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A survey of ergonomic issues associated with a university laptop program

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Abstract
A survey of 361 undergraduate students at a midsized university was conducted to investigate the ergonomic effects of the adoption of a university-wide laptop program. The results include descriptive statistics regarding perceived levels of discomfort—tingling and pain—by users.

Introduction

The use of laptop computers in educational environments is increasingly prevalent. The size and portability of laptops make these powerful, yet practical devices easy to handle and bring many benefits to students. Shears (1995) and McDonald (1995) reported that laptops provide flexibility in the learning process and that students appear to enjoy using them.

The laptop computer was originally created for NASA and for military and business executives in response to their need of having information with them while being away. Their small size made them easy to handle and carry around. Nowadays, laptops are becoming so useful, fast, and powerful, that they are frequently replacing desktop computers.

There seems to be a need for information about the ergonomic effects caused by the frequent use of laptops (Szeto, 2001). Information about the medical problems generated by the daily operation of laptops and notebooks is valuable when attempting to avoid undesired conditions related to their use. Understanding the impact of using laptop computers has become a very important issue to ponder by the increasing number of higher education executives considering adopting a university-wide laptop program.

The literature dealing with ergonomic issues related to the use of laptops appears to be scarce. The development of computer technology (and, specifically, that of notebook and laptop computers) has moved at a much faster pace than that of the ergonomic studies conducted in the area. The goal of this study was to shed some light over the ergonomic consequences of applying a university-wide laptop program at a liberal arts college with an undergraduate population of roughly 2,500 students. At the time of this study, incoming first-year students received a Dell Latitude D600 and kept it for two years. An updated laptop unit was given to them at the beginning of their third year at the university. The University had a wireless network that allowed students to use their laptop almost anywhere on campus. The academic curriculum included a blend of regular and "laptop" courses. In the latter, students were expected to use their laptop in the classroom rather frequently. Students used their laptops not only for studying but also for entertainment, communication, and other activities.

Because of the inherent portability of the laptop computers users frequently assume inconvenient postures when using laptops. These postures include lying on the floor, using desks that are not designed for computers, and placing the laptop on one's laptop. The fact that a laptop keyboard and monitor are attached and do not adjust independently of one another may force a user to choose between comfortable hand/wrist or head/neck postures. This puts the laptop user into awkward or unhealthy postures that may lead to discomfort or

injury. Cornell University (2004) explained this phenomenon in a succinct manner: “The reason is simple - with a fixed design, if the keyboard is in an optimal position for the user, the screen isn't and if the screen is optimal the keyboard isn't. Consequently**,** laptops are excluded from current ergonomic design requirements because none of the designs satisfy this basic need**”** Harris and Straker (2000) shared this opinion and add that the position of the screen is likely to have a negative impact on the user’s head and neck posture. An elegant example of a study of the effects of laptop configuration is that reported by Sommerich et al. (2002), who considered biomechanics, productivity, and comfort factors.

The ergonomic problems associated with the use of laptops may affect different parts of the body. The litany of conditions includes the thoracic outlet syndrome, which affects the neck and the impingement syndrome, which is a common cause of shoulder problems. Injuries related to the elbow could be as different as lateral and medial epicondylitis, radial tunnel syndrome and cubital tunnel syndrome. The list of problems related with hands and wrists includes the intersection syndrome, DeQuervain’s tenosynovitis, Guyon’s Canal syndrome, the trigger finger and thumb syndrome and, of course, the carpal tunnel syndrome. The Carpal Tunnel Syndrome is perhaps the most frequently mentioned type of injury. The carpal tunnel, located at the inside center of the wrist, is a narrow tunnel of bone and ligament in which the median nerve is found. If any of the tendon sheaths become swollen, the median nerve may be compressed. An afflicted patient may experience tingling, numbness and pain in the thumb, index, and middle fingers as a result (Westmoreland, 1993.) If left untreated, the carpal tunnel syndrome may render the hand practically useless.

The injuries mentioned above follow under the rubric of cumulative trauma disorders (CDT). CTDs account for more than half of all occupational illnesses in the United States. Among major disabling injuries and illnesses, the carpal tunnel syndrome accounted for the greatest number of days away from work, surpassing fractures and amputations. In addition, injuries caused by repetitive motion, such as grasping tools, scanning groceries, and typing, resulted in the longest absences from work (Bureau of Labor Statistics, 2003).

It would appear that the use of laptops is even more prevalent than when the aforementioned references were published. Laptops have indeed gained tremendous popularity because of their smaller size and weight, affordability, screen quality, and compatibility. While the original notebook computers may not have intended to serve as a replacement for the more powerful desktops, a societal shift appears to have occurred. Many computer users prefer the smaller, more portable and flexible laptop over their bulky desktop counterparts. This phenomenon appears to coincide with the need to be globally connected and have instant access to information. An ever increasing of public facilities that includes airport terminals, coffee shops, public buildings, and universities now provide wireless networks that allow laptop users to have instant access to the Internet.

Purpose

The goal of this study was to evaluate the ergonomic impact of the university-wide laptop program at an institution with an undergraduate population of roughly 2,500 students. Students are issued a laptop computer when they join the university. After two years, the laptop is exchanged for an updated model. The study focused on musculoskeletal and other effects of the use of laptops and peripherals on the laptop users. Our purpose was to present findings that could assist administrators in institutions of higher education in the decision-making process involved with the implementation of a campus laptop program.

Method

This research focused on the effects of use of laptops, including discomfort in the fingers, hands, arms, shoulders, neck or back. Randomly chosen, a cross section of the undergraduate student body was considered for this survey. A survey of 361 undergraduate students was conducted in an effort to evaluate the use of a laptop computer in terms of its

ergonomic effects. At the time of this study, students at the University used a laptop computer that weighed approximately 2 kg. (4.5 lb.) and featured a 35.5 cm. (14-in.) screen.

The survey was administered at the beginning of each class period. The nature of the survey was explained to the participants and participation was voluntary. A printed questionnaire was prepared that included 28 questions inquiring about different levels of discomfort (pain or tingling). Clear instructions were given to the respondents regarding the necessary seriousness and honesty when filling out the questionnaire. Only anonymous responses were collected. The first of the questionnaire featured questions about classification, student status, sex, time using the laptop, and academic major. Secondly, the questionnaire included questions about pain or tingling in fingers, hands, wrists, forearms, elbows, shoulders, neck, upper back, and lower back. Lastly, there were questions related to non-musculoskeletal issues (eyestrain and headache.)

Questions regarding pain severity utilized a modified six-point graded severity index developed by Fry and Rowley (1989) that incorporated a measure of functionality and problem duration. The scale is featured in Table 1. Fry's scale was used effectively in an

Table 1. Pain scale used in the survey	
Grade 0:	No pain or discomfort.
Grade 1:	Pain while typing; should be consistent rather than occasional; pain ceases when not typing.
Grade 2:	Pain while typing; slight physical signs of tenderness; may have transient weakness or loss of control; no interference with other uses of this body location.
Grade 3:	Pain while typing; pain persists away from laptop; some other uses of this body part cause pain; may have weakness, loss of control; loss of muscular response or dexterity.
Grade 4:	As in grade 3 –all common uses of this body part cause pain (housework, driving, tuning knobs, using a screwdriver, playing an instrument), but these activities are still possible as long as pain is tolerated.
Grade 5:	As in grade 4 –but this body part cannot be used due to disabling pain.

elegant article by Thrasher and Chesky (1998), who conducted a study similar to the present one, except that their goal was to research the ergonomic problems of clarinet players. Questions regarding tingling severity utilized a modified three-point index similar to that used for pain. The tingling scale is portrayed in Table 2.

Table 2. Scale used to evaluate tingling severity	
Grade 0:	No tingling or discomfort.
Grade 1:	Tingling sensation while typing; should be consistent rather than occasional; tingling ceases when not typing.
Grade 2:	Tingling sensation while typing; sensation persists for more than just a few minutes after typing.

DATA ANALYSIS

Descriptive statistics for each question were calculated that included frequency distributions and the mean and standard deviation. A total of 361 subjects (females=197, males=158, no answer=6) participated in this study. All the subjects were undergraduate laptop users.

It was important to gather information from students in all the majors and classification at the university to achieve appropriate representation. The population for the sample was made up of 97 freshmen, 53 sophomores, 79 juniors, and 130 seniors. Two participants did not indicate their classification. A question pertaining career fields revealed that 104 students belonged to engineering, computer science and math programs, 90 were business majors,

96 were registered in the humanities and social sciences, and 64 majored in biology, chemistry, and physics. Seven respondents did not specify their field of study.

We asked the participants how long they had been using a laptop computer. Ninety-nine of the respondents indicated that this was their first year using a laptop. Fifty-five were in their second year of usage, 79 in their third year, 83 in their fourth year, and finally, 38 subjects declared that they had been using the laptop for more than four years. Seven participants did not specify how long they had been using a laptop (Figure 1). In addition, 349 subjects were fulltime students, while only seven were part-time and five failed to answer this question.

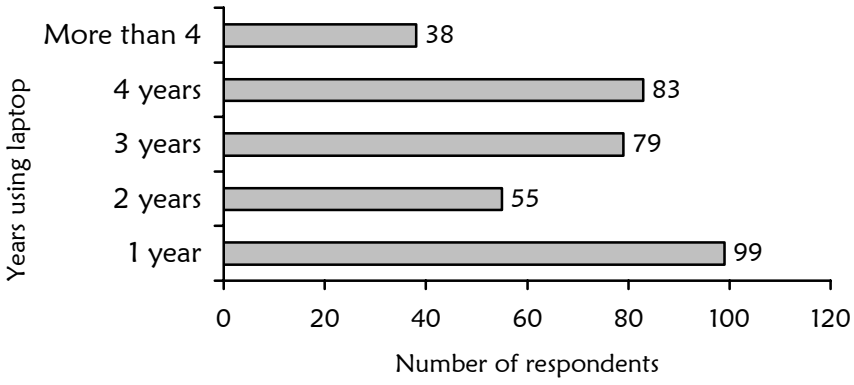

Figure 1. Participants indicated how long they have been using a laptop.

The respondents were prompted to specify the severity of non-musculoskeletal problems such as eyestrain and headache using a qualitative scale that included the categories 'no problem', 'mild', and 'severe'. The number and percentage of students reporting these problems are displayed in Table 3 and depicted in Figures 2 and 3, respectively. A total 206 participants (57 percent) reported some level of eyestrain, while 166 respondents (46 percent) reported different levels of headache. These indexes were relatively high compared those obtained in other categories.

Table 3. Non-musculoskeletal problems

Headache			**Eyestrain**		
No problem	193	53.4%	No problem	152	42.1%
Mild	150	41.6%	Mild	185	51.2%
Severe	17	4.7%	Severe	22	6.1%
No answer	1	0.3%	No answer	2	0.6%
Total	361	100.0%	Total	361	100.0%

For each musculoskeletal problem category, the survey participants were asked to use the pain and tingling scales—if appropriate—to assess the severity index for each area of concern. The severity index was calculated by using the average of the user responses. In Figure 4, the mean severity indexes for all the pain categories are reported. The most common problems included neck pain, (with a mean severity index of 0.85 and a standard deviation of 1.12 on the six-point scale), upper back pain (with a mean of 0.79 and a standard deviation of 1.15), and lower back pain (with a mean 0.81 and a standard deviation of 1.12). Most notably, the proportions of users reporting right and left wrist problems were 31 and 27 percent, respectively.

As with the pain severity index, revealing statistics were calculated for tingling. The tingling severity scale ranged from 0 to 2. The mean tingling severity indexes for several body

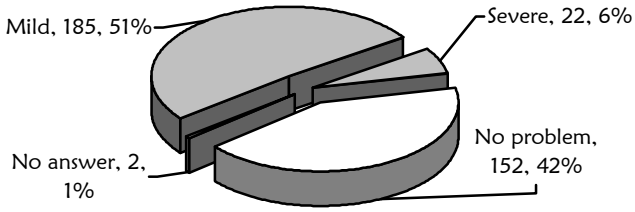

Figure 2. Eyestrain statistics. The number and fraction of respondents are shown.

segments are depicted in Figure 5. Wrist tingling appeared to be the most frequently reported complaint.

As shown in Tables 4 to 6, a noticeable segment of the student population expressed at least minimum discomfort in all the survey areas. Some categories fared better than others (Figure 6). Elbow pain was the category with the largest percentage of respondents indicating no pain (91%). The flipside is that 9 percent of the participants complained of pain in this body segment. The fraction of participants indicating some level of pain or tingling ranged between 10 and 20 percent for fingers, hand, elbow, and shoulder. In the upper and lower back categories, 44 and 45 percent of the respondents reported some level of pain, respectively. Moreover, approximately half of the survey participants complained about neck pain.

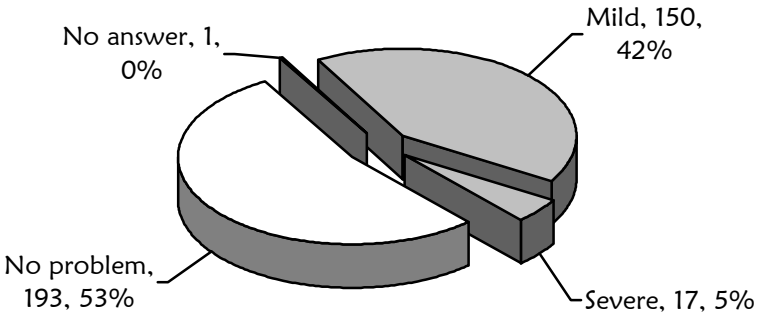

Figure 3. Headache statistics. The number and fraction of participants are shown by each category.

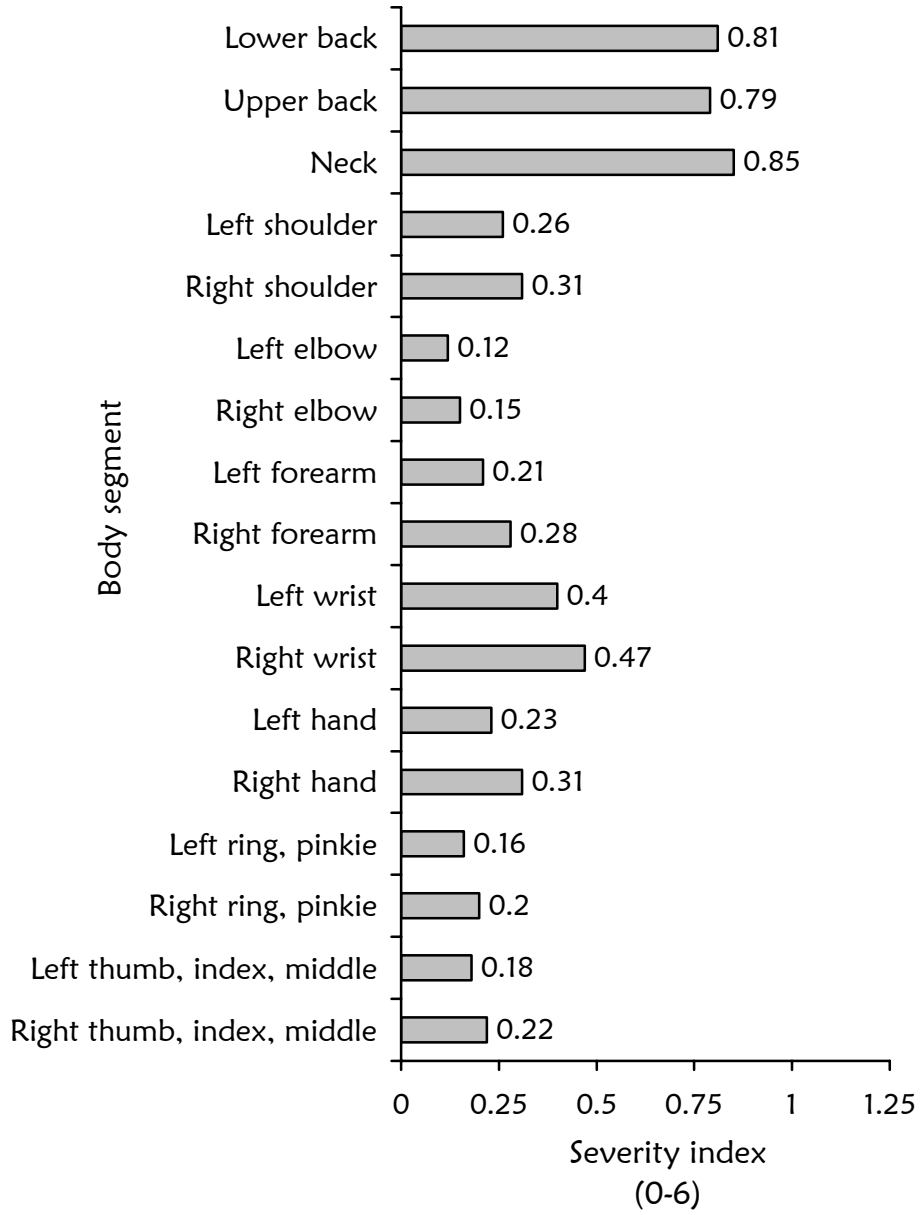

Figure 4. Mean pain severity index. The scale used was from 0 (no pain) to 5 (severe pain).

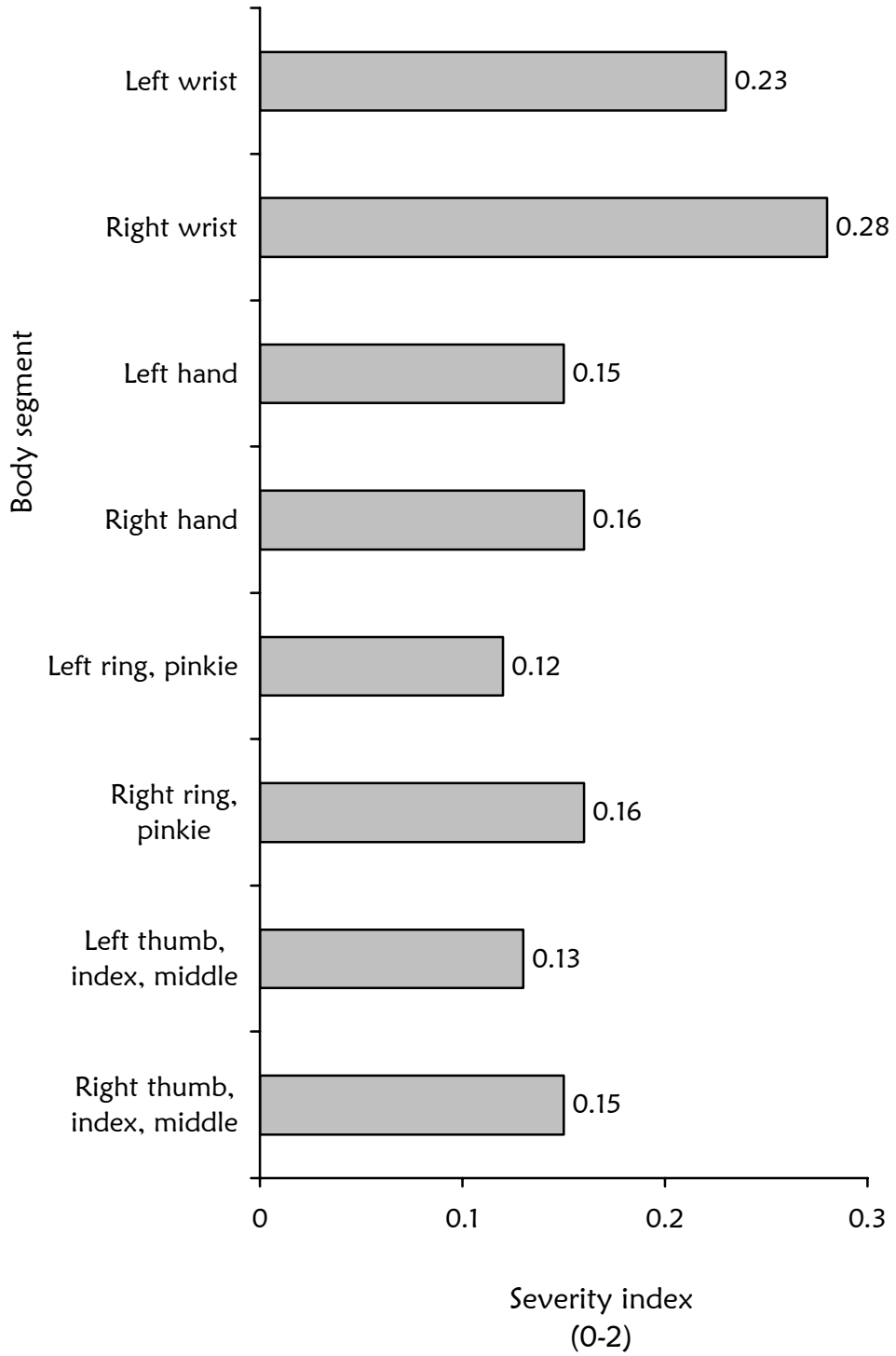

Figure 5. Mean tingling severity index. The scale used was from 0 (no tingling) to 2 (severe).

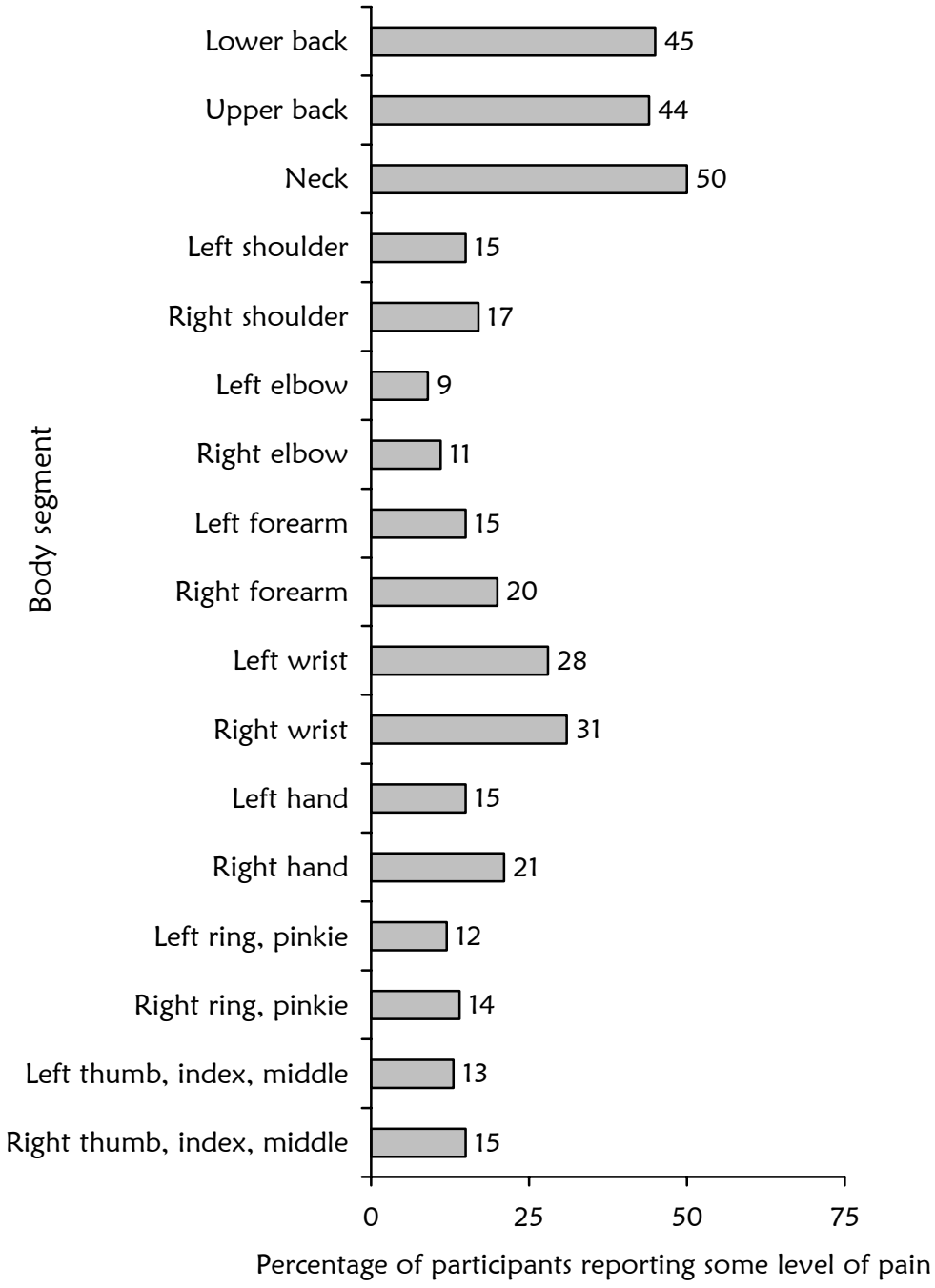

Figure 6. Percentage of participants reporting some level of pain for different body segments

Table 4. Survey results for the left side			
Left side – pain		**Left side - tingling**	
Thumb, index or middle fingers		**Thumb, index or middle fingers**	
Grade 0	87.3%	Grade 0	88.4%
Grade 1	8.6%	Grade 1	9.7%
Grade 2	3.3%	Grade 2	1.9%
Grade 3	0.8%	Blank	0.0%
Grade 4	0.0%		
Grade 5	0.0%		
Blank	0.0%		
Ring or pinkie fingers		**Ring or pinkie fingers**	
Grade 0	88.4%	Grade 0	89.8%
Grade 1	8.0%	Grade 1	8.0%
Grade 2	3.0%	Grade 2	2.2%
Grade 3	0.6%	Blank	0.0%
Grade 4	0.0%		
Grade 5	0.0%		
Blank	0.0%		
Hand		**Hand**	
Grade 0	84.5%	Grade 0	87.5%
Grade 1	9.4%	Grade 1	9.4%
Grade 2	4.4%	Grade 2	2.8%
Grade 3	1.4%	Blank	0.3%
Grade 4	0.0%		
Grade 5	0.0%		
Blank	0.3%		
Wrist		**Wrist**	
Grade 0	72.3%	Grade 0	79.2%
Grade 1	18.8%	Grade 1	15.8%
Grade 2	5.3%	Grade 2	3.6%
Grade 3	1.9%	Blank	1.4%
Grade 4	0.3%		
Grade 5	0.6%		
Blank	0.8%		
Forearm			
Grade 0	85.0%		
Grade 1	10.5%		
Grade 2	3.0%		
Grade 3	1.5%		
Grade 4	0.0%		
Grade 5	0.0%		
Blank	0.0%		

Table 4 (cont.) Survey results for the left side	
Elbow	
Grade 0	90.6%
Grade 1	7.5%
Grade 2	1.1%
Grade 3	0.8%
Grade 4	0.0%
Grade 5	0.0%
Blank	0.0%
Shoulder	
Grade 0	84.8%
Grade 1	8.0%
Grade 2	5.0%
Grade 3	1.7%
Grade 4	0.0%
Grade 5	0.6%
Blank	0.0%

Table 5. Survey results for the right side			
Right side – pain		**Right side - tingling**	
Thumb, index or middle fingers		**Thumb, index or middle fingers**	
Grade 0	85.0%	Grade 0	86.7%
Grade 1	9.7%	Grade 1	10.5%
Grade 2	3.9%	Grade 2	2.5%
Grade 3	1.1%	Blank	0.3%
Grade 4	0.3%		
Grade 5	0.0%		
Blank	0.0%		
Ring or pinkie fingers		**Ring or pinkie fingers**	
Grade 0	85.6%	Grade 0	86.4%
Grade 1	9.1%	Grade 1	10.8%
Grade 2	3.9%	Grade 2	2.5%
Grade 3	1.1%	Blank	0.3%
Grade 4	0.0%		
Grade 5	0.0%		
Blank	0.3%		
Hand		**Hand**	
Grade 0	78.7%	Grade 0	84.8%
Grade 1	13.9%	Grade 1	13.0%
Grade 2	5.0%	Grade 2	1.6%
Grade 3	1.4%	Blank	0.6%
Grade 4	0.6%		
Grade 5	0.3%		
Blank	0.3%		

Table 5 (Cont.) Survey results for the right side			
Wrist		**Wrist**	
Right side – pain		**Right Side -- tingling**	
Grade 0	68.7%	Grade 0	77.0%
Grade 1	20.2%	Grade 1	16.4%
Grade 2	7.2%	Grade 2	5.8%
Grade 3	2.5%	Blank	0.8%
Grade 4	0.8%		
Grade 5	0.3%		
Blank	0.3%		
Forearm			
Grade 0	80.3%		
Grade 1	13.9%		
Grade 2	4.2%		
Grade 3	0.8%		
Grade 4	0.5%		
Grade 5	0.3%		
Blank	0.0%		
Elbow			
Grade 0	88.7%		
Grade 1	8.0%		
Grade 2	2.5%		
Grade 3	0.8%		
Grade 4	0.0%		
Grade 5	0.0%		
Blank	0.0%		
Shoulder			
Grade 0	82.5%		
Grade 1	10.0%		
Grade 2	3.6%		
Grade 3	2.2%		
Grade 4	1.4%		
Grade 5	0.3%		
Blank	0.0%		

Table 6. General pain – both sides	
Lower back	
Grade 0	54.6%
Grade 1	23.3%
Grade 2	13.3%
Grade 3	5.5%
Grade 4	1.9%
Grade 5	1.4%
Blank	0.0%

Table 6 (Cont). General pain – both sides	
Upper back	
Grade 0	56.2%
Grade 1	23.5%
Grade 2	10.5%
Grade 3	5.0%
Grade 4	3.0%
Grade 5	1.4%
Blank	0.4%
Neck	
Grade 0	49.6%
Grade 1	29.4%
Grade 2	12.5%
Grade 3	4.7%
Grade 4	2.2%
Grade 5	1.7%
Blank	0.0%

Concluding Remarks

We completed a study of various ergonomic issues related to the laptop program at a university with an undergraduate population of approximately 2,500 students. All students receive a laptop computer when they join the university. A questionnaire was developed to compile descriptive statistics on the levels of discomfort—tingling and pain—experienced by the student population. A total of 361 students participated in the survey.

The number of participants expressing concerns about discomfort in the different survey categories varied. An analysis of survey statistics reveals the following:

(1) In all pain and tingling categories, except for neck pain, the majority of the survey participants had no complaints.
(2) A certain minimum number of respondents reported some level of pain in ALL categories. Roughly 10 to 20 percent of the participants had finger, elbow, or shoulder pain. A larger number of participants complained about forearm and wrist problems. More than 40 percent of the students had upper or lower back pain. The category with the largest number of respondents indicating pain was the neck. Approximately half the respondents expressed some level of neck pain.

The statistics presented here should be interpreted with caution. The following factors, which are frequently encountered by analysts while conducting ergonomic studies, must be considered when before attempting to draw definite conclusions:

(1) The degree of discomfort is highly subjective. This is a difficulty frequently found in medical and ergonomic studies.
(2) Ergonomic problems may arise from external factors such as practicing a sport, playing a musical instrument, conducting physical work, and playing videogames.
(3) Preexisting injuries are likely to affect the results of any survey similar to that conducted here. Incoming students may already have sustained repetitive motion injuries due to previous computer usage or other factors.
(4) Similarly, it is debatable whether ergonomic discomfort is due to the academic use of the computer alone: most students use their laptop to conduct extra-curricular work such as work, Internet browsing, emailing, and chatting, and the development of personal web pages.

(5) Some students might be using peripherals such as an extended keyboard, a mouse, or a docking station. Such peripherals might attenuate the negative impact of laptops.
(6) Some laptop users may assume an incorrect posture while using the computer. Students are frequently found using their laptop at the cafeteria, in the dorm rooms, and even while sitting on the floor.
(7) Regular desks found in dorm rooms, which may not be designed for computer use, may be used as laptop stations.
(8) Appropriate rest periods when using a laptop may ameliorate its ergonomic impact.

Recommendations

Further research is suggested. It would be of great interest to work with a students from various universities using different laptop computers. Such studies might be conducted via Internet; they may have implications regarding the decision to buy a given brand of laptop computer. This type of research might also drive laptop manufactures to emphasize design for usability. Some other universities may have adopted docking stations, which might arguably diminish some of the negative impact of laptops in that the process of plugging in peripherals is avoided.

In this study there were no questions regarding the posture assumed by students when using their laptops. This information would be useful to assess the potential benefits of educational programs on the ergonomics of laptops and of the possible adoption of docking stations.

It would also be of interest to investigate the ergonomic impact of the design of laptop carrying bags. Carrying the laptop around campus results in an additional burden that might result in back problems especially if one considers the considerable weight of textbooks.

The effect of rest periods while using a laptop could be the subject of further study. Factors to investigate might include (1) the frequency of such breaks, (2) the type of activities conducted during the break (i.e., stretching, closing one's eyes, etc.,) and (3) the general awareness of the need to rest.

Investigators may conduct studies on whether students who use a laptop and also play a musical instrument, use videogames, practice a sport, or perform physical work are at a higher risk of sustaining repetitive stress injuries.

Every university that has implemented a laptop program should adopt a proactive stance. The administration should consider the benefits of implementing a campus-wide education program about the ergonomics of laptops. The program should include issues such as posture, rest periods, and the use of peripherals and ergonomic furniture.

The study reported here was sponsored by an internal grant. It was part of an effort to analyze and prevent ergonomic problems related to the use of laptops at the university.

References

Bureau of Labor Statistics. (2003). *Work Injuries and Illnesses by Selected Characteristics*. U.S. Department of Labor. Retrieved May 3, 2006, from http://www.bls.gov/iif/

Fry, H. and Rowley, G. (1989) "Music related upper limb pain in school children." *Annals of rheumatic diseases*, 48 (12), 998-1002.

Harris, C. and Straker, L. (2000). Survey of Physical Ergonomics Issues Associated with School Children's Use of Laptop Computers. *International Journal of Industrial Ergonomics,* 26, 337-346.

History of Laptop Computers. Retrieved April 24, 2006, from http://inventors.about.com/library/inventors/bllaptop.htm.

Laptop Ergonomics. Cornell University. Gannett Health Services. Retrieved May 15, 2006, from http://www.gannett.cornell.edu/healthAtoZ/healthAdvice/laptopErgo.html.

Laptop Ergonomics and Tips on Using Laptop Computers. Adaptive Technology for Information and Computing at MIT. Retrieved May 26, 2006, from http://web.mit.edu/atic/www/disabilities/rsi/laptopergo.html.

Loy, B. (2006, Sep.). Accommodation and Compliance Series: Employees with Cumulative Trauma Disorders. Retrieved Sep 20, 2006, from http://www.jan.wvu.edu/media/CTDs.html

McDonald, H. (1995). Reflections of a learning community: MLC Initial Research Report. Retrieved September 20, 2006, from http://www.mlckew.edu.au/computing/reflect/initial.htm

Medical Multimedia Group. *A Patient's Guide to Cumulative Trauma Disorder (CTD)*. Retrieved May 4, 2006, from http://www.healthpages.org/AHP/LIBRARY/HLTHTOP/CTD/

Mekhora, K., Liston, C.B., Nanthavanij, S., and Cole, J.H. (2000). "The effect of ergonomic intervention on discomfort in computer users with tension neck syndrome". *International Journal of Industrial Ergonomics,* 26(3), 367-379.

Shears, L. (1995). *Computers and Schools*. Victoria: Australian Council for Educational Research.

Sommerich, C.M., Starr, H., Smith, C.A., and Shivers, C. (2002) Effects of notebook computer configuration and task on user biomechanics, productivity, and comfort. *International Journal of Industrial Ergonomics*, 30, 7-31.

Szeto, G. and Lee, R. (2002). An Ergonomic Evaluation Comparing Desktop, Notebook, and Sub-Notebook Computers. *Arch. Phys. Med. Rehabil.,* 83, 527-532.

Thrasher, M. and Chesky, K. Medical Problems of Clarinetists. Results from the UNT Musician Health Survey. *Texas Music Education Research*. Retrieved March 18, 2006, from http://www.tmea.org/080_College/Research/thr1998.pdf

Westmoreland, R. (1993, May). Cumulative Trauma Disorders: Some Cautions for Conservators. *WAAC Newsletter, 15(2), 37-38.* Retrieved July 21, 2006, from http://palimpsest.stanford.edu/waac/wn/wn15/wn15-2/wn15-210.html

Works Consulted

Aaras A., Horgen, G., Bjorset, H. H., Ro, O., and Thoresen, M. (1998). Musculoskeletal, visual and psychosocial stress in VDU operators before and after multidisciplinary ergonomic interventions. *Applied Ergonomics*, (29) 5, 335-354.

Amell, T.K. and Kumar, S. (2000) Cumulative trauma disorders and keyboarding work. *International Journal of Industrial Ergonomics,* 25(1), 69-78.

Blomé, M., Johansson, C. R., and Odenrick, P. (2005). Visualization of ergonomic guidelines –A comparison of two computer aided systems to support vehicle design. *International Journal of Industrial Ergonomics*.

Delisle, A., Imbeau, D., Santos, B., Plamondon, A., and Montpetit, Y. (2004) Left-handed versus right-handed computer mouse use: effect on upper-extremity posture. *Applied Ergonomics* 35, 21-28.

Fagarasanu, M. and Kumar, S. (2003). Carpal tunnel syndrome due to keyboarding and mouse tasks: a review. *International Journal of Industrial Ergonomics,* 31, 119-136.

National Safety Council. Repetitive Motion Injuries. Body Parts. http://www.nsc.org/issues/ergo/rmiwrist.htm

Szeto, G.P., Straker, L.M., and O'Sullivan, P.B. (2005). EMG median frequency changes in the neck-shoulder stabilizers of symptomatic office workers when challenged by different physical stressors. *Journal of Electromyography and Kinesiology,* 15, 544-555.