Effects of Ergonomic Management Software on Employee Performance

Report by

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ABSTRACT

This study tested the effects of using ergonomic work pacing software (Ergonomic Management System) on typing (accuracy and amount of keying), and mouse work (frequency and duration of mouse use). The performance of twenty-one executive, administrative, customer service, underwriter and accounting personnel was passively monitored for five weeks, to establish a baseline. Then the software was fully activated for 10 people (test group), and all personnel were monitored for an additional five-week period. There was a statistically significant 13% improvement in work accuracy for the test group, representing a 1% increase in their total productivity during in the five-week period. There was a 20% increase in mouse use for the test group, but because of inter-subject variability, this just failed statistical significance. There was no difference in total keystrokes between test and control groups. Results show that alerting users to take more short rest and break periods did not impair their overall keystroke and mouse use, but did improve their work accuracy. Economic analysis shows that the performance benefits alone that may accrue from using ergonomic work pacing software indicate a return on investment of around 3 months.

DISCLOSURE

The author is a Professor of Ergonomics at Cornell University. The author has made a best effort to analyze and present all results contained in this report in an impartial manner, as is customary academic practice. However, the author wishes to disclose that prior to this study, he had purchased stock in the company responsible for the development and commercial production of the Ergonomic Management System software. At the time of writing this report the author still owns stock in this company.

1.0 INTRODUCTION

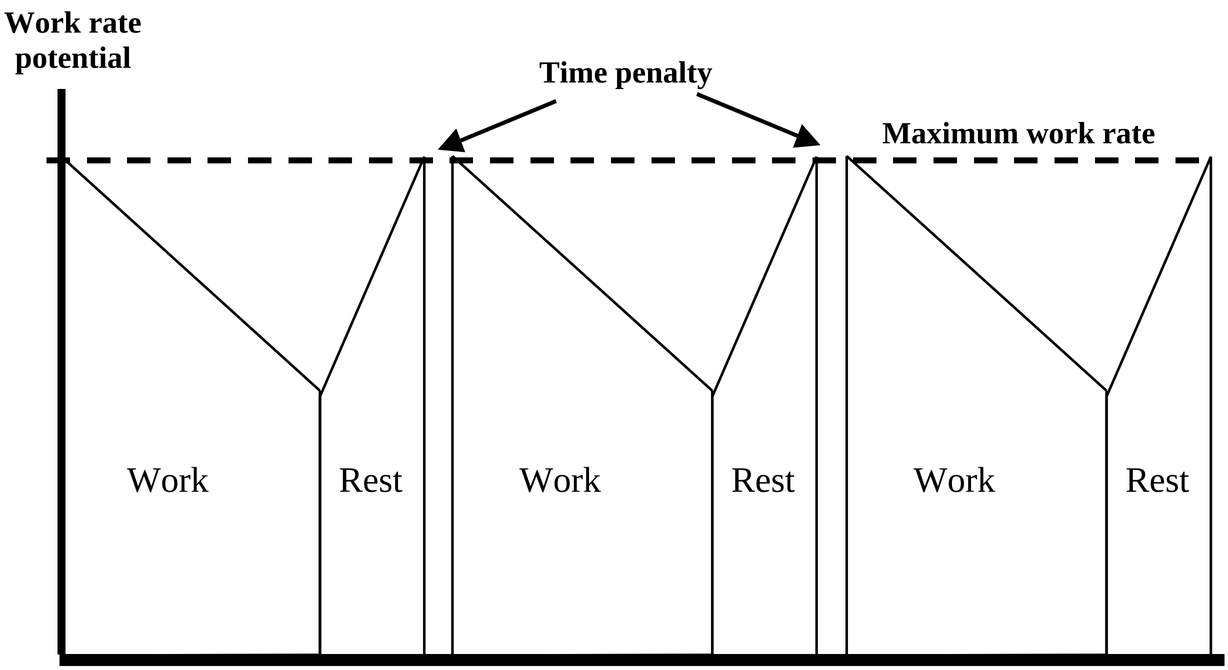
Continuous work cannot be maintained indefinitely by people. Physiological processes limit the ability of muscles to sustain contraction and function under conditions of physical fatigue. For example, the capability of muscles to perform static work typically is less than 1 minute, and to perform heavy, dynamic work the duration typically is less than 30 minutes. In addition to these physiological limitations, cognitive factors, such as boredom and mental fatigue, affect performance and especially human error.

For these reasons, ergonomists and others have studied the effects of several work factors on performance, including workflow rate (i.e. the rate at which work is performed); work load (i.e. the amount of work to be performed and the duration at which the workflow must be maintained); work patterns (i.e. the organization of time into work periods and rest and recovery periods); and work posture. Inappropriate work organization (high workflow rate, high workload, inadequate work patterns and poor posture) eventually has a deleterious effect upon work output and work quality, and workers in this situation also run a greater risk of accidents and injury . Understanding how to develop optimum schedules for work and rest periods is fundamental to designing jobs for optimum productivity, in terms of work performance and accuracy.

Several research studies have investigated the effects of designing appropriate work patterns. Janaro and Bechtold (1985) conducted a laboratory study of the optimal individual rest break schedule for workers performing a physically demanding task. They tested the effects of a variable-k with penalty (VKP) model of work scheduling, where 'k' is the length of a work period, compared with a fixed-k with penalty (FKP) model. In the VKP model the organization or the worker is free to decide the "best" number of rest breaks, their duration and timing (see Figure 1). In contrast, with the FKP model the rest break schedule and duration is fixed. In the VKP model the rate of working declines linearly with time until a rest break is initiated. During the rest period the potential for work rises linearly but no work actually occurs. The penalty is the time that the worker spends not performing work outside of the scheduled work and rest periods. Janaro and Bechtold found that when the VKP model was tested, subjects took rest breaks, worked less time and produced a 12.8% increase in work output.

FIGURE 1

VKP model of Human Performance (Janaro and Bechtold, 1985)



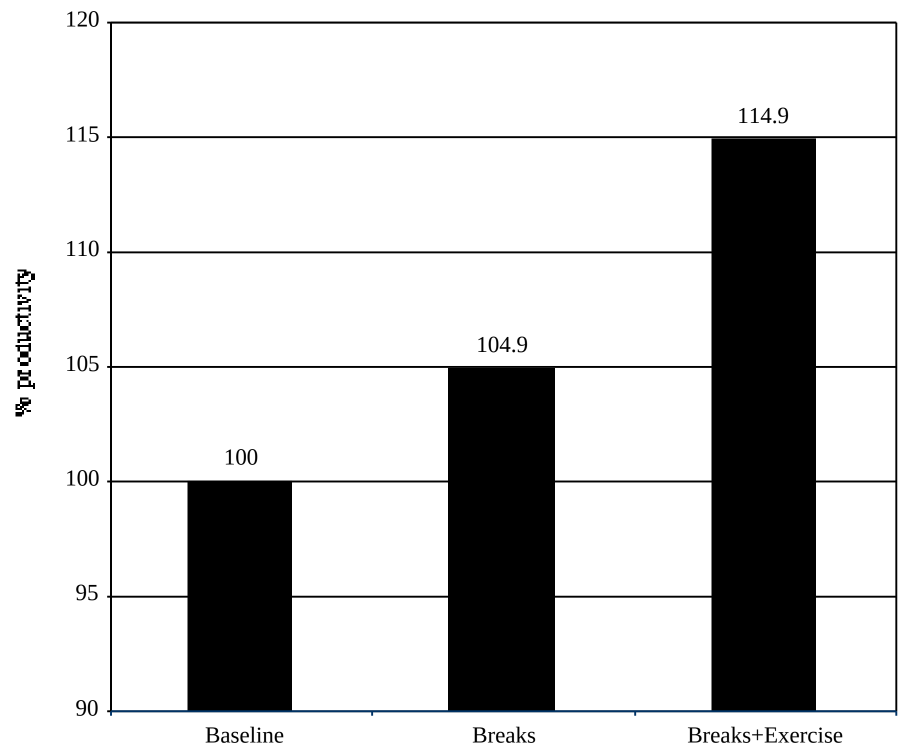
Henning *et al*. (1996) conducted two laboratory experiments to test the effects of discretionary rest breaks on typing performance. Discretionary rest breaks were defined as short rest breaks with and without feedback on computer workers. The target rest break criterion was a total of 30 seconds every 10 minutes, and subjects received feedback about their rest break utilization. Results showed that the rest breaks reduced the risks of musculoskeletal discomfort and repetitive strain injury during intensive computer work. In addition, feedback about discretionary rest break utilization reduced typing errors.

In a field test, Henning *et al*. (1997) compared computer workers typing performance in three conditions: a baseline condition; a "rest breaks only" condition, where workers were given three 30 seconds rest breaks plus a three-minute break each hour; and a "rest breaks plus stretching exercises" condition, where workers were given the same rest break schedule but undertake brief stretching exercises during these. Taking the baseline performance as 100%, they found the most significant increase in typing performance with the combination of rest breaks and stretching exercises (see Figure 2).

FIGURE 2

Effects of rest breaks and rest breaks + stretching exercises on productivity

(Henning *et al*., 1997)



Results from these research studies suggest that with appropriate rest breaks, combined with stretching exercises, computer workers should be able to sustain work at an appropriate work./rest pace, while at the same time minimizing postural injury risks providing their work activities are performed while in appropriate postures.

Recently, a commercially available software program, the Ergonomic Management System (EMS), has been developed that monitors the amount of keyboard and mouse activity and provides users with information on appropriate discretionary rest breaks. The EMS also provides information on appropriate stretching exercises and other ergonomic considerations, such as appropriate postures and appropriate workstation adjustments. Although primarily designed to manage and prevent keyboard and mouse overuse injuries, the EMS also gathers data on work performance. The present study is a field experimental test of the effects of using the EMS on computer work productivity.

2.0 METHODS

2.1 Test Site

The Wall Street office of a nationwide insurance brokerage firm (New Century Global) was chosen as the test site for this study. Employees at the site use their computers for much of the workday. The site did not have a history of ergonomic problems, and employees were not reporting widespread musculoskeletal problems prior to the study, but management was proactively concerned about employee well-being.

2.2 Participants

Twenty-one employees were chosen to participate in this study. Employees were chosen to represent a variety of jobs, including executive, administrative, customer service, underwriter and accounting personnel. Eleven participants were women and 10 were men.

2.3 Software

The test software (Ergonomic Management System - EMS) was installed on the corporate network. The software was used to monitor the computer work performance of all participants.

2.4 Procedure

The participants were informed that an ergonomic study was about to be undertaken, although they were not given precise details on the purpose of the study. At the outset, participants were asked to complete a computer-administered musculoskeletal discomfort questionnaire that is part of the EMS software (see Appendix 2). Following this, the computer use performance of all participants was monitored for a five-week period. Participants were then randomly assigned to either a test or a control group. The baseline performance data were reviewed to check that there was no source of bias this random allocation of participants to the test and control groups. To protect confidentiality, false names were assigned to participants and the data gathered were treated in an aggregate manner. At the end of the baseline five-week period, the EMS was activated for 10 of the participants (test), but not for the other 11 (controls). The test group members received brief individual instruction at their workstations about the nature and function of the EMS, including a brief review of the software-based ergonomic tutorial information that includes animated stretching and relaxation exercises. Data were collected on all participants for a further five weeks. Initial default values were set for the computer-use time period required to activate rest breaks. These values were tuned at the start of weeks 3 and 5 weekly to better match the pace of working of the test group for the five-week test period.

2.5 Research Design

The research was designed as a pre-treatment/post-treatment case/control study.

2.6 Data Analysis

The researchers did not access any of the original logged data files. Rather, these raw logs were processed and summarized and, for all participants, these aggregate data were provided for statistical analysis. Musculoskeletal survey data from the first phase of this research were analyzed.

All performance data were analyzed using a factorial analysis of variance with repeated measures that tested for effects of TIME (pre- and post-) and GROUP (test or control).

Survey ratings data were analyzed as percentages and test/control comparisons were made using Chi-square test.

3.0 RESULTS

3.1 Survey Profile

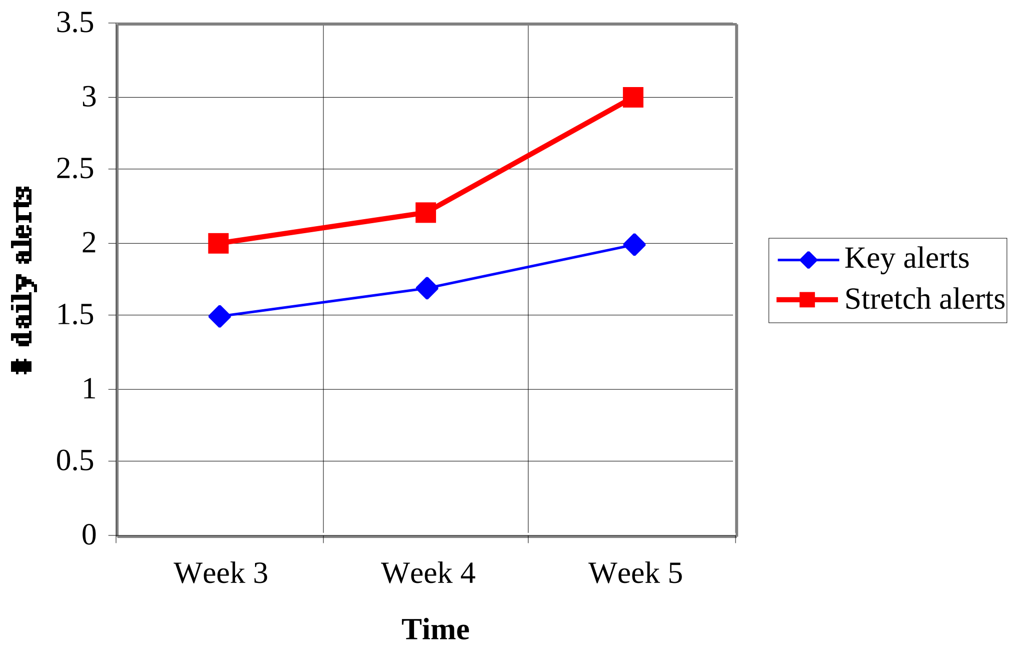
The data gathered in the study covers 6,195 person/hours of computer usage, equivalent to approximately 800 person/days of computer use and some 4 million keystrokes. Participants used a computer an average of 5.9 hours per day throughout the study.

3.2 Alerts

For the test group, the average daily alerts per person increased steadily from weeks 3 to 5 (Figure 3). In part, this is because the EMS software was tuned at the start of weeks 3 and 5 to provide users with more appropriate schedule of rest break alerts.

FIGURE 3

Daily alerts per person for weeks 3 through 5 for the test group.

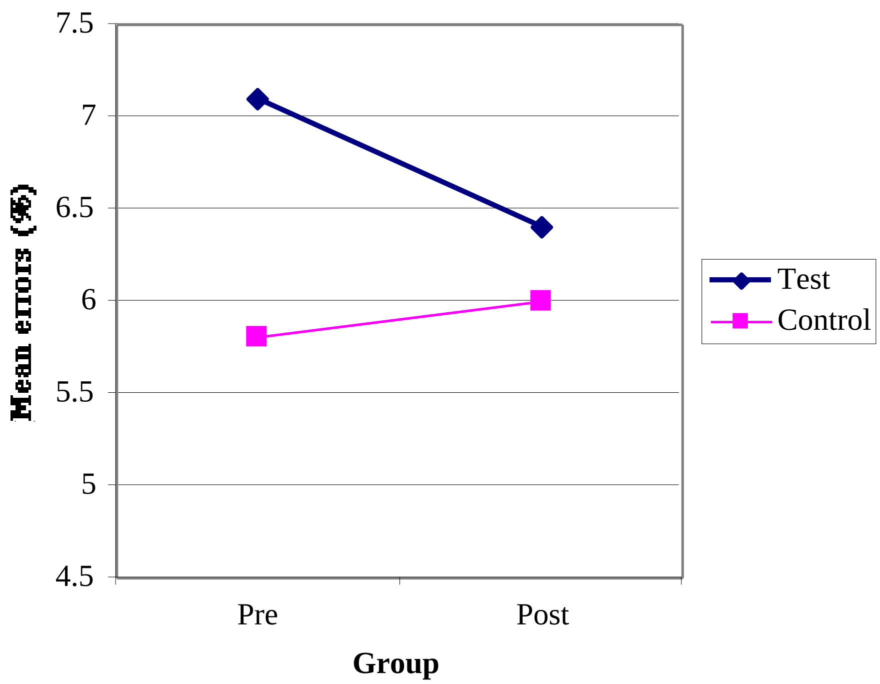


3.3 Error rates

For the percentage errors data there was a statistically significant interaction ($F_{1,19} = 5.759$, $p = 0.027$) between TIME (pre- and post-) and GROUP (test/control). This interaction is shown in Figure 4.

FIGURE 4

Interaction of TIME and GROUP for Percentage Errors.

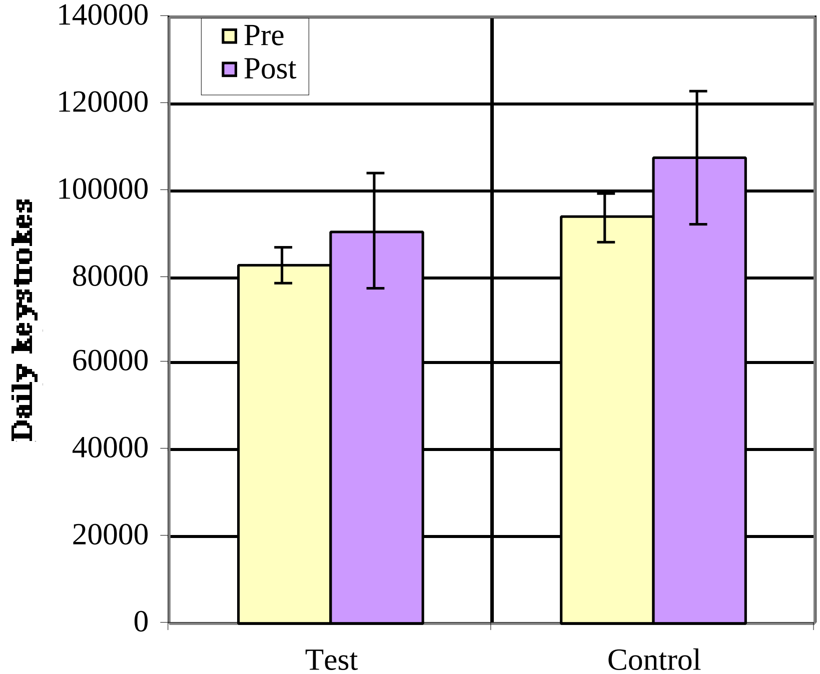


3.4 Keystrokes

There were no statistically significant main or interaction effects of GROUP and TIME for the number of keystrokes per day. The mean number of keystrokes per day for each group is shown in Figure 5.

FIGURE 5

Daily Keystrokes for each GROUP and TIME (mean ± S.E.)

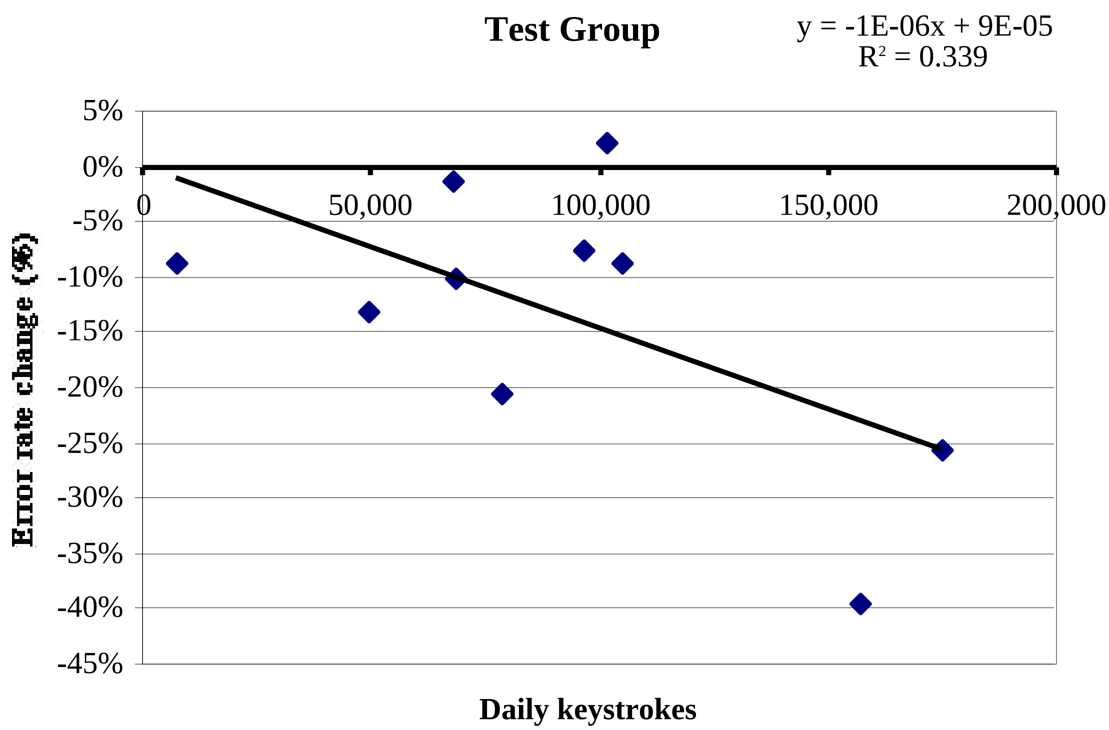


3.5 Performance Accuracy

The relationship between keystroke rate and typing accuracy was explored for the test and control groups. For the test group there was a positive association between the typing rate and the improvement in accuracy (Figure 6 - this shows accuracy improvement as a decrease in error rates).

FIGURE 6

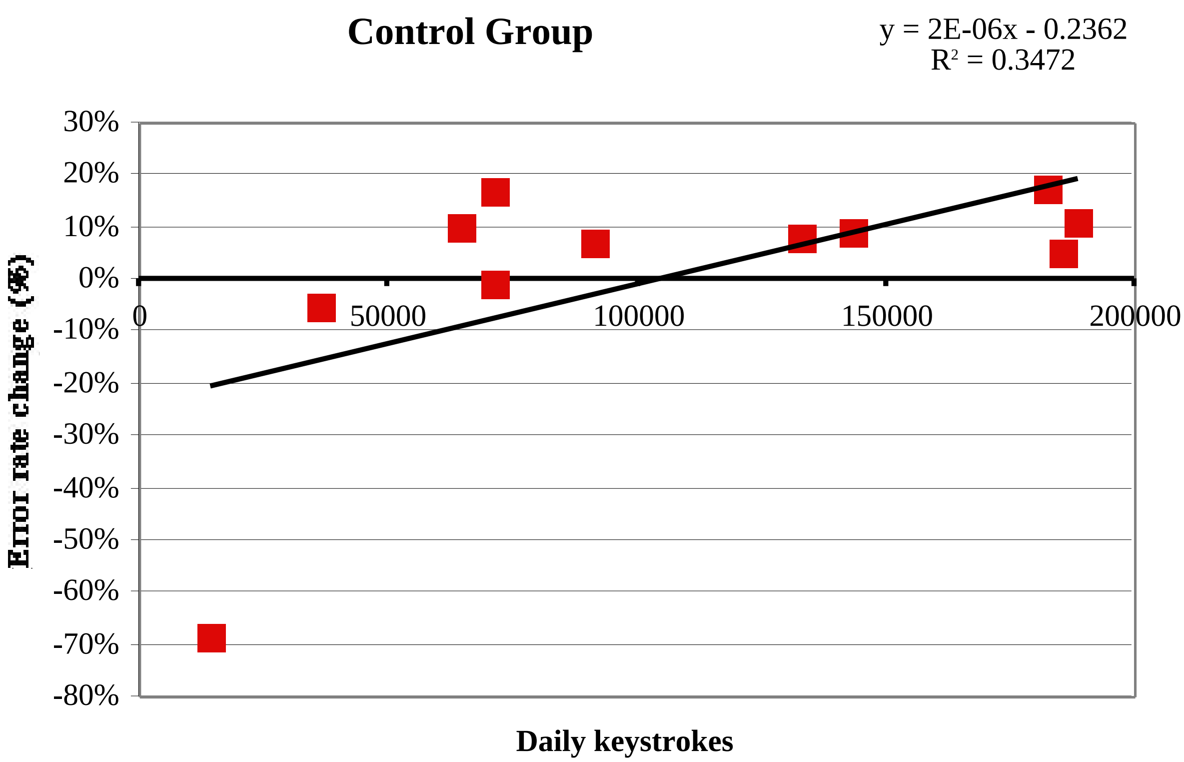
Daily Keystroke and Accuracy rates per person for the TEST group.



No comparable association was found for the control group, where there was a trend for an increase in errors with an increase in typing rate (Figure 7).

FIGURE 7

Daily Keystroke and Accuracy rates per person for the CONTROL group.

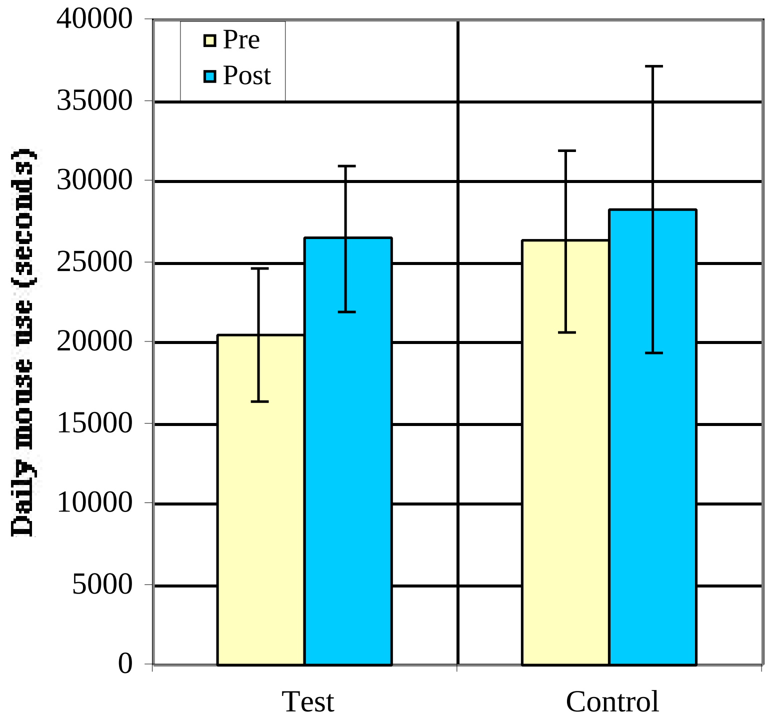


3.6 Mouse Use

Although there was an average 20% increase in mouse use for the test group after the EMS software was activated, this failed statistical significance because of the inter-subject variability. Overall, there were no statistically significant main or interaction effects of GROUP and TIME for the mouse use time per day (seconds). The mean mouse use time per day for each group is shown in Figure 8.

FIGURE 8

Daily Mouse Use for each GROUP and TIME (mean ± S.E.)

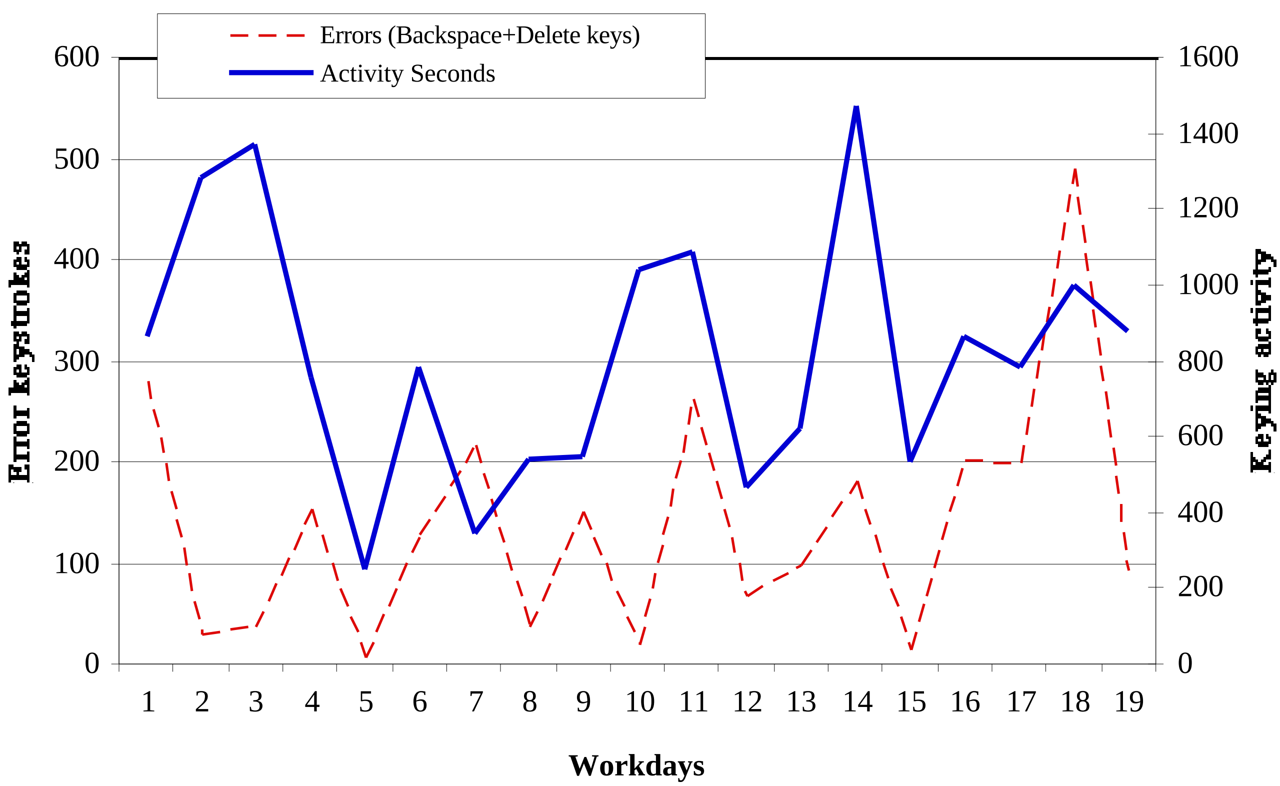


3.7 Speed/Accuracy Tradeoff

Speed-error tradeoff behavior is commonplace in perceptual-motor task performance, such as performing in sequential choice reaction time tasks. There was no statistically significant correlation between keying performance and error rates, which suggests that the results obtained are not influenced by any consistent speed/error performance trade-off effect. Figure 9 shows data for a typical test participant for which there is no significant correlation between keying activity and error rates.

FIGURE 9

Keying activity and Error Rates from the Log File for a typical Test Group Participant.

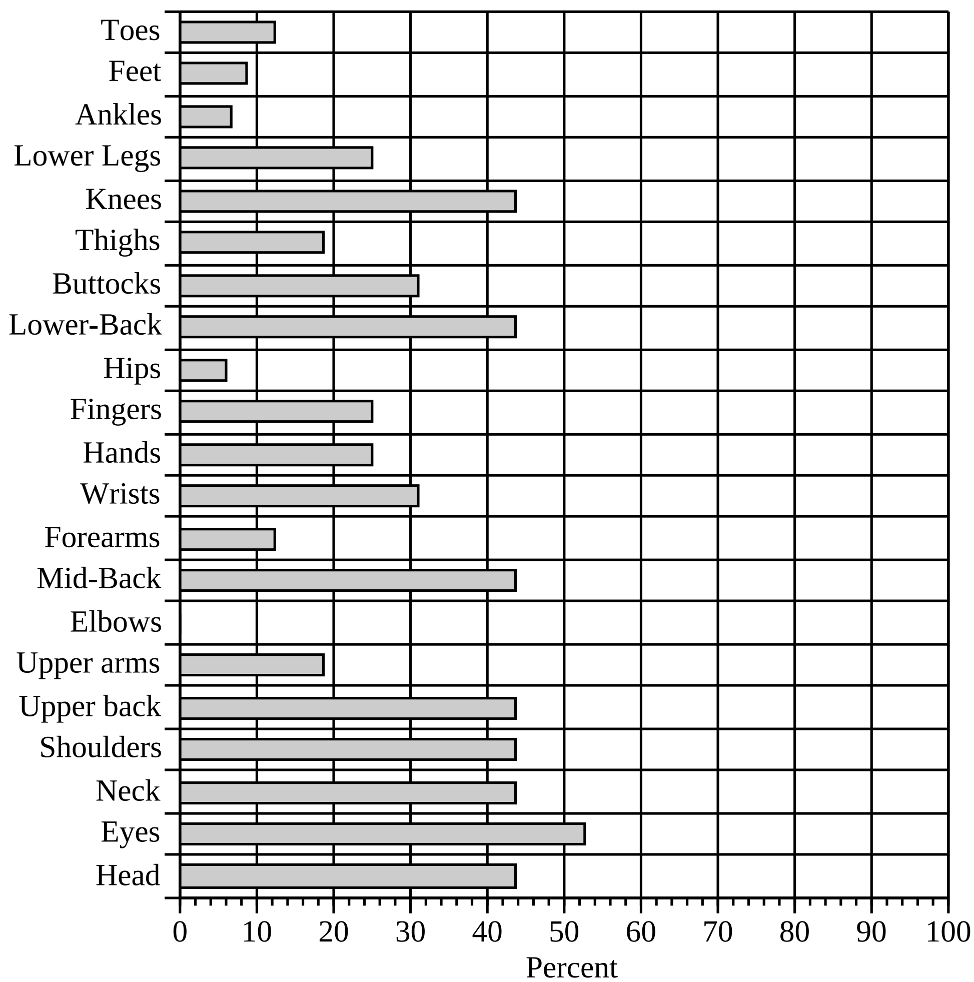


3.8 Musculoskeletal Discomfort

Thirteen participants (subsequently allocated as 6 test and 7 control participants) completed the initial musculoskeletal discomfort questionnaire. The other 8 participants reported not experiencing any musculoskeletal problems and they did not complete this survey. There were no statistically significant differences in the responses of those assigned to the test and control groups for any of the survey questions. Results for the baseline survey are shown below (Figure 10).

FIGURE 10

Musculoskeletal Discomfort experienced at least "Occasionally" for the Participants (n=13)



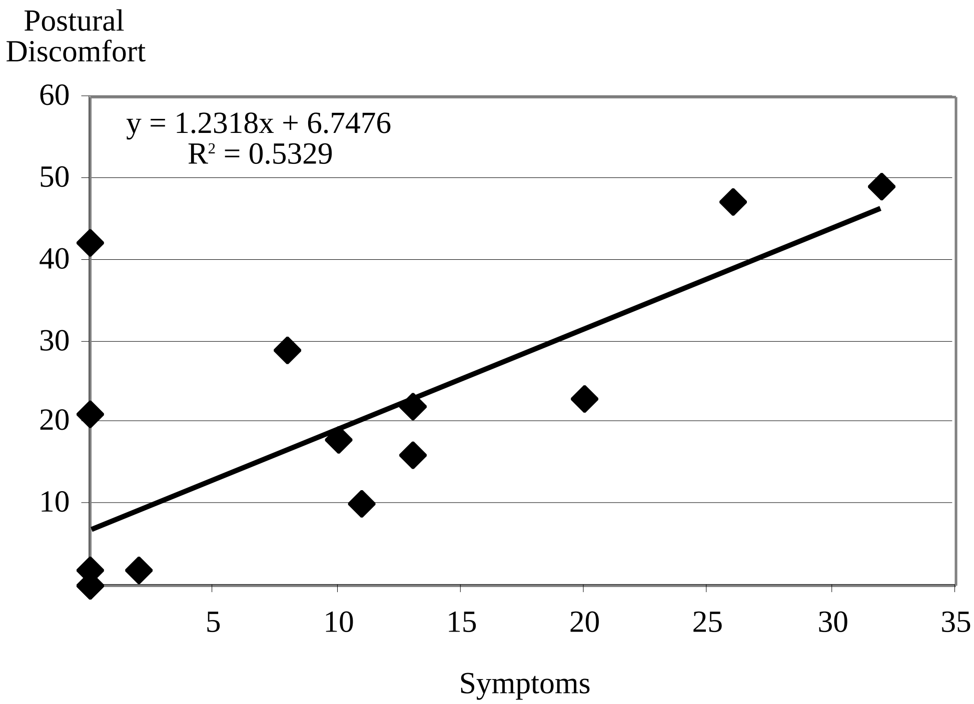
Musculoskeletal discomfort problems could not be assessed at the end of the test period.

3.9 Musculoskeletal Symptoms and Postural Discomfort

There was a statistically significant correlation between the sum of the ratings for the frequency of musculoskeletal symptoms and the sum of the ratings for postural discomfort ($r = 0.835$, $n = 13$, $p = 0.001$). Figure 11 shows this association.

FIGURE 11

Best-fit regression line for the association of musculoskeletal symptoms and postural discomfort (n=13).



3.10 Return on Investment Analysis

Table 1 presents a return-on-investment analysis to quantify the potential economic impact of the significant improvement in accuracy (1% of overall keying activity) that occurred for the EMS test group.

TABLE 1

Return-on-Investment Analysis of the Increase in Keying Accuracy

Number of employees	1,000
Average Salary	$50,000
Estimated Average Time on Computer (% workday)	75%
Salary allocated to time on computer	$37,500
% Increase in Keying Accuracy	1%
Gross Annual Return per person	$375.00
Annual Product Cost @ 1,000 Seats	$79.95
Net Annual Return per person	$295.05
Net Annual Return on Investment	369%
Breakeven/Payback Period (Months)	2.7
Group Total Return	$295,050

4.0 DISCUSSION

This field study investigated the effects of using an ergonomic workflow software system in a real-world office setting over a five-weeks period. The software that was tested is primarily designed to manage ergonomic risks of injuries from keyboard and mouse overuse, as well as educating workers on appropriate ergonomic workstation arrangements and stretch exercises. Prior to the study, participants at the test site chosen were not reporting widespread problems with musculoskeletal discomfort. Management at the site was, however proactive concerning office ergonomics.

Results from the study show that the provision of discretionary rest breaks produced a statistically significant increase in keying accuracy, with a 13.4% difference in errors between the test and control groups for the 5 weeks test period. For the test group, there was a before-after reduction in total keying errors over the 5 weeks test period. This result agrees with previous research (Henning *et al.*, 1996) that has shown that feedback about discretionary rest break utilization reduces typing errors. Further analysis showed that accuracy improvements increased with increasing daily keystroke rate for the test group, but decreased with increasing daily keystroke rate for the control group. The performance effect found in the present study translates into a return-on-investment of around 3 months based upon performance alone. When this effect is combined with the potential reduction in injury risks associated with discretionary rest breaks (Henning *et al.*, 1996), there is quite a compelling economic case for the use of workflow ergonomic software.

The present study also showed that there was no evidence of a speed-error tradeoff that could affect the accuracy finding. The use of workflow software and discretionary rest breaks did not detrimentally affect either the keystroke rate or their mouse use for these computer workers. In fact, for the test group there was a trend for an increase in mouse use. In discussions with the participating company, on obvious confounding variables, such as changes in computers, software, work content etc., could be found to explain this trend.

Although an association between symptoms and postural discomfort was demonstrated, from the outset, a majority of participants in this study did not report experiencing high levels of musculoskeletal discomfort. Consequently, it was not possible to undertake a follow-up survey of musculoskeletal symptoms. Further studies of the effects of the workflow ergonomic software could usefully evaluate the effects for participants who are experiencing postural problems.

Results from the present study are sufficiently promising that it is recommended that future research studies should evaluate the effects of the EMS on a larger number of workers over a longer period.

5.0 REFERENCES

Henning, R.A., Callaghan, E.A., Ortega, A.M., Kissel, G.V., Guttman, J.I. and H.A. Braun. (1996) Continuous feedback to promote self-management of rest breaks during computer use. International Journal of Industrial Ergonomics, 18, 71-82.

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Appendix 1

Musculoskeletal Symptoms and Discomfort Scales from the Ergonomic Comfort Survey

Refer to the body map picture as a guide. During the last work week, how often did you experience aches, pains or discomfort in the last work week?

Never; **1**-2 times last week; **3**-4 times last week; **O**nce every day; **S**everal times every day

Head	Fingers
Eyes	Hip
Neck	Lower Back
Shoulder	Buttocks
Upper Back	Thigh
Upper Arm	Knee
Elbows	Lower Leg
Mid Back	Ankle
Forearm	Feet
Wrist	Toe
Hand	

18. Refer to the body map picture as a guide. If you experienced any aches, pains or discomfort, how uncomfortable was this?"

Slightly uncomfortable, **M**oderately uncomfortable, **V**ery uncomfortable

Head	Fingers
Eyes	Hip
Neck	Lower Back
Shoulder	Buttocks
Upper Back	Thigh
Upper Arm	Knee
Elbows	Lower Leg
Mid Back	Ankle
Forearm	Feet
Wrist	Toe
Hand	

BODY MAP PICTURE