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What is This?

COMPUTER INPUT DEVICES: QUANTIFICATION OF USE AND VARIATION IN USE

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A computer usage monitor (software odometer) was used to collect information on computer input device usage (keystrikes, mouse clicks and movement, and duration of input activity) from 27 professionals, for an average of 17 working days, each. Data from an odometer provides a more extensive means of describing and exploring computer use than more traditional methods, such as self-report of average use in response to a survey question. Further, by collecting data for an extended period of time, considerable day to day variation in computer use was found within subjects. This confirmed the necessity for collecting such data over an extended period of time, and illustrates one of the benefits of the use of software odometers over, or in conjunction with, self-reported usage information via surveys or diaries, or work sampling accomplished through direct observation.

INTRODUCTION

A number of epidemiological studies have sought to determine whether or not computer use is associated with musculoskeletal discomfort or disorders in people who use computers for work. A variety of factors have been explored, including those that describe the physical arrangement of the workstation or worker posture (Hünting *et al.* 1981; Sauter *et al.* 1991; Marcus *et al.* 2002), work organization and psychosocial factors (Smith *et al.* 1981; Hales *et al.* 1994), and temporal descriptors of computer use (Rossignol *et al.* 1987; Bergqvist *et al.* 1995; Marcus *et al.* 2002). Among these studies, results have been inconsistent regarding associations between MSDs and physical factors or temporal factors (Gerr *et al.* 2004). Inconsistencies may be due to inadequate sample size or inadequate variance in the data in some studies, the type of computer work (or other work) the subjects performed, or may be due to inherent difficulties with a cross-sectional design (healthy worker effect, or injured workers reducing their exposure). However, more recent prospective studies also provide differing results regarding temporal factors (Marcus *et al.* 2002; Kryger *et al.* 2003). Another possible reason for inconsistent findings may be that "daily hours of (self-reported) computer use" or a similar variable is not always a valid surrogate for the actual risk factor.

Temporal aspects of computer use are commonly expressed as daily or weekly hours of computer use or typing, and are most often based upon self-report (Bernard *et al.* 1994; Kryger *et al.* 2003; Lindegard *et al.* 2003). Other methods include work sampling via direct observation, diaries, and computer usage monitors (software odometers). Work sampling has been employed to quantify usage and verify self-reports.

Bernard *et al.* (1994) performed work sampling at intervals of 15 minutes for a single, full day on subjects with and without hand/wrist discomfort, obtaining 30 observations per subject. They found both types of subjects overestimated their hours of typing by a factor of 2. Both their self-report data and their work sampling data showed a dose-response relationship between hours of typing and hand symptoms. Usually, after finding a problem, via epidemiological study, exposure limits or some other intervention is produced. Yet, it would be difficult to develop an intervention based on a perceived amount of exposure to a physical hazard.

In a prospective study by Marcus *et al.* (2002), daily diaries of computer use were maintained by subjects for up to 3 yrs. In that study, associations were found between number of hours of keying per week and incidence of hand/arm symptoms and disorders. Matias *et al.* (1998) required subjects to keep logsheets, recording the beginning and end of each VDT task over a period of 4 days, and they found associations between carpal tunnel syndrome and duration of computer work and percentage of workday using the computer. These studies show that more detailed collection of data, though a burden on subjects, may provide more conclusive and consistent evidence of an association between computer use and MSDs.

Computer usage monitors offer a source of supplementary information to traditional surveys and diary methods, or may be used in place of these. A taxonomy for describing computer input device usage, proposed by Dennerlein *et al.* (2003), demonstrates the richness of such data. Further benefits offered by such a tool are the ability to collect those extensive arrays of data over extended periods of time and at virtually no added burden to subjects. The remainder of this presentation will focus on the variation in computer use

among a sample of professionals, which was revealed by prolonged collection of computer use data via a computer usage monitor.

METHODS

From a larger sample of professionals who used computers for work, and who participated in a series of cross-sectional studies of computer use (Sommerich 2002), 27 people volunteered to participate in another phase of the study, designed to produce a more quantitative assessment of computer use, than could be produced via a survey. A computer usage monitor was installed on each participants' computer. The program ran autonomously, and the only burden on the subject was to send the previous day's data file to the researchers, in the form of an email attachment. Subjects also maintained a diary, into which they entered information about start and stop times for work each day and other relevant information.

The odometer software was created specifically for this project. Once installed it initiated on start-up of the computer. A new file was automatically created for each day. Data was logged every 5 seconds. The software provided the number of keystrikes, mouse clicks (by button and single or double), and mouse "mileage", as well as time-based measures. Mileage was recorded in pixels, but converted to screen diagonals in order to have a common measure across subjects, regardless of the resolution of their computer screens. The data were also identified by work location and by application in use.

Per Dennerlein *et al.* (2003)'s taxonomy, data representing keyboard, mouse, and idle episodes are recorded by the software, and can be reported in terms of event tallies and durations of activities. In this presentation, keyboard events are only represented as any keystrike, but the software provides the data in more detail. Mouse episodes are described by quantities of mouse clicks, limited to total clicks in this presentation, and mouse movement, expressed as cursor movement, in units of screen diagonals traversed.

Because data are collected continuously, it is possible to describe not only daily counts, but day-to-day variation, variation by location (for notebook computer users) or application, and patterns of use within a day (activity and break periods). It may be data at one of these levels of detail that will help resolve the inconsistencies in the research that currently exist, regarding the existence of a causal association between computer use and MSDs.

RESULTS & DISCUSSION

An average of 17 days of data were collected for each subject (range: 13-33 days). Average time per day spent inputting to the computer was 153 minutes, across subjects, with one subject's average as low as 90 minutes per day and another's as high as 278 minutes. Expressed as a percentage of the work day, the

corresponding values were 30%, 19%, and 50%, respectively. Activity averages appear in Table 1.

Table 1. Average daily counts of keystrikes, mouse clicks, and mouse movements, across the 27 subjects.

Activity	Average	Range of subjects' averages
Keystrikes	6603	1907-18719
Mouse clicks	1693	738-4906
Mouse movement, in number of screen diagonals	740	368-1809

More interesting than these average values, however, may be the data when examined at the level of the individual subject. For example, Figure 1 shows the range in daily keystrikes across the subjects. The average coefficients of variation (CV) for daily keystrikes, across subjects, is 54% and ranges from 22 - 121%. The CVs calculated for each subject's data set provide an approximation of the number of days of data that would have to be collected from the subject in order to achieve a confidence interval of 90% and a margin of error equal to 10% of the mean (assuming a population of 250 work days). With this level of variation, it is no wonder that subjects' estimates of their use of their computers do not match measurements of use.

An example of daily computer inputting activity over a three week collection period (standard time frame for this study) can be seen in Figure 2 for subject T01. The extent of the day-to-day variation is typical of both the desktop and notebook users in this study. The monitoring software that was used to collect these data provide a means to understand the variation in activity. For example, because all of the data are linked to specific applications, we can understand the reason for the maximum data point for subject E01 (14th from the left in figure 1). Four hours of activity were logged on that day to a word processing program and another 4 hrs to a presentation software program, indicating the subject was working under a deadline that day to prepare a presentation and supporting documentation.

Within day usage variation can also be explored through examination of odometer data. An example of computer use variation within a day for T01, is provided in Figure 3. Breaks, or lack of them, which can be identified in such data, have been identified as an important factor in the computer use/MSD puzzle (Bergqvist *et al.* 1995). In the first of two cross-sectional surveys administered to the professionals from whom the odometer participants were recruited, 34% of respondents reported only taking "very brief breaks" throughout the work day, and another 34% reported taking only very brief breaks plus a lunch break of more than 30 minutes (similar to the pattern seen in Figure 4). From that same survey, the reporting of frequent musculoskeletal discomfort was positively correlated with a score that was derived from each subject's

propensity for working at the computer for various, uninterrupted extended periods of time.
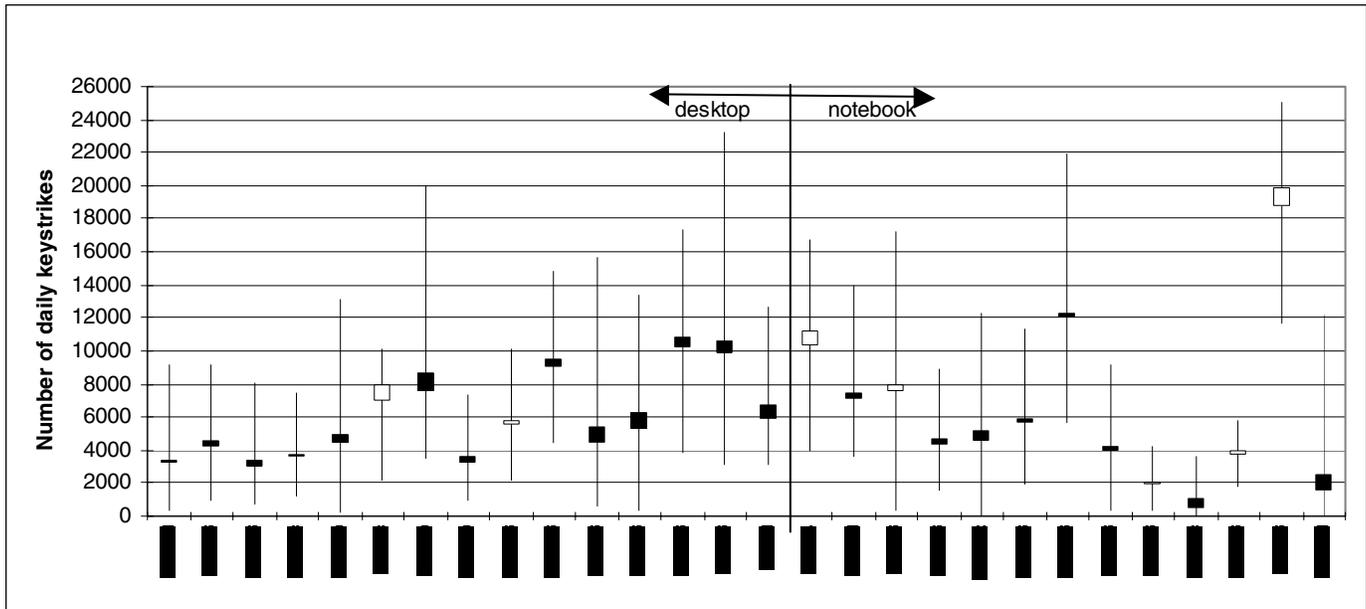

Figure 1. A summary of daily keystrike data for each subject (mean, median, minimum and maximum). Mean and median values are displayed as either end of the box, where a black box indicates the mean exceeds the median and a white box indicates the median exceeds the mean. (Note that there are 28 entries, because one subject provided data from his desktop (primary) and his notebook (secondary) computers and these are treated as separate data sets.)
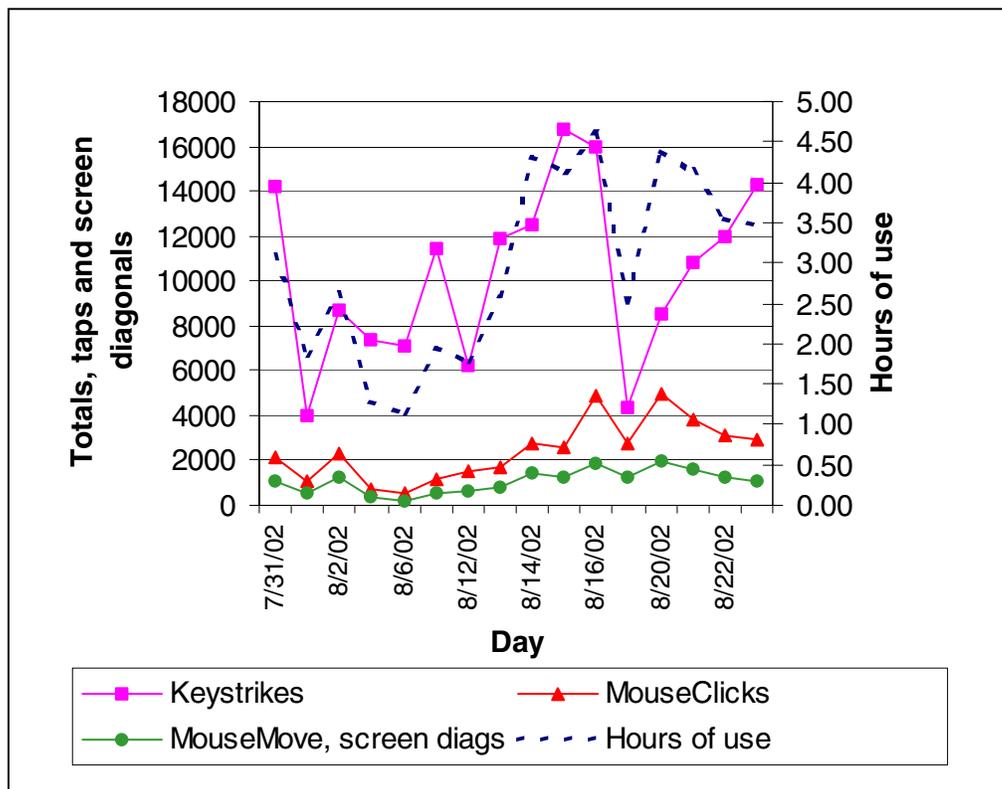

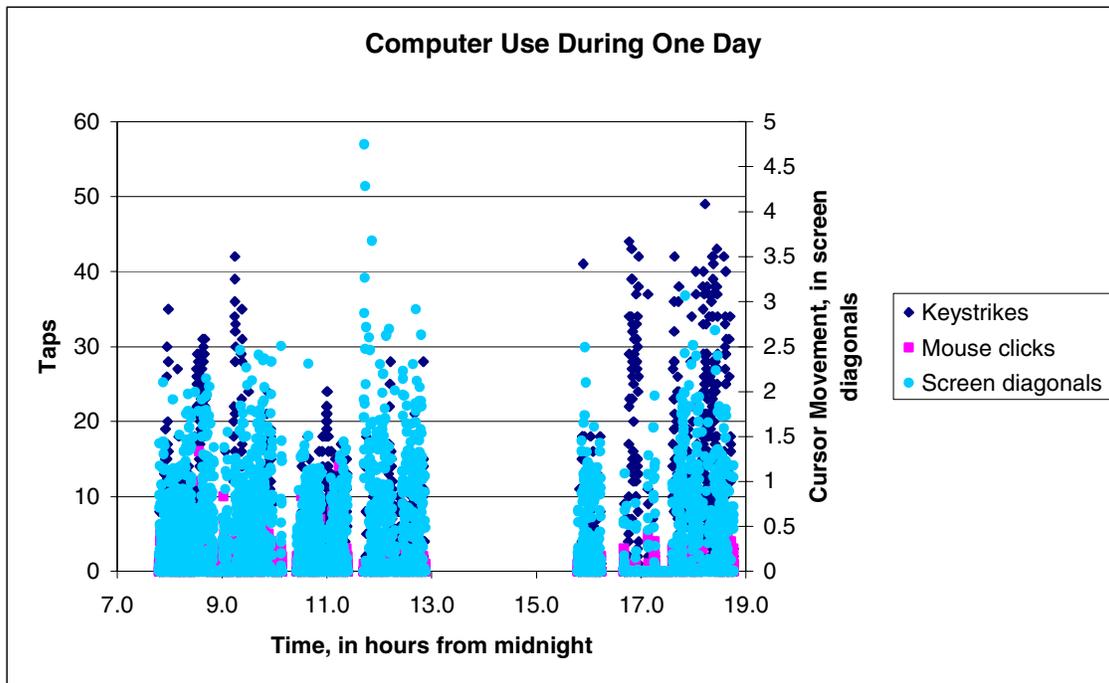Figure 2. Day-to-day variation in input to the computer, subject T01.

Figure 3. Variation in computer input activity over the course of a single day (T01).

Limitations

As stated by Dennerlein *et al.* (2003), computer use monitoring software is currently limited to collecting information about input activities, and cannot capture total time spent using the computer, which also includes those periods of time where someone is reading from the computer. This may become a greater limitation to this method of data collection, as more documents are provided electronically.   In spite of this limitation, computer usage monitoring programs have the potential to provide objective, quantitative data that describe computer use at a level of detail not possible through more traditional methods.

CONCLUSIONS

The purpose of this presentation is to provide an introduction to the richness of the data that are provided by computer monitoring software. Variation within and between subjects can be quantified to an extent not possible from self-reported surveys, and with lower burden on subjects than occurs with use of diaries. This method of examining computer usage may yield new insight into questions concerning the nature of the association between computer use and MSDs, as well as provide new directions and methods for intervention solutions for computer users.

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