GENDER DIFFERENCES IN THE RELATIONSHIP BETWEEN DAILY COMPUTER USAGE AND MUSCULOSKELETAL SYMPTOMS AMONG UNDERGRADUATE STUDENTS

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We conducted a repeated measures pilot field study on 27 undergraduate students (14 males and 13 females) to investigate the relationship between daily computer usage time and musculoskeletal symptoms. For three one-week periods during a single semester, students reported symptoms (outcome) 3-5 times daily while computer usage time (exposure) was objectively measured by a usage monitor software installed onto participants' own computer. Generalized estimating equation (GEE) regression models tested the relationship between outcome and exposure. In males, each additional hour of daily computer usage was associated with an increased odds ratio of reporting symptoms to 1.18 (1.05-1.34). In females, the corresponding increased odd ratio for each additional hour of daily usage was 1.02 (0.96 to 1.08). The results also suggested a potential dose-response relationship between daily computer usage time and musculoskeletal symptoms; however, the significance of relationship was different between genders.

INTRODUCTION

Undergraduate and graduate students have high prevalence of computing-related musculoskeletal symptoms and disorders (MSD's). Katz et al., 2000 reported that 41% of a senior undergraduate cohort experienced upper extremity musculoskeletal symptoms after using computer for several hours at a time. A high prevalence (60%) of persistent or recurrent upper extremity or neck pain related to self-reported computer usage was also found in a cohort of engineering graduate students (Schlossberg et al., 2004). Female students' prevalence of computing-related MSD's could be as high as 81% within a two-week period (Hamilton et al., 2005). These symptoms can become severe enough to create functional limitations on the students' school performance, and result in disabilities that affect the future career and health of this next generation of workers (Hupert et al., 2004; Katz et al., 2002).

Computing time is the most consistently reported risk factor for computing-related MSD's among both workers and students (Gerr et al., 2004; Katz et al., 2000; Schlossberg et al., 2004). In previous studies, however, the duration estimates of computer usage were based upon self-reported data and might not be accurate (Homan and Armstrong, 2003). To objectively quantify exposure, in this study, we estimated the computer usage time with a usage monitor software which records input device activities.

Females' prevalence of computing-related upper extremity MSD's is higher than males in both worker (Gerr et al., 2002; Punnett and Bergqvist, 1999) and student population (Katz et al., 2000). When specific physical exposure is controlled for, the difference between genders could, however, be mitigated (Punnett and Bergqvist, 1999). Laboratory studies have demonstrated gender differences in physical exposure to postural and force load (De Smet et al., 1998; Karlqvist et al., 1998; Wahlstrom et al., 2000). To further explore gender differences, this study compared male and females' relationships between computer usage and MSD's.

The goal of this study is to investigate the relationship between musculoskeletal symptoms and daily computer usage time among undergraduate students. We test the hypothesis that 1) longer durations of daily computer usage are associated with more musculoskeletal symptoms and 2) males and females have different relationships between computer usage and musculoskeletal symptoms.

METHOD

We measured computer input device activities and musculoskeletal symptoms on a pilot cohort of 27 undergraduate students (13 females and 14 males, 20.6±1.5 years old) for three separate one-week periods during the spring semester of 2004. The study protocols were approved by the human subject committees of the

Harvard School of Public Health, the University of Texas Houston Health Sciences Center and the participants' institute. To be included in study, all participants met the criterion of using their own computer at least 80 percent of their computing time.

Measuring musculoskeletal symptoms

To measure musculoskeletal symptoms, each participant reported their musculoskeletal symptoms multiple times a day to a personal digital assistant (PDA) carried with him/her. The PDA randomly prompted the participant 10 times a day, and the participant reported their symptoms to the PDA questionnaire if he/she was available at the time of the prompt. The PDA questionnaire assessed pain and discomfort for 13 parts of the upper extremities and back areas with a five-level scale (none, mild, moderate, severe and non-severe). We obtained an average of 4.0 reports per subject per day. Each PDA symptom report represented a data point in the analysis. We afterwards dichotomized the symptom severity and defined the outcome of data point to be "symptomatic" when the symptom level was moderate, severe or very severe for any body part; the outcome of a data point was defined to be "asymptomatic" when symptom severity was none or mild for all the body parts.

Measuring computer usage time

A customized computer usage monitor software was installed onto each participant's primary computer to continuously measure input device activities (keyboard and pointing device use). For each data point in the data analysis, the PDA symptom report was the outcome, and the corresponding exposure was the daily computer usage time calculated from the software-recorded data. We calculated the estimate of daily computer usage time for the 24-hour period prior to the time when a PDA questionnaire was filled in. The estimate was calculated by summing up input device activity times along with input device inactivity periods that lasted less than 60 seconds (Chemor-Ruiz et al. 2003). The inclusion of short inactivity periods was aimed to capture the users' passive interactions with the computer, such as viewing the monitor.

Statistical analysis

To compare the symptoms between genders, we tested the difference of symptom reporting rate (symptom/day) between female and male participants with a two-sample t-test. To compare computer usage patterns between genders, we also used two-sample t-tests to examine gender differences in average daily computer usage time and in ratios of average daily pointing device usage to keyboard usage (input device usage patterns).

Generalized estimating equation (GEE) mixed models were used to test the hypothesis that longer daily computer usage is associated with reporting musculoskeletal symptoms. The data was analyzed first with all participants included, and then stratified by genders. The dependent variable was the dichotomous musculoskeletal symptom; independent variables included preceding daily computer usage (fixed effect), subject (random effect) and the interaction term. The interaction term was dropped from the final model for its statistical insignificance. Preceding daily computer usage time was treated in three ways: continuous, dichotomized by cut points (2, 2.5, 3, 3.5 and 4 hour of daily usage), and categorized by quartiles. Each different exposure variable was tested separately for its relationship with musculoskeletal symptoms.

RESULTS

For all participants, daily computer usage longer than three hours was significantly related to higher odds of reporting symptoms when exposure was treated as dichotomous (see Table 1). The odds ratio of reporting symptoms increased with the quartiles of daily computer usage time but with only marginal statistical significance (see Table 2). The relationship between the continuous exposure variable and the outcome was also of marginal statistical significance (OR=1.05/hour, CI=0.99-1.1).

Table 1. Odds ratios of reporting musculoskeletal symptoms for the dichotomous daily exposure variables. Each variable was tested separately in a different model. The reported odds ratios were associated with the high exposure levels (daily computer usage time > cut point).

Daily exposure	%of all reports	OR	95% CI for OR
>2hr	46%	1.43	0.92 - 2.24
>2.5hr	38%	1.44	0.98 - 2.09
>3hr	**32%**	**1.50**	**1.01 - 2.25**
>3.5hr	**27%**	**1.51**	**1.01 - 2.25**
>4hr	23%	1.28	0.85 - 1.93

Table 2. Odds ratios of reporting musculoskeletal symptoms for the categorical daily exposure variable. The exposure was categorized by the quartiles of daily computer usage time across all data points.

daily usage time (hr)	OR	95% CI for OR
<0.32	1	-
0.32-1.74	1.49	0.87 - 2.56
1.74-3.73	1.5	0.8 - 2.82
>3.73	1.95	0.91 - 4.17

Females' symptom reporting rate was marginally higher than males (0.8±1.0 symptom/day vs. 0.2±0.2 symptom/day, p=0.052). Only one female (8% of the females) and three males (21% of the males) were free from any musculoskeletal symptom throughout the study period. Average daily computer usage time was not different between males and females (1.9±0.9 hours vs. 1.8±1.4 hours, p=0.78). Ratios of daily pointing device usage time to keyboard usage time (input device usage patterns) were also not different between males and females (4.8±0.8 vs. 3.2±0.8, p=0.23) (Figure 1).

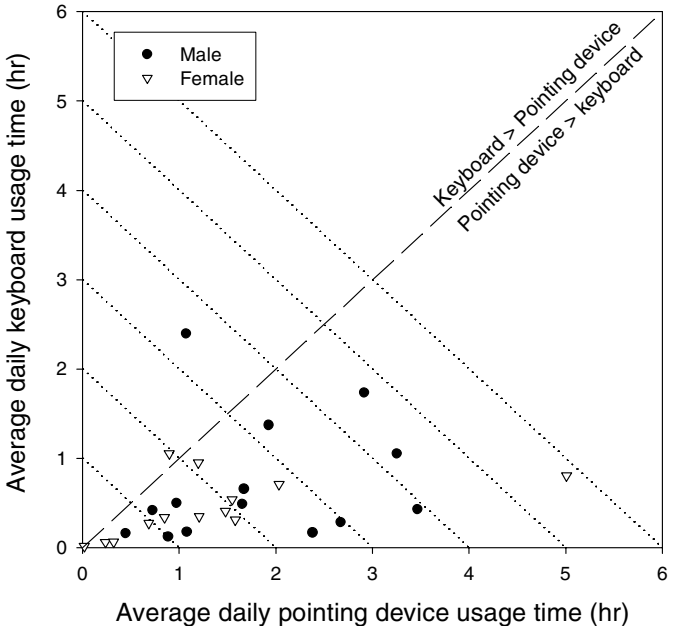

Figure 1. Average daily pointing device usage time versus keyboard usage time for the 27 participants throughout the study period. The dash line represents one-to-one relationship. A majority of this cohort used their pointing devices more than keyboards.

Table 3. Odds ratios of reporting musculoskeletal symptoms associated with every hour increase of daily computer usage time (exposure variable treated continuous).

	OR	95% CI
All participants	1.05	0.99 - 1.1
Males	**1.18**	**1.05 - 1.34**
Females	1.02	0.96 - 1.08

Table 4. Odds ratios of reporting musculoskeletal symptoms for the dichotomous daily exposure variables in the gender-stratified models. Each variable with a different cut point was tested separately in a different model. The reported odds ratios were associated with the high exposure level (daily computer usage time > cut point).

	Male			Female		
	%of reports	OR	95% CI	% of reports	OR	95% CI
>2hr	46%	2.01	0.91-4.44	45%	1.23	0.72-2.1
>2.5hr	**39%**	**1.96**	**1.12-3.42**	38%	1.25	0.78-1.98
>3hr	**34%**	**2.09**	**1.17-3.72**	30%	1.29	0.76-2.2
>3.5hr	**28%**	**1.88**	**1.16-3.05**	27%	1.36	0.78-2.34
>4hr	23%	1.64	0.93-2.89	23%	1.13	0.65-1.98

Table 5. Odds ratios of reporting musculoskeletal symptoms for the categorical daily exposure variable in the gender-stratified models. The exposure was categorized by the quartiles of daily computer usage time across all data points within each gender.

Male		Female	
Daily usage time (hr)	OR (95% CI)	Daily usage time (hr)	OR (95% CI)
0-0.6	-	0	-
0.6-1.9	2.18 (0.58-8.25)	>0-1.6	1.51 (0.83-2.77)
1.9-3.73	**3.22 (1.06-9.74)**	1.6-3.7	1.28 (0.60-2.73)
>3.7	**4.12 (1.51-11.22)**	>3.7	1.62 (0.65-4.05)

In the gender-stratified models, preceding daily computer usage time, when treated as a continuous variable, was significantly related to symptom reporting among the males, but not among the females (Table. 3).

When dichotomized, daily usage time longer than 2.5 hours was related to higher odds of reporting MSD in the males, but not in the females (Table. 4). When males' preceding daily computer usage time was categorized by the quartiles, odds of reporting symptom also increased with the quartiles of exposure (Table 5). Despite the statistical insignificance observed on females, their odds ratio of reporting symptoms inconsistently increased with the quartiles of exposure.

DISCUSSION

A potential dose-response relationship between daily computer usage time and musculoskeletal symptoms was observed among 27 undergraduate students within a framework of single days. The observed relationship was based on objectively quantified exposure, and was sensitive to gender where we observe a stronger statistically significant relationship among the males and greater variability in outcomes and exposure among the females.

Although the females in the study cohort had marginally higher symptom reporting rate, their symptoms were not related to daily computer usage time. The lack of an association might be due to misclassification of the outcome or the exposure, or confounders.

If females' symptoms were caused by activities or factors irrelevant to computer usage, outcome misclassification might bias the result towards the null. In the general population, females have higher prevalence of more severe, more frequent and longer pain (Unruh, 1996). These pains include musculoskeletal pain over the neck, shoulders, upper extremities and back, which were also the outcomes of interest in our study. Our outcome measure might have captured symptoms that were irrelevant to computer usage.

Our exposure estimate examined the computer usage within a 24 hour exposure window right before the outcome was measured. The 24-hour exposure window was chosen to test the short term relationship between computer usage and musculoskeletal symptoms. Our assumption of no exposure lagging and the short exposure window might result in exposure misclassification and contributed to the observed gender differences. Further study will investigate different exposure windows and exposure lagging.

There were four females (30% of the females) with a large amount of symptom reporting, and two of them had little computer usage. When symptoms were severe enough, participants might be limiting computer use during recovery. We have also observed decreased usage time for the most severe symptom reporting. Interaction between computer usage and symptoms might bias the observed relationship towards the null. The limited number of participants in this study might amplify the sensitivity to the aforementioned limitation.

In the analysis, we did not control for other MSD risk factors such as anthropometric dimensions, postures, and other potential transient risk factors. These factors might be potential effect modifiers or confounders depending upon their relationship with the exposure and outcome. Repeated measures design was applied in this study to prevented possible biases resulting from individual risk factors that do not change in a short period of time (e.g. anthropometric dimension).

Posture has been related to musculoskeletal symptoms/disorders over upper extremities, neck, upper back and carpal tunnel syndrome (Bergqvist et al., 1995; Brandt et al., 2004; Faucett and Rempel, 1994; Marcus et al., 2002; Matias et al., 1998). Using computer usage time as the estimate of exposure is, however, based on the assumption that the type of exposure remains consistent (e.g. small or no change of posture) throughout the time. The assumption needs to be further verified; nevertheless, Ortiz et al. (1997) suggested that single postural measurement on an individual is sufficiently stable over time.

Other potential transient risk factors, such as physical activities or instrument practice, were unlikely related to daily computer usage time. If these transient risk factors were correlated with daily computing time, a negative correlation is more plausible (e.g. longer computing time could be correlated with shorter exercise time) and therefore might have biased our results towards the null. We did not have supporting data from the study cohort to clarify these potential confounding factors, and, therefore, collecting information on these factors should be considered in further studies.

Although keyboard use and pointing device use are associated with different physical exposures (Dennerlein and Johnson, 2006; Laursen et al., 2002), the observed gender difference could not be explained by input device usage patterns. Firstly, input device usage pattern was not different between males and females. Secondly, including the input device usage pattern as a covariate in the statistical models did not result in statistical significance. When preceding daily computer usage time was divided into keyboard usage and pointing device usage and tested separately for their relationships with the symptoms, similar gender difference was still observed for pointing device usage time. Keyboard usage time was not associated with the symptom in both genders due the overall short usage time and small variance observed in this cohort.

In conclusion, we observed a potential dose-response relationship between daily computer usage time

and musculoskeletal symptoms among the males in a small cohort of undergraduate students. The lack of an association for the females might be due to misclassification of outcome or exposure, or potential confounders. The results and information obtained from this pilot study will be applied into promising future studies.

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