The notebook computing experience among university students

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Abstract

There is a growing body of evidence suggesting that university students are self-reporting experiencing musculoskeletal discomfort with computer use similar to levels reported by adult workers. This study investigated how university students use notebook computers. Forty-eight participants were randomly assigned to one of four conditions. Each condition included participants completing baseline and post-study a health and comfort survey and ergonomics quiz. Computer usage software was installed on participants' notebook computer and all received participatory ergonomics training and external notebook accessories, e.g. keyboard and mouse. Participants in experimental conditions received an external notebook riser, an ergonomic computer workstation chair or an external desktop display. Each participant was loaned a personal digital assistant (PDA), which contained a 45-question survey. The PDA randomly "beeped" 7 times in a 24-hour day for the participants to complete a survey. The use of the repeated measure survey was part of the Ecological Momentary Assessment (EMA) method. Over the duration of the study (3 months) participants met with researchers and completed a weekly visual analog comfort scale where they rated their workstation comfort. Notebook accessories, e.g., external mouse, external keyboard, notebook riser; an ergonomic chair; and participatory ergonomics training appear to contribute to a trend of decreased self-reported notebook computer-related musculoskeletal discomfort in specific areas of the body of participants. Based on the study's results, a university-wide notebook computing education plan was initiated.

Introduction

There are approximately 14.5 million undergraduate students in the United States and the majority of these students use a computer daily. In addition, notebook computer use across college campuses is rising. It has increased from 52.8% in 2005 to 75.8% in 2007 (Salaway and Caruso, 2007), One of the appeals of notebook computers is their size and transportability. However, the compact design of the notebook computer does not typically allow for a proper ergonomic arrangement

There is a growing body of evidence suggesting that university students are self-reporting experiencing musculoskeletal discomfort with computer (Katz et al, 2000, Robertson, et al 2002, Hupert, et al 2004, Hamilton et al 2005, Menendez et at 2007, Jacobs et al 2009) use similar to levels reported by adult workers (Taylor, 2007, Jacobs et al.). Katz et al (2000) reported that more than half of the undergraduates in a private university reported having upper extremity symptoms while using the computer; and 1 in 8 reported symptoms after computing for an hour or less. .Katz et al and Menendez at al both that students described onset of their symptoms after one or more hours at the computer.

Although there is a growing body of evidence on university students' computer use, 52.8% in 2005 to 75.8% in 2007 (Salaway and Caruso, 2007), but despite this growth in popularity, there are limited studies that specifically investigate notebook computer use in this population (Fay, 2006, Jacobs, et al). This study investigated how university students use notebook computers.

Method

Study participants

Forty-eight undergraduate students (52% males; 48% females) were recruited in fall 2007 from a single college dormitory at a private university in the New England area of the United States. Only students using notebook computers were invited to participate, 48 undergraduates participated for the full duration of the study. Institutional Review Board approval was obtained from the university.

Study design

An open randomized controlled trial was used. At baseline, all participants completed an ergonomics quiz and a

notebook computing survey. Anthropometric measurements were taken to ensure that all participants were comparable in body size. *The Rapid Upper Limb Assessment (RULA)* was used to measure posture at the start and conclusion of the study. At the same time, participants were photographed in their dormitory room while using their notebook computers in non-poised postures. In addition, a computer usage software, WorkPace® software by Wellnomics® was installed on each participant's notebook computer which measured patterns of usage.

Participants were randomly assigned to one of four conditions. Participants in the control condition completed the survey, quiz and had the respective computer usage software installed on their notebook computer and received participatory ergonomics training and external notebook accessories, e.g. keyboard and mouse. Participants in experimental condition #1 received control conditions plus an external notebook riser. Participants in experimental condition #2 received control conditions plus an ergonomic computer workstation chair. Participants in experimental condition # 3 received control conditions plus an external desktop display. Upon completion of training in computer ergonomics, each participant was loaned a personal digital assistant (PDA), which contained a 45-question survey. The PDA randomly "beeped" 7 times in a 24-hour day for the participants to complete a survey. The use of the repeated measure survey was part of the Ecological Momentary Assessment (EMA) method. Over the duration of the study (3 months) participants met with researchers and completed a weekly visual analog comfort scale where they rated their workstation comfort. At these sessions, the researchers retrieved PDA data from the previous week.

Survey methods and instruments

There were two methods of data collection: self report and direct measurement.

Self-report methods

There were four self-report methods used: 10-question true/false ergonomics quiz, the notebook computing survey, the PDA Survey, and the visual analog scale. The 10-question true/false ergonomics quiz and notebook computing survey were completed at baseline and post-intervention. The visual analog scale was administrated weekly. The PDAs beeped 7 times in a 24-hour day and the participants were instructed to complete each survey.

Ergonomics Quiz: The 10-question true/false ergonomics quiz was composed of content from the participatory ergonomics training. The quiz was administered to participants prior to the participants' completion of notebook computing survey at baseline and post-intervention. The sum of all of the correct answers was calculated as the ergonomic score. The objective of the quiz was to ascertain the participant's knowledge and beliefs about ergonomics.

Notebook computing survey: This survey was used to record demographic information and document physical and behavioral change, and discomfort associated with computer usage. This survey has been used in studies of university students and was adapted to focus questions around the notebook rather than desktop computer (Katz, et al, 2000: Amick, et al, 2003; Hupert, et al, 2004; Jenkins et al, 2007; Menendez et al, 2007; Jacobs et al, 2009).

Ecological Momentary Assessment (EMA) method: This method measured self-reported discomfort throughout the study. The Palm Z22™ PDA was programmed with a quick 2-minute survey, which was adapted from one used in a study by Menendez et al (2007). The PDAs software was from an open source, the NSF-funded experience-sampling program found on http://www.experience-sampling.org, which successfully tested its usability. The 45-question survey asked about current musculoskeletal discomfort; location of student when using computer (classroom, dormitory, library, etc.); computer set-up (desk, table, bed, floor, etc.); and use of external notebook computer accessories (mouse, keyboard, trackball, etc.).

Visual Analog Comfort Scale: The visual analog comfort scale was used to assess the self-reported comfort level of each participant's workstations for the previous week. Participants rated their workstation comfort level by marking "Not Comfortable", "Comfortable", or "Very Comfortable" and provided short written feedback.

Direct methods

Four types of direct measurement methods were used: the computer monitoring software installed on the participants' notebook computer that measured usage, anthropometric measurements of participants, photographs of participants' computer workstations, and *The Rapid Upper Limb Assessment (RULA)*.

WorkPace® software was installed on all participants' notebook computers. It recorded exposure level factors, such as usage, and breaks. WorkPace® software was selected for its compatibility on both PC and Apple computers.

Computer usage software developed by Dennerlein et al (2006) was installed on PC notebook computers to confirm external accessory use, e.g. mouse and keyboard. This software was not installed on Apple computers due to incompatibility.

Anthropometric measurements such as seated eye height, seated elbow height and popliteal height were measured by research assistants to ensure that all participants were comparable in body size.

Photographs were taken by the research assistants at baseline and post-intervention of the participants' computer workstation in their dormitory room.

The Rapid Upper Limb Assessment (RULA) was used to measure posture at baseline and post-intervention by the research assistants because it allowed for a quick, systematic assessment of postural risk while the student used the notebook computer.

Participatory ergonomic training

Participatory ergonomics training involved all participants in planning, developing, and implementing ergonomic solutions to a notebook computer workstation in a typical dormitory room (Greene et al, 2005). Content for the participatory ergonomics training was based on a variety of current evidence-based sources, such as the Hewlett-Packard Company's *Safety & Comfort Guide* (2002) and *Healthy Computing Microsoft Hardware's Guide to Ergonomics at*

Work (2003). Participants were provided with a checklist on how to arrange their notebook computer workstation, instructed on how to use this checklist and provided with the opportunity to implement this knowledge. Each participant also received a mouse pad with printed ergonomics information that included the key principles reinforced during participatory ergonomics training. The tag line: "Work in Comfort: Change and Vary Your Posture Often" was reinforced.

Statistical Analysis

All data was entered into Microsoft Office Excel 2007 and analyzed using SAS version 9.1 (copyright SAS Institute, Cary NC). Categorical data was summarized using percentages and analyzed using the chi-square test for independent samples and McNemar's test for paired designs. Numerical variables were summarized using means and standard deviations and analyzed using independent sample t-test and paired t-test as appropriate. Linear regression was conducted to test for trends between experimental groups. Pearson product-moment correlation was used to describe and test the strength of association between numerical variables. Each test was two-sided and conducted at the 0.05 level of significance.

Results

Study Population

Study population included 48 participants, 52% males and 48% females.

Prevalence of self-report notebook computer related discomfort and associations

From baseline to the conclusion of the study (3 months), there were significant changes in self-reported comfort in condition#1 (78% versus 65%; p = 0.008) and condition #2 (61% versus 49%; p = 0.007) but no change in the control condition (58% versus 55%, p = 0.23). The differences in discomfort reduction across the three conditions displayed a trend towards significance (p-value =0.24).

Participants spent 84% of their computing time at a desk, in comparison to 5% at a table, 7 % on a bed and other and 1% on the floor.

Of the data retrieved from the 45-question questionnaires, 47% of the questions held significant statistical differences between all groups, 17% held borderline differences between all groups. There was a significant differences between all groups for experience with discomfort in areas such as the left fingers and right fingers (p-value=0.043; 0.039 respectively), the left hand (p-value=0.047), the right forearm (p-value=0.021); with numbness in the left wrist (p-value=0.011); with stinging (p-value=0.020), itching (p-value=0.041), gritty (p-value=0.038), aching (p-value=0.013), light sensitive (p-value=0.036), redness (p-value=0.010), tearing (p-value=0.013), and dry feeling (p-value=0.039) of the eyes. There was a borderline association between all groups for discomfort in the right wrist (p-value=0.052), left elbow (p-value=0.078), left shoulder (p-value=0.098), the neck (p-value=0.055), the upper back (p-value=0.086) and difficulty focusing (p-value=0.078). There was a significant difference between the control condition and experimental condition #2 for discomfort in the right fingers, right wrist, right forearm, the neck, for numbness in the left wrist, for stinging, gritty, aching, light sensitive, redness, and tearing of the eyes (p-value<0.05). There was significant differences between the control condition and experimental condition #1 for numbness in the left wrist and stinging, redness, and tearing of the eyes (p-value=0.05). There was significant difference between the control condition and experimental condition #3 for numbness in the left wrist (p-value<0.05).

Discussion

Participants self-reported notebook computer-related musculoskeletal discomfort comparable to those reported in other studies of computer use by university students (Katz, et al, 2000; Amick, et al, 2003; Menendez, 2007, Jacobs et al 2009) as well as those by adults working in office environments (Gerr, et al. 2002, Taylor, 2007). Notebook accessories, e.g., external mouse, external keyboard, notebook riser; an ergonomic chair; and participatory ergonomics training appear to contribute to a trend of decreased self-reported notebook computer-related musculoskeletal discomfort in specific areas of the body of participants. The most common area of self-reported discomfort was the eyes.

Based on the study's results, a university-wide notebook computing education plan was initiated. To promote the health of university students who will be future employees, universities are encouraged to increase the availability of informational reminders on computer ergonomics, create adaptable workstations in learning areas including dormitory rooms, and promote proactive problem solving.

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