Ascertaining computer use in studies of musculoskeletal outcomes among computer workers: differences between self-report and computer registration software

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The results of a large prospective study of computer users show little association between input device use and musculoskeletal outcomes. Ordinarily, this study would simply be one more addition to the already large body of literature examining associations between computer use and musculoskeletal outcomes and one more citation included in the 'negative association' column of review papers. This is not an ordinary study, however. Unique to this investigation was its use of newly developed memory resident computer registration software that allows for the automated collection of computer and mouse activity over months or years. Using data collected with this software, IJmker *et al*[1] observed no association between computer and mouse use and severe distal upper extremity or neck–shoulder symptoms. Even more provocative was the simultaneous observation by IJmker *et al*[1] (***see page 502***) that self-reported daily duration of computer use *was* significantly associated with distal upper extremity and neck–shoulder symptoms. With over one billion computers in use worldwide, the health effects of computer work continue to be relevant to occupational health practice.

To our knowledge, nearly all previous large studies examining associations between computer use and musculoskeletal outcomes used self-reported metrics of computer use (most commonly hours per day or hours per week) as no other method was feasible for large epidemiological studies. Prior to the publication of the report by IJmker *et al*,[1] only one study was available in the literature in which computer use was ascertained with computer registration software.[2] Although associations between computer activity and musculoskeletal symptoms were observed in that study, the small sample size (N=27) and other methodological limitations make it difficult to extend the results to other populations. Given their inclusion of new objective metrics of computer use duration, do the results of IJmker *et al*[1] supersede the earlier literature that used self-report? Are readers to conclude that the common opinion that computer use has adverse musculoskeletal effects is in doubt?

What is the basis for the common opinion that computer use has adverse musculoskeletal effects? Space does not allow for a full review of this literature here. However, the authors of several recent reviews have observed that associations between computer use and musculoskeletal outcomes reported in the literature are mostly positive, especially for the distal upper extremity (as opposed to the neck and shoulders). For example, in a recent review of 39 published epidemiological studies, Gerr *et al*[3] wrote that a "somewhat consistent finding is an observed association between hours of computer use and adverse hand/arm musculoskeletal outcomes and, to a slightly lesser extent, between hours of computer use and adverse neck/shoulder musculoskeletal outcomes". In another review of computer use and musculoskeletal outcomes, IJmker *et al*[4] concluded that the literature "showed moderate evidence for an association between the duration of [computer] mouse use and the incidence of hand-arm symptoms". Consistent with these opinions, Wahlström[5] noted that "there seems to be more evidence for an association between the duration of VDT [video display unit] work and musculoskeletal disorders in the forearm and hand compared to associations between the duration of VDT work and symptoms/disorders in the neck/shoulder region".

Is the difference in association between musculoskeletal outcomes and computer use metrics ascertained with computer registration software and self-reported computer use due to differences in ascertainment of computer use? Certainly, the differences in strength of association observed by IJmker *et al*[1] suggest this to be true. Which one is right? A modest literature examining relationships between self-report of computer input device use and objectively registered input device activity shows that (1) keying and mouse times ascertained from computer user self-report are greater than those measured objectively and (2) correlations between the two methods of ascertaining exposure lack consistency. In a validation study by Homan and Armstrong,[6] the Spearman correlation between keying time measured with an activity monitor (analogous in function to computer registration software) and keying time estimated with self report was 0.78 when data were collected over 1 day of computer use. Interestingly, Homan and Armstrong[6] also noted that computer users spent a non-trivial amount of time with hands held over the keyboard but without keying. Such static postural loads would not be well captured by computer registration software but might still contribute to risk of musculoskeletal outcomes. Furthermore, some of the difference between self-report of computer use and computer registration software data might be accounted for by this activity. In another study comparing computer registration software and self-report of daily computer work, Douwes *et al*[7] observed a Pearson correlation coefficient of 0.41. A study by Mikkelsen *et al*[8] compared self-report of computer use to computer registration software and found Spearman correlations of 0.51, 0.51 and 0.36 for computer, mouse and keyboard times. The duration of observation and recall in that study was 4 weeks. Comparison of the results of Homan and Armstrong[6] and Mikkelsen *et al*[8] raise the question of whether shorter recall periods are associated with stronger correlations between self-report and computer registration software results.

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Neither random error nor non-differential over-reporting can account for the stronger associations observed between self-report of computer use and musculoskeletal outcomes than computer use ascertained with computer registration software and musculoskeletal outcomes. Random error alone would attenuate observed associations, not create them. Because self-report is a behavioural method, it may be influenced by the experience of study participants, especially the experience of pain. In a study comparing methods of assessing the duration of computer use, Heinrich *et al*[9] noted that, compared to computer registration software, computer users with musculoskeletal outcomes overestimated total duration of computer use by 1.8 h and computer users without musculoskeletal outcomes overestimated computer use by 1.5 h. Mikkelsen *et al*[8] observed that distal arm pain was positively associated with self-reported computer time as well as self-reported mouse time, and negatively associated with self-reported keyboard time after controlling for computer registration software ascertained computer time and other covariates. Only if the assumption is made that computer registration software data provide the true measure of the hazard associated with keying, do these results show differential error (ie, exposure reporting bias due to the experience of symptoms). If, rather, self-report captures some hazardous aspect of computer use not captured by computer registration software, these results may simply reflect a true causal association.

Two distinct hypotheses emerge from these data. The first is that computer registration software is the true, objective, gold standard to measure computer use and is a scientifically appropriate replacement for self-reported computer use. If true, this would suggest that associations observed between self-report of computer use and musculoskeletal outcomes are the result of biased reporting (ie, greater overestimation of exposure among those with musculoskeletal outcomes than among those without musculoskeletal outcomes). The second hypothesis is that computer registration software, while 'objective', does not quantify the full set of musculoskeletal hazards associated with computer use. For example, as noted above, time spent with arms poised over the keyboard may place static postural loads on the musculoskeletal system without being captured by computer registration software. If true, then differences in associations with musculoskeletal outcomes observed between self-report and computer registration software are the result of differences in what they capture rather than how well they capture it.

The methodological limitations of self-reports have been known for a long time and some studies of musculoskeletal outcomes among computer users have attempted to minimise bias that might result from their use. For example, in a prospective study of musculoskeletal outcomes among computer users, Marcus *et al*[10] gathered computer use information on a daily log that was distributed and collected weekly. Furthermore, only participants who did not meet criteria for musculoskeletal outcomes were recruited into the study, making it likely that exposure information was collected before participants developed clinically significant symptoms. Such methods are well established approaches for minimising the collection of biased exposure information.

Computer registration software is a relatively new tool for ascertaining computer use information. Unlike the simple question 'How many hours did you use a computer this week?', computer registration software requires the reduction of large amounts of time series data into simpler summary measures. Typically, software developers select 'inter-event periods' which define periods of input device use that are summed to create daily or weekly computer, keyboard and mouse use duration values. Preliminary investigations suggest that cut-offs ranging from 28 s to 60 s produce computer use durations that correlate strongly with video observation of computer users.[11] The software used by IJmker *et al*[1] used a computer duration of 30 s, a mouse duration of 5 s and a keyboard duration of 2.5 s. Such choices are somewhat arbitrary, as noted by Mikkelsen *et al*,[8] and varying them may affect observed associations. It is also possible that additional examination of raw data collected with computer registration software will result in additional summary measures more strongly associated with musculoskeletal outcomes. Given the extraordinary amount of raw data that can be collected with these methods, it is possible that the most useful estimates of computer use have yet to be characterised.

In summary, the paper by IJmker *et al*[1] is an important and provocative addition to the literature examining associations between computer work and musculoskeletal outcomes. The mostly null associations observed between computer registration software measures of computer use and musculoskeletal symptoms raise important questions about the validity of the large body of literature based on self-report of computer use. However, the failure to observe associations between computer registration software and musculoskeletal symptoms in this study does not invalidate the much larger literature in which self-reported computer use was associated with musculoskeletal symptoms. We will be well served to better understand, from a biological perspective, exactly what attributes of work are captured by self-report and by computer registration software. Such knowledge will be the building blocks for more useful epidemiological investigation of the relationship between computer use and musculoskeletal outcomes.

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