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Computer Use Patterns Associated with Upper Extremity Musculoskeletal Symptoms

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Abstract

Introduction—Over half of surveyed college students are experiencing pain they are attributing to computer use. The study objective was to evaluate the effect of computing patterns on upper extremity musculoskeletal symptoms.

Methods—Symptom experiences and computing/break patterns were reported several times daily over three weeks for 30 undergraduate students over a semester. Two-level logistic regression models described the daily association between each computing pattern and both *any* and *moderate or greater* symptom experienced, for covariates.

Results—The associations between most computing/break patterns and experiencing *any* symptoms were positive: total hours of computer use adjOR = 1.1 (90% CI 1.1–1.2), 1–2 breaks versus none adjOR = 1.3 (90% CI 0.9–1.9), 3–6 breaks versus none adjOR = 1.5 (90% CI 1.1–2.2), >15 min break versus none adjOR = 1.6 (90% CI 1.1–2.2), and number of stretch breaks adjOR = 1.3 (90% CI 1.1–1.5). However, breaks for less than 15 min were negatively associated

with experiencing *any* symptoms: adjOR = 0.6 (90% CI 0.5–0.9). The associations between most computing/break patterns and experiencing *moderate or greater* symptoms were positive: total hours of computer use OR = 1.1 (90% CI 1.1–1.2), 1–2 breaks and 5–6 breaks versus none OR = 1.8 (90% CI 1.1–2.9), 7–8 breaks versus none OR = 2.0 (1.0–4.2), >15 min break versus none 1.8 (1.1–3.1), and number of stretch breaks OR = 1.3 (1.0–1.5).

Conclusion—Computing/break patterns were consistently associated with experiencing symptoms. Our findings suggest evaluating breaks with computing duration (computing patterns) is more informative than assessing computing duration alone and can be used to better design ergonomic training programs for student populations that incorporate break times.

Keywords

Computer use; Musculoskeletal symptoms; Upper extremity; College student

Introduction

Work-related upper extremity musculoskeletal disorders are a well-known public health burden in the United States; the annual costs are estimated in the tens of billions (in dollars) [1]. Because computing-related jobs play a dominant role in the US economy [2], upper extremity musculoskeletal disorders related to computer use have the potential to be a major public health concern. In 2003, the US Census Bureau reported more than half of working Americans used a computer at work. One aspect of computer use, computing patterns, has been the focus of health studies in identifying risk factors related to upper extremity musculoskeletal disorders [3]. Twenty hours or more of weekly computer use and years of computer use were identified as probable risk factors for upper extremity musculoskeletal disorders [3]. Further research investigating computer use patterns (breaks, temporal variations) and incidence of upper extremity musculoskeletal disorders is needed to inform office ergonomic intervention design.

College students, because of their promising role as knowledge workers in a computing-dominated career, are a population well suited for studying the effects of computer use on upper extremity musculoskeletal symptoms and disorders. Computing-related upper extremity musculoskeletal symptoms have been reported in two cross-sectional studies of two separate undergraduate student populations [4, 5]. Additionally, clinical examinations administered to graduate students as part of a validation study found approximately 15% met criteria for an upper extremity musculoskeletal disorder [6]. Recently, using software installed on college students' computers to monitor computer usage a positive association with upper extremity musculoskeletal symptoms after 3 h of computer use was observed [7]. Studying computer use patterns of college students within a typical semester provides a significant opportunity to learn about an important part of the development of a major occupational disorder.

Previous studies examining computer use among workers has not been consistent when defining computing exposures [3]. Among prospective studies, computer use as an exposure has been measured in hours per week with varying cut points, no computer use versus any and proportion of time at work [3]. Data on frequency, duration and type of breaks are generally not collected so only time using a computer, rather than computer use patterns, can be described [3]. Inconsistencies in computer use exposure classification make it difficult to summarize exposures and generalize research findings when synthesizing research. Consequently, it becomes more challenging to design evidence-based office ergonomics interventions. A recent systematic review concluded few high quality studies examined the effect of office ergonomic interventions on health: interventions focused on rest breaks (4

studies) found mixed evidence to support a positive impact of rest breaks on musculoskeletal health and moderate evidence (2 studies) to support no impact of rest breaks with stretching exercises on musculoskeletal health [8]. It is crucial that consistent and more comprehensive computer use exposure classifications be used to facilitate synthesizing findings in the literature that will in turn allow for better designed office interventions.

The purpose of this study is to evaluate the effect of computer use patterns on upper extremity musculoskeletal symptoms status characterizing: (1) the relationship between hours of computer use and symptoms, (2) the association between number and length of breaks taken and symptoms, and (3) the role rest/stretch breaks play in symptoms occurrence.

Methods

Study Design

In the Spring 2004 academic semester, a repeated measures study on a convenience sample of 30 students (15 men and 15 women) from a single residential college at a private university was conducted [9]. Flyers advertising the study were circulated throughout the college a week prior to the event. A day before the event the student government association distributed emails to all students in the residential college. Enrollment occurred after the study was presented to the students and informed consent was obtained. The study was comprised of a 20-min baseline survey and three weeklong data collection periods held during the semester. Contact information obtained at baseline was used to schedule the 7-day data collection periods. The data collection periods were used to distribute a handheld computer to each participant in order to administer a 2-min electronic survey. Participants were prompted to respond to the survey approximately 5 times a day by random beeping of the handheld. At the time of handheld distribution the meaning of survey questions were explained and discussed with each participant.

Study Sample

Undergraduates aged 18 years and older from a private university were eligible to participate if they owned a computer. All study participants belonged to a single college (dormitory) during the Spring, 2004, academic semester. The university's Institutional Review Board and the University of Texas at Houston Health Science Center Committee for the Protection of Human Subjects approved the study protocol.

Outcome Measures

The symptom severity (outcome) measures were measured throughout the semester by using the handheld electronic surveys. Upper extremity musculoskeletal symptom questions asked "How much pain are you now experiencing in your _?" for each of 13 upper extremity body parts: left fingers, right fingers, left wrist, right wrist, left forearm, right forearm, left upper arm, right upper arm, left shoulder, right shoulder, neck, upper back and lower back. Possible responses were none, mild, moderate, severe and very severe. Based on preliminary analyses, two dichotomous dependent variables were created describing overall symptom severity. The vast majority of symptom experienced were mild, so the first outcome measure indicated any symptoms reported in any body part (any symptoms). To explore whether a different set of risk factors exist with increased severity, a second outcome was created to indicate moderate, severe or very severe symptoms in any body part (moderate or greater symptoms).

Predictor Variables

Data on computing patterns were obtained from the electronic surveys collected throughout the semester and include: hours of daily computer use, break frequency, break length and stretch break frequency. Data regarding daily computer use was obtained from two different questions: “for how long have you been working on your computer today” and “for how long have you been working on another computer today”. Possible responses to both of these questions were 0, <2, 2–4, 4–6, 6–8, 8–10 and >10 h. Responses to both questions were combined to get one value of total daily computer use for each survey response. Break frequency was obtained from the following two questions: “Have you taken any breaks (15 min or longer) away from the computer today” and “if you have taken breaks, how many”. Responses included none, <2, 2–4, 4–6, 6–8 and 8–10 h. Break length was calculated from the following question, “how many minutes has a typical break from the computer been today”, where possible responses were none, less than 5, 5–10, 10–15, 15–30, 30–45 and more than 45 min. Stretch break frequency was obtained from the following questions: “Have you taken any breaks to specifically rest or stretch your hands, wrists, arms, neck or shoulders?” where, if responding “yes”, participants were then prompted to answer <2, 2–4, 4–6, and 6–8 and not applicable when asked “how many times”.

Based on preliminary analyses, computer use and stretch break frequency were kept as continuous variables. Number of breaks was categorized into none, 1–2, 3–4, 5–6, 7–8 and 9 or more. Break length was classified as none, less than 15 min, 15–45 min, and more than 45 min. In order to compare with previous work, a set of indicator variables was created to estimate the association between symptoms and 1–2, 3–5, 6–8 and 9–14 h of computer use compared to no computer use [7].

Covariate Selection

The covariate selection process was described previously [10]. The four categories of the potential covariates collected at baseline were pain, workstation characteristics, healthcare utilization and individual factors. The covariates relating to pain were: pain associated with working on a computer ever or in the past 2 weeks, pain affecting the academic experience, the Brigham & Women's Symptom Severity Scale [11], severity of bodily pain in the past four weeks, pain at the time of the baseline survey, difficulty performing tasks due to pain, pain interfering with normal activities, overall health and the SF-36 MHI-5 scale for affective mood disorders [12]. Potential covariates describing healthcare utilization were: seeking help from others when in pain, seeing healthcare provider when in pain and taking medications to relieve pain. Individual factors included: undergraduate class, study concentration, gender, playing a musical instrument, playing a sport and minority status. A single workstation characteristic was assessed: ergonomic improvements made to the computing environment. Briefly, information obtained from the baseline survey were individually entered into a multilevel logistic regression model. Any potential covariates associated with either of the two symptoms outcomes at $p < 0.05$ were considered further in the model-building process. A backwards stepwise logistic regression model-building process was used to further evaluate the status of each covariate. At the end of the process pain felt within two weeks of baseline was found to be associated with both *any* symptoms and *moderate or greater* symptoms.

Three separate potential covariates collected from time-stamping of the electronic surveys were evaluated. These time-related variables were created to describe temporal variations in upper extremity musculoskeletal symptoms. Specifically, they are: time of day/24-h period (dichotomized into before midnight which represents 6 am to 11:59 pm and after midnight which represents 12 am to 5:59 am of the same 24-h cycle), day of week (Sunday through Saturday) and number of days into the semester (represented as dummy variables with 35–

57 as the referent, 58–76, 77–90 and 91–117 days). Days into the semester began at 35 rather than 1 because that is the day sampling started (February 14, 2004).

One potential covariate directly from the electronic survey, type of computer used, was evaluated. Possible responses were none, laptop, desktop and both. An analysis using dummy variables created from this question revealed computer type was associated with both *any* symptoms and *moderate or greater* symptoms.

Statistical Analysis

Two-level logistic models were constructed to separately test the association of computer use variables with each outcome measure adjusting for covariates. The two data levels are participant (level 2) and repeated symptom measures within each participant (level 1). The following model was used to describe the relationship of the outcome to the predictor variables:

$$\text{logit} [\pi_{ij}] = \beta_{0j} (\text{constant}) + \beta_p (\text{Computer use variable})_{ij} + \beta_c (\text{Covariates})_j$$

$$\beta_{0j} = \beta_0 + u_{0j}$$

where π_{ij} is the probability of experiencing *any* or *moderate or greater* musculoskeletal symptoms, β_{0j} is the intercept for each individual, β_p the effect of computer use variable(s) within individual j , β_c the effect of selected covariate(s) per individual j , u_{0j} follows a normal distribution with mean 0 and variance σ^2_{u0} .

Separate multilevel logistic models were estimated for each computer use variable to identify significant associations ($p \leq 0.10$). Level 2 residual analyses were performed to determine if distributional assumptions were violated or if systematic variation in the residuals occurred. Although the distributional assumptions were not fully met, no anomalies were discovered. The multilevel models were fitted using MLwiN 2.0 and all other analyses were carried out with STATA 8 [13, 14].

Due to the average number of time points of electronically collected data throughout a day, a decision was made a priori that the data would be kept cross-sectional rather than made longitudinal for the analyses. Analyzing cross-sectional data means all data collected are used for the analyses rather than in longitudinal analyses where both the first symptoms report for each participant for each day and the last computing patterns report on each participant for each day would have been dropped. A cut point of 0.10 for significance was decided upon a priori as the pilot research was exploratory and the goal was to meet objectives rather than test hypotheses.

Results

Study Population

Fifteen men and fifteen women, all undergraduates, agreed to participate. Briefly, more than half were upperclassmen and approximately one-third were freshmen. Just over half identified themselves as belonging to a minority group. The majority of students were science/engineering majors (54%), while 43% were liberal arts majors. Self-reported computer use collected at baseline averaged 3.2 h a day (SD 1.8). Most of the computing (81%) was done in student rooms. Computing was done at the desk of 97% of the participants who reported computing in their room. A laptop served as the personal

computer for more than half of the participants (55%). More than half of the participants played a sport (55%) and 35% played a musical instrument [9].

Outcome Distribution

The 30 participants contributed to a total of 2,112 survey events (symptoms and computer use data). Of these survey events, 26% ($n = 553$) were symptomatic. The majority of the symptoms were mild (19% of all responses), followed by moderate symptoms (9% of all responses). The remaining 1% of events represented severe and very severe symptoms.

Unadjusted Effects

Hours of Computer Use—The continuous variable for hours of computer use was statistically significantly associated with both *any* symptoms (OR = 1.1, 90% CI 1.1–1.2) and *moderate or greater* symptoms (OR = 1.2, 90% CI 1.1–1.3). Hours of computer use ranged from 0 to 14 (see Table 1).

Number of Breaks—Only 1–2 breaks, 3–4 breaks and 5–6 breaks were associated with *any* symptoms (compared to no breaks). Interestingly, they were positively associated with *any* symptoms: 1–2 breaks, OR = 1.4 (90% CI 1.0–1.9), 3–4 breaks, OR = 1.4 (1.1–1.8) and 5–6 breaks, OR = 1.4 (1.0–1.8). *Moderate or greater* symptoms were statistically significantly associated with 1–2 breaks (OR = 1.6, 90% CI 1.0–2.5) and 9 or more breaks (OR = 3.5, 90% CI 1.9–6.3), both compared to no breaks.

Break Time—For *any* symptoms, all break lengths were positively and significantly associated with symptoms. Specifically, breaks for less than 15 min were associated with an OR = 1.7 (90% CI 1.3–2.2), breaks from 15 min to 45 min were associated with an OR = 1.6 (90% CI 1.2–2.2) and breaks longer than 45 min were associated with an OR = 1.5 (90% CI 1.1–1.9). For *moderate or greater* symptoms only breaks from 15 to 45 min were associated with symptoms (OR = 2.3, 90% CI 1.5–3.6).

Stretch Breaks—Stretch breaks were positively associated with both symptom outcomes: OR = 1.2 (90% CI 1.1–1.3) for *any* symptoms and OR = 1.3 (90% CI 1.1–1.4) for *moderate or greater* symptoms. Number of stretch breaks ranged from none to 7.

Adjusted Effects

The association between hours of computer use and either symptoms outcome did not substantially change after adjustment (Table 2). The odds ratios for stretch breaks did not change notably after adjustment as well (for *any* symptoms, OR = 1.2 to OR = 1.1 after adjustment; for *moderate or greater* symptoms, OR = 1.3 to OR = 1.1 after adjustment). Only 3–4 breaks and 5–6 breaks per day remained statistically significantly associated with *any* symptoms after adjustment for covariates; 9 or more breaks was no longer significantly associated with *moderate or greater* symptoms after adjustment for covariates. Break length greater than 15 min compared to no breaks remained positively associated with both symptoms outcomes after adjustment for covariates, although the association with *moderate or greater* symptoms was attenuated after adjustment (OR 2.3 to OR 1.8).

When dichotomized at 4 h or more of computer use versus less than 4, 4 h or more was statistically significantly associated with both *any* symptoms (OR = 1.4, 90% CI 1.1–1.8) and *moderate or greater* symptoms (OR = 1.6, 90% CI 1.1–2.3). Compared to no computer use, computing for 1–2 h was statistically significantly associated with *any* symptoms (OR = 1.8, 90% CI 1.2–2.7), 3–5 h was statistically significantly associated with *any* symptoms (OR = 2.6, 90% CI 1.7–4.0), 6–8 h was statistically significantly associated with *any* symptoms (OR = 2.3, 90% CI 1.3–4.2) and computing 9–14 h was statistically significantly

associated with *any* symptoms (OR = 5.5, 90% CI 2.7–11.4). Regarding *moderate or greater* symptoms, computing for 1–2 h, 3–5 h and 6–8 h were not significantly associated with the outcome compared to no computing (OR = 0.9, 90% CI 0.5–1.5; OR = 1.2, 90% CI 0.7–2.2; OR = 1.0, 90% CI 0.4–2.3; respectively). However, computing for 9–14 h was positively significantly associated with *moderate or greater* symptoms (OR = 3.8, 90% CI 1.5–9.5).

Discussion

In a repeated measures study design, we sought to characterize the association between computer use patterns and two different symptoms outcomes. Previous literature has focused on weekly self-reported estimates of computer use whereas we examined estimates of computer use throughout the day, along with estimates of break frequency and length captured throughout the day [15–21].

In previous research, we reported the significance of baseline measurements of pain and time-related variables in describing symptom severity outcomes [10]. When adding computer type and computing patterns into the models, these associations remained statistically significant and positive. This reinforces and supports the importance of temporal variations in predicting upper extremity musculoskeletal symptoms.

Cumulative hours of computer use throughout the day was statistically significant and consistent in describing both *any* symptoms and *moderate or greater* symptoms before and after covariate adjustment. Because most studies in this field have examined weekly computer use our use of daily computer use is a novel approach. It was considered a logical approach after Amick et al. 2003 [22], found among computer users average symptoms increased throughout the workday (not the workweek), peaking at the end of the workday (late afternoon) and resuming the same average levels the next morning. This finding suggested symptoms responded in a matter of hours to computer use exposures. We found the odds of experiencing both *any* symptoms and *moderate or greater* symptoms increased linearly (test for trend with computing measured as continuous variable) for each hour of computer use reported. Direct comparisons with earlier work are not appropriate since symptoms were measured on a different scale for this study (none, mild, moderate, severe and very severe) in contrast with the 0–10 point modified Nordic scale used in Amick et al. [22]. However, our findings show a peak in the probability of symptoms occurring after midnight compared to before midnight, the student version of an end of workday effect seen in earlier work.

To compare with previous work that found computing for 3 h or more was significant, we assessed the association of computer use with both outcomes using an alternative classification: none, 1–2 computing hours, 3–5 computing hours, 6–8 computing hours and 9–14 computing hours. Similar to Chang et al. [7], we found generally increasing odds ratios for increasing hours of computer use using this classification of exposure. However, we also found a statistically significant association with experiencing any symptoms after 1–2 h of computer use compared to no use. A similar odds ratio for computing for 6–8 h was seen as with 3–5 h, with the highest odds ratio observed for computing 9–14 h. For this analysis, we did not observe any compelling reason why computing 3 h or more should be used as a cut point in lieu of any other hours of computer use. Furthermore, associations with moderate or greater symptoms were not significant until a threshold of nine or more hours of computing was used (OR = 3.8, 90% CI 1.5–9.5). Additional research evaluating a full enumeration of one residential dorm of college students is expected to provide more insight into optimal classifications of exposures like computing hours.

The positive associations between break frequency and break length with symptoms were unexpected. It was anticipated that taking more breaks and greater break length would be associated with not experiencing symptoms. However, after adjustment, only taking breaks for less than 15 min was negatively associated with *any* symptoms (OR = 0.6, 90% CI 0.5–0.9). This brings attention to the idea that smaller breaks may be as beneficial or, possibly, more beneficial than larger breaks when computing. In this study a smaller break may be considered as one lasting more than 15 min: all larger breaks were consistently positively associated with experiencing symptoms. This could be that participants were not taking breaks until they were symptomatic and symptoms did not subside quickly in response to the larger breaks. An alternative explanation is participants who are more susceptible to symptoms take more and longer breaks. However, we find this explanation unlikely since participants with baseline pain (found to be associated with symptom experience in the covariate selection process) would also be more susceptible to symptoms and consequently take more frequent and lengthy breaks, but should be controlled for in the analysis as baseline pain was a covariate. To further investigate these questions, a software program designed to quantify computer use, keyboard use, mousing and absence of input device use (breaks) was installed on the computer of each study participant [23]. It is expected the information obtained from this software and linked to symptoms reports will be able to further refine definitions of break time (smaller versus larger) and evaluate their association with symptoms using a direct measure of computer use. Furthermore, a cohort study designed to better evaluate such issues is currently being conducted and will specifically address the relationship between break frequency and length with symptom experience.

The finding regarding the association of computer use hours with both symptoms is novel as most studies in the field have examined weekly hours of computer use. A systematic review of the computing duration literature and office ergonomics intervention literature revealed there is inconsistent evidence in the field regarding break length and frequency [3, 8]. Questions as to how to define break length remain as new ideas of larger (macro) and smaller (micro) breaks have evolved, prompting the need for further research in this area as the evidence describing the positive association between computer use and symptoms becomes more certain. Furthermore, previous work has described the phenomena of “binge computing” which has suggested a positive association between symptoms and computer use for 4 h without taking a break. Resolving the role of break frequency and length and their interaction with computing duration has implications for office ergonomic interventions. While we have reported findings on the most comprehensive aspect of computer use (computing patterns) to date, much still remains unanswered.

Another finding is the different associations seen between each outcome and number of breaks, and to a lesser extent, break length. We had pondered the possibility of a different set of risk factors for each outcome but feel our findings are too premature to do anything more than explore this possibility in future work with a considerably larger sample size and longitudinal analysis. Additionally, more data would provide the power needed to evaluate associations with individual or multiple body parts rather than grouping all of the body parts together to describe symptom experience. Such targeted analyses require considerably more participants and more time points for each participant. Future work planned by the research team will involve a larger population.

A limitation to this work is the cross-sectional approach to the statistical analyses. Although the electronic surveys prompted each participant repeatedly throughout the day, not every prompt was answered, leaving most students with one or two observations in one day. In order to make judicious use of the data that was collected, symptom experiences along with reported computer use for the day until that experience occurred were analyzed together. Prospective analyses would have involved eliminating the first symptom experience for one

day for each individual and pairing subsequent (if available) symptom experiences with prior reports of computer use for that day. This would involve not using a good part of the symptoms data. It is our thought that the cross-sectional approach to the analyses is beneficial because all data are used and the questions on the exposures were worded such that previous exposures are included and cumulated until a symptom experience occurs. For example, a report at 5pm asking about symptoms and computer use would document symptom experience at 5pm but number of hours computing from the beginning of that day until 5pm, giving history of exposure. Future research using this method of sampling and questionnaires will strive to obtain more observations within a day for every participant to allow for prospective analyses to be conducted.

Another limitation is the combination of two populations that may possibly experience symptoms differently: students who had computing-related symptoms from the beginning and students who did not but later experienced symptoms. This may explain some of the unexpected positive associations between break length and frequency with symptom experience. Although two populations with different symptom experience may have been present in the study, we feel all but one (who had symptoms after only a few minutes of computing) would have been included in the study had it been longitudinally analyzed. Based on our previous work we believe it is more likely the positive association between break length and frequency is due more to students not taking breaks until symptomatic. However, data collected by a software installed on each participant's computer to directly monitor computer use and breaks will help resolve the issue of being positively associated with symptoms (and will be analyzed longitudinally). Data collected with this software will also be used to validate self-reported computing time measured for this project.

Overall, we have characterized computing duration and breaks in a population of 30 undergraduates and estimated their association with upper extremity musculoskeletal symptoms. Future research on computer users and computing should evaluate the role break length and break frequency, in addition to computer use, play in symptom experience and development. Knowledge gained from such studies would benefit the design of office ergonomics interventions.

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Table 1

Association between event-specific total computer use, number of breaks, length of breaks and number of stretch breaks by symptoms outcome

	Any symptoms OR (90% CI)	Moderate or greater symptoms OR (90% CI)
<i>Model 1</i>		
Total computer use (hrs)	1.1 (1.1–1.2)	1.2 (1.1–1.3)
<i>Model 2</i>		
Number of breaks		
None	1.0	1.0
1–2 breaks	1.4 (1.0–1.9)*	1.6 (1.0–2.5)*
3–4 breaks	1.4 (1.1–1.8)*	1.4 (0.9–2.1)
5–6 breaks	1.4 (1.0–1.8)*	1.5 (0.9–2.3)
7–8 breaks	1.3 (0.9–2.0)	1.6 (0.9–2.9)
9 or more breaks	1.3 (0.8–2.1)	3.5 (1.9–6.3)*
<i>Model 3</i>		
Break time		
None	1.0	1.0
<15 min	1.7 (1.3–2.2)*	1.2 (0.8–1.8)
15–45 min	1.6 (1.2–2.2)*	2.3 (1.5–3.6)*
>45 min	1.5 (1.1–1.9)*	1.4 (0.9–2.2)
<i>Model 4</i>		
Stretch breaks (frequency)	1.2 (1.1–1.3)*	1.3 (1.1–1.4)*

Unadjusted odds ratios and 90% confidence intervals presented

*
 $p < 0.10$

Table 2
Logistic regression models of computer use with symptoms outcomes, adjusted for covariates, presented by OR (90% CI)

	Any symptoms				Moderate or greater symptoms			
	Model 1	Model 2	Model 3	Model 4	Model 1	Model 2	Model 3	Model 4
Pain	19.3 (8.9–41.7)	18.5 (8.6–40.1)	17.3 (8.0–37.4)	23.6 (9.3–60.0)	20.3 (7.0–50.9)	21.3 (7.2–63.0)	18.0 (6.2–52.3)	18.7 (6.5–54.4)
Laptop	2.3 (1.7–3.0)	3.0 (2.0–4.6)	2.3 (1.7–3.1)	2.1 (1.6–2.9)	2.7 (1.8–4.1)	3.0 (2.0–4.6)	3.0 (2.0–4.6)	2.8 (1.8–4.2)
Desktop	2.2 (1.6–2.9)	2.1 (1.4–3.3)	2.3 (1.8–3.0)	2.3 (1.7–2.9)	1.8 (1.2–2.8)	2.1 (1.4–3.3)	2.1 (1.4–3.1)	2.0 (1.3–3.0)
Both	2.7 (0.9–8.6)	3.3 (0.6–17.1)	2.6 (0.8–8.3)	1.9 (0.6–6.6)	3.4 (0.7–16.2)	3.3 (0.6–17.1)	3.5 (0.7–17.3)	4.4 (1.0–19.3)
<i>Days in semester</i>								
35–57	1.0 (referent)	1.0 (referent)	1.0 (referent)	1.0 (referent)	1.0 (referent)	1.0 (referent)	1.0 (referent)	1.0 (referent)
58–70	0.6 (0.4–0.8)	0.4 (0.3–0.7)	0.6 (0.5–0.8)	0.7 (0.5–0.9)	0.4 (0.3–0.6)	0.4 (0.3–0.7)	0.4 (0.3–0.7)	0.5 (0.3–0.7)
71–90	0.3 (0.2–0.4)	0.5 (0.3–0.8)	0.3 (0.2–0.4)	0.3 (0.2–0.4)	0.4 (0.3–0.7)	0.5 (0.3–0.8)	0.4 (0.3–0.7)	0.4 (0.3–0.7)
91–117	0.5 (0.3–0.7)	0.5 (0.3–0.9)	0.5 (0.4–0.7)	0.5 (0.4–0.7)	0.5 (0.3–0.7)	0.5 (0.3–0.9)	0.5 (0.3–0.8)	0.5 (0.3–0.8)
Time of day	–	–	–	–	7.4 (2.4–22.9)	10.9 (3.4–35.6)	8.8 (2.8–27.6)	11.5 (3.8–34.4)
Total use (hours)	1.1 (1.1–1.2)	–	–	–	1.1 (1.1–1.2)	–	–	–
<i>No. breaks</i>								
None	–	1 (referent)	–	–	–	1 (referent)	–	–
1–2	–	1.3 (0.9–1.9)	–	–	–	1.8 (1.1–2.9)	–	–
3–4	–	1.5 (1.1–2.0)	–	–	–	1.4 (0.8–2.3)	–	–
5–6	–	1.5 (1.1–2.2)	–	–	–	1.7 (1.0–2.8)	–	–
7–8	–	1.3 (0.8–2.2)	–	–	–	2.0 (1.0–4.2)	–	–
>9	–	1.1 (0.5–2.1)	–	–	–	1.9 (0.7–5.0)	–	–
<i>Break length^a</i>								
None	–	–	1.0 (referent)	–	–	–	1.0 (referent)	–
<15 min	–	–	0.6 (0.5–0.9)	–	–	–	0.9 (0.5–1.4)	–
15–45 min	–	–	1.6 (1.1–2.2)	–	–	–	1.8 (1.1–3.1)	–
>45 min	–	–	1.6 (1.1–2.2)	–	–	–	1.7 (1.0–2.8)	–
Stretch breaks	–	–	–	1.3 (1.1–1.5)	–	–	–	1.3 (1.0–1.5)

^aTest for trend: 1.14 (1.01–1.28) for any symptoms and 1.23 (1.04–1.46) for moderate or greater symptoms