Computer Use, Workstation Design Training and Cumulative Trauma Disorders in College Students

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Abstract

Currently, very little is known about computer use in college students, associated Cumulative Trauma Disorders (CTDs) and musculoskeletal discomfort, or the impact and availability of proper workstation design education and training in this population. Given the expanding use of technology in university settings, it is important to determine how computer use may be causing pain and discomfort for college students, whether workstation education and training is being provided to this population, and whether such education, if provided, is effective. Five-hundred twelve college students completed a survey on health and computer usage. The most frequently reported disorders related to health were eyestrain affecting nearly 85% and, upper back and neck pain affecting 70% of computer users. Only 26.6% of the sample indicated receiving training on workstation design. Identifying college students at risk for CTDs and other musculoskeletal discomforts provides a prime opportunity for health education professionals to intervene at an early stage.

Keywords: Ergonomics, Cumulative Trauma Disorders, Musculoskeletal Injuries, College Students

In recent years there has been an increase in the occurrence of cumulative trauma disorders (CTDs) and other musculoskeletal injuries due to ergonomic hazards (National Safety Council, 2001; MacLeod, 1995). Major causes of many of these disorders and injuries are technological advances (e.g., faster, more powerful computers), increased use of repetitive motions, competitive work environments, inflexible workstation designs, and poor education/training on proper workstation design (U.S. Department of Labor, 1991).

CTDs are disorders of the musculoskeletal and nervous systems – the nerves, tendons, tendon sheaths, and muscles, with the upper extremities being the most frequently affected (U.S. Department of Labor, 1991). Some examples include: tendonitis, tenosynovitis, De Quervain's disease, trigger finger, and the most recognized - carpal tunnel syndrome. CTDs may be caused or aggravated by repetitive motions, forceful exertions, vibration, mechanical compression, sustained or awkward postures, or by exposure to noise over extended periods of time.

In 1999, nearly 1 million people took time away from work to treat and recover from work-related musculoskeletal pain or impairment of function in the low back or upper extremities (Bernard, 2001; Grant & Brody, 1994). In the United States, employers pay more than $15-20 billion in workers' compensation costs for these disorders every year, and indirect costs total $45-60 billion (Occupational Safety and Health Administration, 2002). Several companies have taken action to address and prevent these problems (Hendrick, 2002), but perhaps prevention of these problems should begin at an earlier stage in one's life. It may be more effective to train individuals in the school systems or at the university level rather than relying on the private sector/industry to provide VDT workstation design training. If CTDs occur in collegiate populations, this training is warranted at an earlier point in time, and may prevent later cumulative trauma.

Currently, very little is known about computer use in college students, associated CTDs and musculoskeletal discomfort, or the impact and availability of proper workstation design education and training in this population. Using younger samples, Jones and Orr (1998) found that duration of computer use and type of environment (home, school, work) where computers were used most frequently were the best predictors of musculoskeletal discomfort in high school students, and Oates, Evans and Hedge (1998) found almost 40% of third to fifth graders used computer workstations that put them at postural risk. However, no studies have been conducted to examine the predominance of video display terminal (VDT) education and training, its effectiveness, incidence of CTDs, or risk of musculoskeletal discomfort in a collegiate population. This may be an important period in which to intervene, however, considering findings at Harvard University, the University of California, and other institutions of higher education where increases in the number of students seeking treatment for carpal tunnel syndrome, tendonitis, and other medical conditions have been reported (Rasicot, 2002). These increases are thought to be attributable to an increase in computer use among college students. Given the expanding use of technology in university settings, it is imperative to determine how computer use may be causing pain and discomfort for college students, whether workstation education and training is being provided to this population, and whether such education, if provided, is effective.

Method

Participants

Permission was granted from fourteen college instructors of upper division general education classes at a western university to administer a survey on computer use, education, and health in college students. Five-hundred twenty-three students completed the survey, which took approximately 10-12 minutes to complete. The survey was confidential, anonymous and had been approved by a Human Subjects Institutional Review Board. Five-hundred twelve surveys were included in the data analyses after excluding 11 surveys considered incomplete (missing over 50% of the information). The demographic characteristics of the sample are listed in Table 1.

Instruments

Computer Use, CTD Incidence, and Workstation Design Survey: The survey was divided into four sections. The first section contained questions identifying duration (<30-min, 30-min to 1-hr, 1 to 2-hrs, 2 to 4-hrs, or >4-hrs) of computer use at home, work, and school locations.

The second section focused on computer-use related symptoms or discomforts. Students were asked whether they had experienced discomfort in the past 12 months, whether any of these symptoms resulted in a visit to a doctor, and whether they had missed any days of school or work because of these symptoms in the last 30 days.

Section three asked about students' experience with workstation design and lifting-technique education and training. Specifically, participants were asked (yes or no) if they had received any workstation design training at work, school, home, or other location, and they were asked if they had ever received effective lifting technique training. In addition, students were asked to respond with their level of disagreement to nine statements concerning the computer where they spent the most time. These statements correspond to the guidelines set by the Occupational Safety and Health Administration (OSHA) for effective workstation design. (i.e., "workstation is arranged to minimize glare", "seat and backrest provide comfort", "seat allows proper foot placement", "screen is slightly below eye level", "keying is performed in a relaxed manner", "keyboard is placed in a neutral position", "frequent rest breaks are taken", "body positions change regularly", and "stretching/ exercises are done and eye breaks are taken") (Department of Industrial Relations, 1999). Responses were made on a Likert-type scale ranging from 1 "strongly agree" to 4 "strongly disagree."

Table 1
Demographic Characteristics

Variable	**n**
Gender	
Male	177
Female	332
DNR[1]	3
Age of Participants	
17-21	143
22-25	225
26-30	75
31 and over	62
DNR[1]	7
Ethnicity	
White	242
Hispanic	107
Asian	96
Other	63
DNR[1]	4
Academic Level in College	
Freshman	4
Sophomore	25
Junior	180
Senior	293
Graduate Student	7
DNR[1]	3

[1] DNR= did not respond

In addition, students were asked about the design of their workstation at home, school, and work. Three questions were included to determine the use of computer-related devices designed to minimize CTDs in each of these settings. In each setting, students were asked if they used an adjustable chair, an adjustable monitor, a foot rest, a wrist rest, an anti-glare screen, a document holder, or an other computer-related devices specified by the student.

The final section (see Table 1) asked participants to provide relevant demographic information (i.e., age, sex, height, weight, ethnicity, and collegiate year of enrollment).

Data Analyses
To determine the effectiveness of training on students' use of ergonomic workstation design, one-way (training) Multivariate Analysis of Variance (MANOVA) was conducted. Because there was some overlap among the individuals who had received training at home, school, work, and other locations, and because of the small number of students who had received training, a composite independent variable was created to indicate whether the student had received training in <u>any</u> location or no training at all (training or no training). The dependent variables were those that comprised effective workstation design, namely disagreement with the 9 OSHA-related statements for their most-used computer, and the sum of computer-related devices used at home, school, and work, respectively.

To determine the predictors of CTD's and other musculoskeletal injuries among college students, hierarchical regression analysis was performed entering demographic variables (i.e., age, sex, and body mass index: BMI) simultaneously on the first step, and demographic variables, computer use time at home, school and work, the sum of computer-related devices used at home, school and work, and disagreement with the 9 OSHA-related statements simultaneously on the second step. The sum of computer-related traumas reported by students served as the criterion variable for this analysis.

Results

Descriptive Information

Reports of the number of classes in which participants were currently enrolled ranged from one to eight classes with an average of four classes. Students stated that an average of three of their courses required the use of a computer. At school, students reported that they used their computer for an average of less than 30 minutes per day. Almost 14% (n=69) of the students reported receiving training on workstation design/set-up at school.

Ninety-five percent (n=488) of the students used a computer at home. Students reported using the computer at home an average of 1-2 hours per day. When asked about training on workstation design provided at home, almost 10% (n=49) responded that they received such training.

Of the employed students (n=409), 75.6% (n=310) utilized a computer at their workplace. Students reported using the computer an average of 1-2 hours per day at work. Students were also asked whether they had received training on workstation design and lifting at their workplace. Sixty (11.9%) reported receiving training on workstation setup and 213 (51.8%) reported receiving training on lifting techniques. Combining the reports of training at home, at school, and at work demonstrated that 26.6% of students had received training in any of the three locations.

Table 2 shows the percentages of students reporting different types of discomforts due to their use of a VDT. The average duration of CTD-related discomfort equaled 2 days, though this duration ranged from 0-150 consecutive days. Days taken off school due to CTDs ranged from 0-21, and work ranged from 0-30. The total number of CTDs reported by each participant ranged from zero to eight with an average report of three CTDs, and this distribution was normal-like (31% of respondents reported less than three CTDs, 31% reported three CTDs, and 38% reported greater than three CTDs).

Training Effectiveness

Of the 512 students who returned completed surveys, there were complete data for the variables in this analysis for 375 students. Inspection of the data revealed that many of the subjects did not use a computer in one of the three locations (home, school or work), thus resulting in the reduced sample size for this analysis. One-way (training) MANOVA demonstrated significant differences between those who had received some form of workstation training and those who had not, Wilks' Lamda = .94, $F(11, 363) = 2.10$, $p < .05$. Univariate follow-up analyses were conducted to examine which variables were contributing to group differences. Significant differences and descriptive statistics for levels of disagreement with the OSHA statement are listed in Table 3.

Table 2
Discomforts Reported Among College Students

Variable	n	% of Total
Hand Discomforts in Past 12 months		
No	243	47.46
Yes	234	49.10
Don't Know/DNR[1]	35	6.84
Pain in Upper Back or Neck After Computer Use		
No	152	29.69
Yes	360	70.31
Pain in Any Part of the Body After Computer Use		
No	165	32.22
Yes	346	67.58
DNR[1]	1	.20
Eye Fatigue/ Eye Strain After Computer Use		
No	71	13.87
Yes	440	85.94
DNR[1]	1	.2
Computer Symptoms Result in Visit to Doctor		
No	460	89.84
Yes	50	9.77
DNR[1]	2	.39
Diagnosis of Carpal Tunnel Syndrome		
No	433	84.57
Yes	18	3.52
DNR[1]	61	11.91
Missed Days at School or Work in the Past 30 days Due to Discomfort		
No	466	91.02
Yes	43	8.40
DNR[1]	3	.56

[1] DNR=did not respond

Table 3
Effectiveness of Workstation Design Training in College Students

	Training		No Training			
Dependent Variable	**M**	**SD**	**M**	**SD**	**F (1,373)**	**p**
WSD: Glare	2.19	0.92	2.29	0.92	0.83	n.s.
WSD: Adjustable Seat	1.95	0.98	2.27	0.98	7.81	.005
WSD: Foot Placement	1.74	0.91	1.78	0.96	.012	n.s.
WSD: Screen Position	2.32	1.05	2.61	1.03	5.62	.018
WSD: Relaxed Keypunch	2.04	0.92	2.12	0.93	0.50	n.s.
WSD: Neutral Wrist	2.00	0.84	2.17	0.92	2.64	n.s.
WSD: Take Breaks	1.84	0.76	2.01	0.95	2.73	n.s.
WSD: Change Position	2.01	0.82	1.98	0.88	0.08	n.s.
WSD: Stretch/Move	2.26	1.00	2.40	1.00	1.44	n.s.
Ergonomic Aids: School	1.29	1.14	0.94	1.07	7.69	.006
Ergonomic Aids: Home	1.29	1.14	0.94	1.07	7.69	.006
Ergonomic Aids: Work	1.51	1.67	1.22	1.46	2.65	n.s.

Note. WSD = Workstation Design (level of disagreement with 9 OSHA-based statements concerning design of most-used computer workstation). Ergonomic Aids = Sum of computer-related devices used as ergonomic aids.

Regression Analysis
For the hierarchical regression, only participants with complete data for all of the predictor variables and the criterion (n = 295) were used. Significant predictors of injury in the final equation were sex, time using a computer at work, use of anti-injury devices at home, and disagreement that the workstation they used most allowed a relaxed keypunch. Male gender, greater time spent using a computer at work, use of anti-injury devices at home, and subjects' disagreement that their most frequently used workstation allowed a relaxed keypunch were all positively related to the number of reported CTDs. Descriptive data and the results of this analysis are reported in Table 4.

Table 4
Descriptive Statistics and Results for Variables Predicting CTDs

Step					
Variable	**M**	**SD**	**β**	**p**	R^2
Step 1					
Age	24.43	5.58	.05	n.s.	
Sex (Males=1)	0.62	0.49	.19	.002	
BMI	23.26	3.88	-.01	n.s.	.056**
Step 2					
Computer Use: School	1.55	1.23	.01	n.s.	
Computer Use: Home	2.72	1.17	.09	n.s.	
Computer Use: Work	2.75	2.00	.16	.036	
Anti-inj. Use: School (Yes=1)	0.61	0.49	.11	n.s.	
Anti-inj. Use: Home (Yes=1)	0.84	0.37	.14	.025	
Anti-inj. Use: Work (Yes=1)	0.63	0.48	.00	n.s.	
Workstation Training	0.26	0.44	-.06	n.s.	
WSD: Glare	2.27	0.90	.07	n.s.	
WSD: Adjustable Seat	2.20	0.99	.07	n.s.	
WSD: Foot Placement	1.77	0.95	.00	n.s.	
WSD: Screen Position	2.55	1.04	.01	n.s.	
WSD: Relaxed Keypunch	2.10	0.93	.19	.017	
WSD: Neutral Wrist	2.14	0.91	-.01	n.s.	
WSD: Take Breaks	1.94	0.89	.06	n.s.	
WSD: Change Position	1.96	0.85	-.06	n.s.	
WSD: Stretch/Move	2.35	0.99	.00	n.s.	.135***

Note. Criterion variable: sum of reported CTDs; **P<.01; ***P<.001

Comments
The results of the present investigation suggest that CTDs are a health concern among college students. Because this study was only conducted at one university, future studies should collect data on a more representative sample of college students. The most frequently reported disorders were related to eyestrain affecting nearly 85%, and upper back and neck pain affecting 70% of computer users. These findings are consistent with work done in other studies (Pealer & Dorman, 1998; Alexander, 1994). Diagnosis of carpal tunnel syndrome by a physician was reported by 3.5% of participants in the present study, which is slightly higher than corresponding results from a study of U.S. workers, 1.47% (Tanaka, Wild, Seligman, Halperin, Behrens, & Putz-Anderson, 1995). This rate of incidence, however, appears to be consistent with findings in high school students

(Jones & Orr, 1998) and a recent Denmark study (Anderson, Thomsen, Overgaard, Lassen, Brandt, Vilstrup et al., 2003).

This study confirms that most college students commonly use VDTs, but that there is little training in effective workstation design (only 26.6 percent of the sample indicated receiving such training). The results of MANOVA suggest that those who received workstation design training indicated greater agreement that their seat was adjustable and that their screen was below eye level for the computer they used most. This appears to confirm the effectiveness of training in workstation design considering that these two recommendations are among the most recommended strategies in the workstation design literature (Department of Industrial Relations, 1999; Grant & Brophy, 1994; Rasicot, 2002). It is likely that students' training included these components and this is reflected in their reported behavior. It should also be noted that mouse use may be a significant predictor of cumulative trauma disorders. Mouse use has only recently been investigated separately from keyboard use and found to increase risk of carpal tunnel syndrome (Anderson et al., 2003). Future studies should include mouse use as an item of interest.

As expected, time spent using a computer at work was positively related to number of musculoskeletal injuries reported, thus confirming the findings of previous studies (Tanaka, Wild, Seligman, Halperin, Behrens, & Putz-Anderson, 1995; Hales, Sauter, Peterson, Fine, Putz-Anderson, & Schleifer, 1994). Males were more likely to report a greater number of musculoskeletal injuries than their female counterparts. Some studies have found a higher prevalence of some musculoskeletal injuries in women (Hales, Sauter, Peterson, Fine, Putz-Anderson, & Schleifer, 1994; Bernard, Sauter, Fine, Peterson, & Hales, 1994). However, in a study on carpal tunnel syndrome among industrial workers, no gender difference could be seen after controlling for work exposure (Silverstein, 1985). This is likely not causing the discrepant results of the present study because males ($\underline{M}$=6.69) did not report using computers more than females ($\underline{M}$=6.83). A reporting bias may exist because women may be more likely to report pain and seek medical treatment than men (Hales, Sauter, Peterson, Fine, Putz-Anderson, & Schleifer, 1994; Norman, 1991). In the present investigation the dependent measures constituting injury were not derived from actual visits to doctors, but rather, reports of trauma. Therefore, the present methodology may have prevented reporting biases, though it is still unclear why males would encounter a greater incidence of trauma. One possibility may be tied to video game play, which may be greater for males than females (Nagourney & Games, 2002; Norman, 1991). Because the results of the present investigation differ from previous studies, gender differences in CTD reporting and their ultimate cause deserve further attention.

As expected, subjects' *disagreement* that their workstation was arranged so that keypunches could be performed with relaxed arms and shoulders was positively related to number of CTDs reported. In other words, proper workstation design with respect to arm and shoulder position was associated with fewer CTDs, perhaps indicating that arm and shoulder position may be an important prevention strategy for this population (National Safety Council, 2001; Bernard, 2001; Rasicot, 2002, Department of Industrial Relations, 1999; Lucas, 1997). In contrast to expectations, use of anti-injury devices at home was positively related to number of CTDs reported. The correlational nature of this study does not permit causal conclusions, yet it makes sense that the CTDs are causing the use of anti-injury devices in this case, rather than vice-versa. It may be expected that use of preventative measures are greater for those who have encountered injury or trauma, or who spend greater amounts of time using the computer. While it remains for future studies to determine if this is the case, exploratory analyses not reported here examining the interaction of computer use time and ergonomic workstation design failed to reach significance.

While results suggest that some participants may not be seeking workstation design training until they incur injury, it does appear that those who have had training are putting it to some use. These results are encouraging, but it should be noted that this study is limited in its ability to make any causal statements because of its cross-sectional design. Identifying musculoskeletal symptoms at an early age provides a prime opportunity for healthcare professionals to prevent possible disorders. Health education professionals in the college setting may be a valuable resource to enhance education and training of these risks.

References

Alexander, M. (1994). Physical problems associated with computer use and implemented ergonomic measures. The Delta Pi Epsilon Journal Vol. XXXVI No. 4. Fall, 189-202.

Andersen, J., Thomsen, J., Overgaard, E., Lassen, C., Brandt, L., Vilstrup, I., Kryger, A., & Mikkelsen, S. (2003). Computer use and carpal tunnel syndrome. Journal of the American Medical Association, 289, 2963-69.

Armstrong, T. J., Buckle, P., Fine, L. J., Hagberg, M., Jonsson, B., & Kilbom, A. (1993). A conceptual model for work related neck and upper limb musculoskeletal disorders. Scandinavian Journal of Work, Environment & Health, 19, 2, 73-84.

Bernard, B., Sauter, S., Fine, L. J., Peterson ,M. R., & Hales T. (1994). Job task and psychosocial risk factors for work-related musculoskeletal disorders among newspaper employees. Scandinavian Journal of Work, Environment & Health, 20, 417-426.

Bernard, B. P. (Ed.) (2001). Musculoskeletal disorders and the workplace. Executive summary. Retrieved November 25, 2003, from http://books.nap.edu/books/0309072840/html/1.html

Department of Industrial Relations. (1999). Four step ergonomics program for employers with video display terminal (VDT) operators. Retrieved November 25, 2003, from http://www.dir.ca.gov/dosh/dosh_publications/ergonomic.html

Grant, C. & Brophy, M. (1994). An ergonomics guide to VDT workstations. American Industrial Hygiene Association, 1-35.

Hales, T. R., Sauter, S. L., Peterson, M. R, Fine, L. J., Putz-Anderson, V., & Schleifer, L. R. (1994). Musculoskeletal disorders among visual display terminal users in a telecommunications company. Ergonomics 37, 1603-1621.

Hendrick, H. (1996). Good ergonomics is good economics. Proceedings of the Human Factors and Ergonomics Society 40th Annual meeting. Retrieved November 25, 2003, from http://hfes.org

Jones, C., & Orr, B. (1998). Computer-related musculoskeletal pain and discomfort among high school students. American Journal of Health Studies.14, 26-30.

Lucas, G. M. (1997). Proactive ergonomics. Hand care begins with prevention in elementary schools. WORK: A Journal of Prevention, Assessment & Rehabilitation, 9, 267-273.

MacLeod, D (1995). The ergonomics edge. Improving safety, quality, and productivity. NY: Van Nostrand Reinhold.

Nagourney, E. (2002). Games' "rumble' linked to hand pain. The New York Times. February 12, 2002 pD7(N) pF7(L) col4 (5 col in).

National Safety Council. (2001). Injury Facts,76-78.

Norman, L. A. (1991). Mouse Joint- another manifestation of an occupational epidemic? The Western Journal of Medicine, 155, 413-16.

Oates, S., Evans, G., & Hedge, A. (1998). A preliminary ergonomic and postural assessment of computer work settings in American elementary schools. Computers in the Schools, 14, 3-4, 55-63.

Occupational Safety and Health Administration (2002). OSHA Home page. Retrieved November 25, 2003, from http://www.osha-slc.gov

Pealer, L. N., & Dorman, S. M. (1998). Video display terminals: Safe use guidelines. Journal of School Health, 68, 307-308.

Rasicot, J. (2002). Ergonomics 101. How to guard against health problems in the computer lab. Retrieved November 25, 2003, from http://www.electronic-school.com/2000/01/0100f2.html

Silverstein, B.A. (1985). The prevalence of upper extremity cumulative trauma disorders in industry (Dissertation). Ann Arbor, MI: The University of Michigan.
Tanaka, S., Wild, D.K., Seligman, P.J., Halperin, W.E., Behrens, V.J., & Putz-Anderson, V. (1995). Prevalence and Work-Relatedness of Self-Reported Carpal Tunnel Syndrome Among US Workers: Analysis of the Occupational Health Supplement Data of 1988 National Health Interview Survey. American Journal of Industrial Medicine, 27, 451-470.
U.S. Department of Labor. (1991). Ergonomics the study of work. OSHA 3125.1991; 1-19.

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