follow the study protocol, which included filling out daily questionnaires for 8 weeks. Twenty seven of those workers were released from employment or resigned before the study was completed. Questionnaire data from 12 of the remaining participants were too incomplete for statistical analyses. An individual’s data set was deemed incomplete if more than 4 consecutive days of questionnaires were missing, or if more than a total of 8 days of questionnaires were missing from either the first or second 4-week period of the study. The resulting sample of data available for analyses included 47 women and 4 men, aged 23–60 years, with a mean age of 36 years. Data-entry experience ranged from 1 month to 24 years, with a mean of 6 years.

Rest Break Schedules

The two rest break schedules used in this study were identical to those used in the preceding study [Galinsky et al., 2000]. The “conventional” break schedule included 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” break schedule included those 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. For each 8 hr shift, the supplementary schedule provided four extra 5 min breaks for a total of 20 extra minutes of break time. Under each schedule, a 30 min lunch period, additional to the 8 hr of work and break time, occurred in the middle of the shift.

Stretching Exercises

The stretching exercises used in this study were selected based on information from Lee et al. [1992], who conducted a comprehensive review of numerous exercises to assess their suitability for VDT workplaces. A set of nine exercises, all of which satisfied biomechanical criteria for safety and practical criteria for minimal work disruption and conspicuity, were chosen. They included brief stretches targeting the neck, shoulders, back, and upper extremities, and required no more than a total of 2 min to perform.

Experimental Design

This study employed a mixed design with stretching exercise condition as a between subjects factor and rest break

schedule as a within subjects factor. Half of the 90 volunteers were assigned at random to the Stretching Exercise condition and half were assigned to the No Stretching Exercise condition. The 8-week study period was divided into two 4-week phases in which all participants alternated between the Conventional and Supplementary rest break schedules. Approximately half (23) of the volunteers in each exercise condition were assigned at random to work for 4 weeks under the Conventional schedule and then switch to the Supplementary schedule for the second 4-week phase. The remaining 22 volunteers in each exercise condition were assigned at random to experience the opposite sequence of rest break conditions. As described above under “Study Participants,” data from 51 of the original 90 volunteers were sufficient for analyses, following attrition due mainly to work releases and partially to noncompliance in filling out questionnaires. Table I shows how the remaining participants were distributed between the two exercise conditions and the two break schedule sequences. Results of a chi square test indicate that attrition was independent of exercise condition, that is, the loss of participants in the exercise group was not significantly greater than that in the no exercise group, $\chi^2(1, n = 90) = 3.66, P > 0.05$.

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.

Feeling state questionnaire

As in the preceding study, 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. Participants used this questionnaire to rate their levels of musculoskeletal discomfort, eye soreness and visual blurring, headache, cheerfulness, energy, tension and fatigue. Musculoskeletal discomfort ratings were made for several parts of the body, including the neck, shoulders, upper arms, elbows, forearms, wrists, hands, back, buttocks, and legs. The items for cheerfulness, energy, tension, and fatigue were derived from

the Profile of Mood States [POMS; McNair et al., 1971]. Responses to each questionnaire item were made using a 5-point category rating scale in which the whole numbers 1–5 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 ratings were clearly influenced by extraneous factors unrelated to their data entry jobs, such as playing sports, gardening, accidents, prescription medications, bereavement, etc. When processing the questionnaires for data analyses, responses associated with such instances were recorded as missing values in the data set.

Break activities questionnaire

A break activities questionnaire was administered twice weekly in order to assess participants’ self-reported compliance with the rest break schedules and exercise conditions assigned for the study. Participants were asked to use this questionnaire each Tuesday and Thursday to record break times, durations, and activities.

Instructions

Prior to the beginning of the study, participants attended an orientation session to receive study information and instructions.

Instructions for rest break schedules

Participants were asked to follow the assigned rest break schedules as closely as they could, with the understanding that perfect compliance to the exact schedules would not always be possible. As in the original study [Galinsky et al., 2000], they were shown how to use custom-made electrical timers, attached to the top of each video display terminal, to automatically signal their scheduled breaks. All participants were encouraged to get up and walk away from their workstations during each break, regardless of their assigned break schedule or exercise condition.

Instructions for stretching exercises

Participants in the Exercise condition viewed a demonstration of the stretching exercises performed by the principal

TABLE I. Attrition and Final Distribution of Participating Data Entry Operators Among Exercise Conditions and Break Schedule Sequences

	Weeks 1–4 conventional	Weeks 1–4 supplementary	
	Weeks 5–8 supplementary	Weeks 5–8 conventional	Final participants
Stretch exercises	23–12 = 11	22–12 = 10	21
No stretch exercises	23–6 = 17	22–9 = 13	30
Final participants	28	23	n = 51

investigator, with opportunities for questions and answers. They also kept a paper copy of exercise instructions at their workstations. They were instructed to do the stretches at the beginning of each break in the order specified in the instructions. The first six stretches were performed while seated, and the last three stretches could be done while standing or walking. The nine stretches required no more than 2 min to complete. It was emphasized that they should be done gently and smoothly, and that if any of the stretches caused any pain to a participant, s/he should stop doing it, make a note on the feeling state questionnaire, and contact the service center ergonomist. No such instances were reported during the study.

Following the 8-week study period, participants in the No Exercise condition who were still employed at the site were given the opportunity to do the stretching exercises during their breaks for the remainder of their temporary employment.

Instructions to minimize expectancy effects

Due to the obvious intervention aspects of this study, it was not possible to prevent likely assumptions regarding positive effects of frequent rest breaks and stretching exercises. Thus, instructions were used in an attempt to prevent or minimize expectancy effects. The participant's responsibility to respond to all questionnaire items as honestly as possible was strongly emphasized. Participants were explicitly discouraged from allowing their responses to be influenced by any assumed expectations of the researchers, the management, the union, or themselves. They were told to fill out the feeling state questionnaire only at designated rating times and to focus on each body part or mood state as they rated it. They were also told that if they forgot to fill it out during a previous rating time, they should leave those previous items blank rather than try to recall them from memory.

Data-Entry Performance Measures

The data-entry task was identical to that performed by workers in the original study [Galinsky et al., 2000]. Three electronically recorded measures of data-entry activity were provided by the service center. They included "duration on terminal" per day, "total documents entered per day," and "keystrokes per hour."

RESULTS

Compliance With Assigned Rest Break Schedules

Using the electronically-recorded "duration on terminal" measure, it was determined that participants were

engaged in data-entry activity for an average of 405 min per day while under the conventional break schedule, and for an average of 386 min per day while under the supplementary schedule. Since 20 extra minutes of break time were provided under the supplementary schedule, this 19 min difference suggests that participants followed the assigned schedules fairly closely.

Data from the twice-weekly rest break activities questionnaire also indicated close compliance with the assigned schedules. While under the conventional schedule which assigned two 15 min breaks per day, participants reported taking an average of 3 breaks per day, with a modal duration of 15 min per assigned break, and a modal duration of 5 min for unassigned breaks. While under the supplementary schedule which assigned two 15 min breaks and four 5 min breaks per day, participants reported an average of 6 breaks per day, with modal durations of 5 and 15 min per break, as assigned.

Compliance With Stretching Exercises

Responses to the rest break activity questionnaire were used to quantify the overall extent to which the 21 participants in the exercise condition complied with the stretching exercises. Compliance was computed as a percentage in which the total number of scheduled breaks during which participants reported exercising was divided by the total number of reported scheduled breaks. Compliance was 25% and 39% under the conventional and supplementary rest break schedules, respectively.

Statistical Analyses of Feeling State Questionnaire Ratings

Mixed design multivariate analyses of variance were performed on participants' ratings for each item of the feeling state questionnaire. These analyses were used primarily to examine the separate and combined effects of the two main variables of interest, the between groups factor "Exercise Condition" (Stretch Exercises vs. No Stretch Exercises) and the within groups factor "Rest Break Schedule" (Conventional vs. Supplementary). In addition, inclusion of the within groups factor "Time of Day" (Before Shift, Before Lunch, After Lunch, After Shift) permitted assessment of potential changes in exercise and break schedule effects over time during the work shift.

Rest break schedule

A significant main effect of Rest Break Schedule on feeling state ratings was detected for ten of the questionnaire items. Graphs illustrating these effects and their corresponding F statistics are displayed in Figure 1. As shown, mean ratings of musculoskeletal discomfort and eyestrain

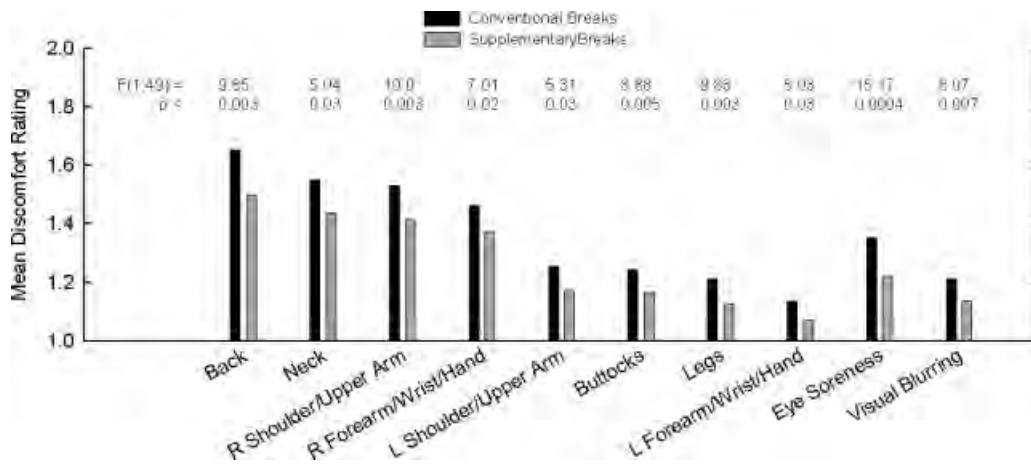


FIGURE 1. Significant main effects of rest break schedule on data entry operators' ratings of musculoskeletal discomfort and eyestrain (1 = none at all, 2 = a little, 3 = moderate, 4 = quite a bit, and 5 = extreme).

symptoms were slightly but significantly lower when the participants worked under the supplementary schedule than when they worked under the conventional schedule.

Rest Break Schedule interacted significantly with Time of Day for six of the questionnaire items, all pertaining to musculoskeletal discomfort in different regions of the body. The interactions and corresponding F statistics are displayed in Figure 2, where mean discomfort ratings under the two rest break schedules are plotted as a function of time of day. As shown, mean discomfort ratings were equal under the two schedules at the beginning of the work shift, and increased during both the pre-lunch and post-lunch work periods, most markedly in the back, neck, and right shoulder/upper arm regions. In all regions, discomfort was highest at the end of the work shift. Discomfort in the left shoulder/upper arm, left forearm/wrist/hand, and legs increased to a lesser extent, and returned to pre-shift levels following the 30 min lunch period. Discomfort levels in the back, neck, and right shoulder/upper

arm also decreased following lunch, but not to pre-shift levels. In all six body regions, increments in discomfort during pre-lunch and post-lunch work periods were less pronounced under the supplementary as compared to the conventional rest break schedule.

Stretching exercises

No significant effects of Exercise Condition on feeling state questionnaire ratings occurred.

Data Entry Performance

Rest break schedule

Although participants spent an average of 19 fewer minutes per day entering data while assigned to follow the supplementary rest break schedule, their mean rate of data

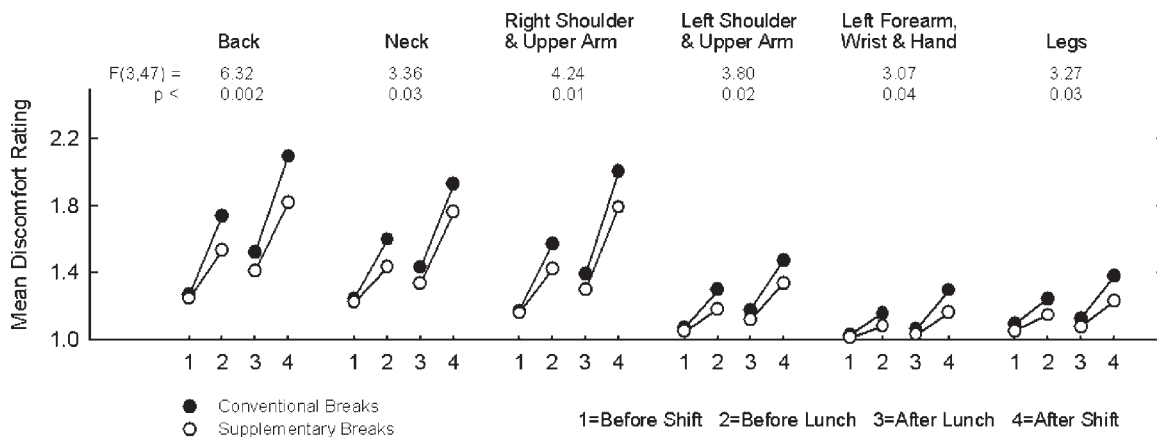


FIGURE 2. Significant rest break schedule x time of day interactions on data entry operators' ratings of musculoskeletal discomfort (1 = none at all, 2 = a little, 3 = moderate, 4 = quite a bit, and 5 = extreme).

entry under that schedule (7,805 keystrokes/hr) was significantly faster than their rate under the conventional rest break schedule (7,550 keystrokes/hr), $F(1, 49) = 17.49$, $P < 0.0002$. This resulted in a negligible difference between the mean number of documents entered per day under the supplementary schedule (195 documents) as compared to the conventional schedule (200 documents) that was not statistically significant, $F(1, 49) = 1.62$, $P > 0.05$.

Stretching exercises

No significant effects of Exercise Condition on data entry performance occurred.

DISCUSSION

Replication of the Positive Effects of Supplementary Rest Breaks

Questionnaire ratings

One purpose of the study reported here was to determine if computer workers at the Cincinnati IRS Service Center would experience effects of supplementary rest breaks comparable to those observed in the previous study at the Austin Service Center [Galinsky et al., 2000]. The outcomes of the two studies were notably similar in this respect. Once again, participants complied closely with the assigned rest break schedules. In both studies, the only evident deviation was the tendency to take one extra brief break per day while assigned to the conventional schedule. Workers in both studies performed the same right-handed data entry task, and the magnitudes of their discomfort ratings for the various body parts were similar, with the highest ratings most evident for the back, neck, and right shoulder and upper extremity. Discomfort accumulated during daily work periods, sometimes to the highest scale ratings of “quite a bit” and “extreme.” As in the replicated study and other similar studies, however, overall mean ratings of discomfort were relatively low, and mean reductions in discomfort produced by statistically significant rest break effects were small [Winkel and Oxenburgh, 1990; Sauter and Swanson, 1992; Henning et al., 1993; Swanson and Sauter, 1993; Henning et al., 1997; Galinsky et al., 2000; McLean et al., 2001; Balci and Aghazadeh, 2003, 2004]. These seemingly modest effects are considered to be clinically relevant, in light of theories suggesting that chronic musculoskeletal disorders can result from the cumulative effects of repeated “micro-traumas” signaled by small increments in discomfort during work [Hagberg, 1983; Putz-Anderson, 1988; Carter and Banister, 1994].

As in the previous study, overall levels of musculoskeletal discomfort and eyestrain in this study were significantly reduced when twice-daily conventional rest breaks were

supplemented with hourly 5 min breaks. Similarly, the growth in discomfort ratings which occurred during pre-lunch and post-lunch work periods was again significantly attenuated when workers followed the supplementary rest break schedule, as in the previous study. Thus, supplementary rest breaks appear to reliably confer subtle alleviative effects to counteract low levels of discomfort caused by continuous periods of data entry work. It is reasonable to expect that subtle effects such as these, over a long period of time, would serve to minimize workers' risk of acquiring chronic and/or disabling injuries. That possibility is supported by the results of a 2-year epidemiological study in which the introduction of hourly 10 min breaks was significantly associated with reductions in medically-diagnosed injuries among workers performing computer-intensive tasks [Ferreira et al., 1997].

In addition to their positive effects on musculoskeletal discomfort, supplementary rest breaks also reduced eye soreness and visual blurring, as in the previous study [Galinsky et al., 2000]. Similar effects have been reported by other researchers [Ong, 1984, 1990; Balci and Aghazadeh, 2003, 2004]. Since eyestrain symptoms occur in 50–90% of computer workers [Anshel, 1998; Lim et al., 1998], these findings provide further justification for emphasizing rest breaks as an important variable in the design of computer-intensive jobs.

Data-entry performance

The manner in which supplementary rest breaks influenced data-entry performance was also very similar to that observed in the previous study. Once again, productivity did not differ significantly under the two break schedules, in spite of replacing 20 min of work time with break time under the supplementary schedule. The absence of significant productivity loss with supplementary breaks was most likely attributable to increased data-entry speed that occurred under that schedule. Taken together with similar results from eight previous studies, this recurring outcome provides convincing evidence that productivity concerns should not prevent managers from considering frequent rest breaks for workers in computer-intensive jobs [Floru and Cail, 1987; Sauter and Swanson, 1992; Henning et al., 1997; Galinsky et al., 2000; McLean et al., 2001; Balci and Aghazadeh, 2003; van den Heuvel et al., 2003; Balci and Aghazadeh, 2004].

Difficulties in Studying Effects of Stretching Exercises

No significant differences in discomfort or performance between participants in the “stretching exercise” and “no stretching exercise” groups were detected. Participants in the former group were instructed to perform the stretches during every scheduled break. Nevertheless, while working under

the conventional rest break schedule, they reported stretching during only 25% of their breaks, and under the supplementary break schedule they reported stretching during only 39% of their breaks. The low levels of self-reported compliance preclude an optimal evaluation of the effects of stretching exercises per se. In addition, participants in the “no stretching exercise” group walked during most of their breaks—a factor that also lessened the difference between physical activity levels in the two groups. Some other researchers who have reported null effects of stretching exercises also noted that their study participants walked while in the “no exercise” condition, which may have undermined the ability to detect stretching exercise effects [Henning et al., 1997; van den Heuvel et al., 2003]. Since the relative influences of walking and stretching exercises on discomfort and performance are unknown, it would be beneficial to control and/or measure both variables in future research of this type.

Future studies of stretching exercises would also benefit from having large samples of workers to draw from in order to recruit an adequate number of participants who will comply with the stretching exercises over prolonged periods of time. As noted by Fenety and Walker [2002], few previous studies have measured and reported the level of adherence to assigned exercises, thus it is possible that null results in some studies can be accounted for by low adherence. In the current study, it is likely that compliance was higher under the supplementary break schedule because that schedule provided more opportunities to exercise (6 per day) than were provided under the conventional schedule (2 per day). Nevertheless, compliance was relatively low under both schedules, preventing valid assessment of exercise effects. Thoroughly identifying factors which either increase or decrease the likelihood that workers will follow exercise programs may be a necessary first step in determining their long-term impact on workers' discomfort and performance.

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