Technology in the classroom: College Students' computer usage and ergonomic risk factors

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Abstract – The personal computer (PC) is essential in today's workplace, and as a result has become a critical component of the educational system. Many colleges and universities have instituted requirements for students to purchase or lease computers upon admission. However, despite the immense investment of finances and time to implement such programs, little is known about the effects on student education or potential physical harm due to increased computer usage. Training in healthy computing techniques may reduce risk factor exposure, as seen from ergonomics programs in the workplace. However, few colleges include such programs in conjunction with the computer ownership requirement. This paper provides results of an examination of computer ownership programs in a number of US higher educational institutions. Also provided is an overview of research studies that have examined the prevalence of computer-use-related musculoskeletal discomfort in college students, and associated risk factors associated.

Keywords: Ergonomic Risk Factors, Computer Usage, University Students, Musculoskeletal Discomfort, Education.

INTRODUCTION

Educational settings must maintain pace with technology in order to prepare students for their futures. With the rapid changes in technology, one challenge for education is incorporating the newest technology effectively. Incorporating new technology is a multidimensional endeavor that includes assisting users to become familiar with the technology through training sessions and workshops and accommodating the technology within existing physical spaces or modifying those spaces to better accommodate the technology. When new technologies are introduced in a university setting, an important dimension that is often overlooked is ergonomics. Using computers as an example, much has been written about incorporating computers into office work environments and problems that can arise that are linked to mismatches between the technology and the physical environment (such as use of desks that are too high to afford comfortable use of a keyboard or overhead lights that produce glare on computer screens). Additional problems have been identified with certain patterns of use, such as prolonged hours of computer use (for work or for pleasure), as well adoption of awkward postures when using a computer. Yet, based on our review of a number of programs, this knowledge is commonly not incorporated into university-sponsored technology training and also does not seem to be widely considered when technology is integrated into physical spaces on campuses (such as classrooms or lecture halls). The available literature indicates that musculoskeletal discomfort (MSD) associated with computer use is prevalent not only in adults, but in students, including those in college [Katz, 7, Noack, 8, 9], as well as high school and grade school [Harris, 10, Jacobs, 11, Royster, 13]. As computer usage is now an integral part of training the next generation workforce, studying computer user discomfort must extend outside the typical workplace settings and into the education environment. This paper discusses college students' computer usage in the United States, reports of computer-use-related musculoskeletal discomfort in this group, and possible measures to reduce students' risk factor exposure, including what role colleges may or should play.

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COLLEGE COMPUTING PROGRAMS

Universities and colleges compete to attract the top students and provide them with the finest possible education to prepare them for their future careers. In today's society nearly every field requires not only specialized knowledge, but also a strong computer skills base. Candidates without computer skills are at a disadvantage in the job market, and therefore many universities and colleges now require personal computer ownership for their students.

Reasons for Computer Requirement

Understanding a university's goals in implementing a computer requirement provides for measures to gauge success. In order to determine the institutional technology requirements this review began with an examination of a list maintained by Brown, that is described as providing "a quick overview of institutions with some sort of notebook or laptop computer initiative", at some point in time [Brown, 14]. This list currently contains the names of about 250 institutions and provides information about hardware specifications, when the program was initiated, and who (or what organization) maintains the computer requirement [Brown, 14]. Our addition to this base of knowledge includes documenting each institution's motivation for its computer requirement, if that information could be located on the institution's website. This is presented in Table 1.

Based on this review there do not appear to be any trends linking the colleges' demographics, history, or the resulting technical level of degree to the computer requirement. The adoption of a computer requirement did not predominately trend toward private or public institutions, as seen in Table 2. The U.S. colleges in this review vary from an enrollment as low as 245 students at Harrisburg University of Science & Technology to those exceeding 20,000 students, such as Illinois State University. A few institutions focus on educating professionals through online classes or condensed coursework, making the computer requirement apparent. However, the vast majority of institutions with computer requirements are traditional colleges.

Table 1: Common Reasons for the Computer Requirement Amongst U.S. Higher Education Institutions with a Notebook/Laptop Initiative *

Institution	All students access	Access anywhere	Future Career relevance	Learning tool	Warranty & Service	Financial Aid is available	Provided to student	Reduce hardware, facilities costs	Software compatibility
Arizona State University #	√	√	√	√	√				√
Berea College	√	√	√	√	√		√		√
Berklee College of Music	√	√	√	√	√		√		√
Bridgewater State College	√	√		√	√				√
Centenary College	√	√		√	√		√		√
Chatham College		√		√			√		√
College of Mount Saint Joseph		√	√	√		√			√
College of New Rochelle	√						√		√
College of William and Mary	√	√		√	√	√			√
Coppin State University	√	√	√				√		√
Cornerstone University		√	√	√			√		
Dakota State University	√		√	√			√		
DePauw University		√		√	√			√	√
Drew University			√		√				√
Fort Hayes State University		√	√	√					√
Framingham State College	√		√	√					
Houghton College			√					√	√

Institution		All students access	Access anywhere	Future Career relevance	Learning tool	Warranty & Service	Financial Aid is available	Provided to student	Reduce hardware, facilities costs	Software compatibility
Johnson C. Smith University			√		√			√		
King College		√	√	√	√			√		
Lawrence Technical University		√		√	√			√		√
Mayville State University			√	√	√			√		
Meredith College			√	√	√	√		√		√
Milwaukee School of Engineering			√			√		√		√
Minnesota State University	#	√		√	√	√				√
Mississippi State University	#	√	√	√						√
Morningside College		√	√		√	√		√		√
Morrisville State College			√		√			√		
New Mexico University	#		√			√	√			
Northern Michigan University						√		√		√
Northwest Missouri State University			√			√		√		
Oklahoma Christian University			√	√	√	√		√		
Polytechnic University of NYU					√	√				√
Quinnipiac University		√			√	√	√			√
Rensselaer Polytechnic Institute			√		√	√	√			
Rose-Hulman Institute of Technology			√			√	√			√
Sacred Heart University		√	√			√		√		√
Salem State College					√	√				√
San Jose State University	#			√	√	√				√
Seton Hall University			√		√	√		√		√
Sierra Nevada College					√				√	√
Southern New Hampshire University			√	√	√	√				
Southwestern College		√	√	√	√	√				√
St. Francis University			√			√		√		
St. John's University		√	√	√	√	√		√		√
Temple University	#	√	√	√				√		√
Texas A&M University	#			√	√	√				√
The Pennsylvania State University	#			√	√					√
The University of Texas	#			√	√	√				√
Thiel College		√	√			√		√		√
University of California	#	√		√			√			
University of Cincinnati	#	√				√			√	
University of Houston		√			√	√				√
University of Louisiana at Lafayette	#			√	√					√
University of Minnesota	#	√	√			√		√		√
University of North Carolina at Chapel Hill			√	√	√	√	√			√
University of North Carolina at Greensboro				√		√	√			√
University of North Carolina at Wilmington			√		√	√	√			

Institution		All students access	Access anywhere	Future Career relevance	Learning tool	Warranty & Service	Financial Aid is available	Provided to student	Reduce hardware, facilities costs	Software compatibility
University of Oklahoma	#		√		√	√	√			√
University of Oregon	#				√	√	√			√
University of South Florida	#				√	√	√			√
University of North Dakota	#		√	√	√			√		
Ursinus College		√	√		√	√		√	√	
Valley City State University			√	√	√			√		
Vanderbilt University	#		√	√	√					√
Wayne State University	#			√	√	√	√			√
Wentworth Institute of Technology		√				√		√		√
Western Michigan University	#		√	√	√					
Winona State University			√		√	√	√	√		
Worcester State College			√	√	√					√

* Information gathered from publicly available University websites

\# Entire Institution not participating in requirement

As expected, 'future career relevance' and viewing the computer as a 'learning tool' were commonly cited as motivations for the requirement. The practical benefit of software compatibility was the most common reason identified; it was considered so important that a number of universities either provided the computer to the student or specified a specific model and vendor. This ensured that all students had a computer that could accommodate the required software, and with all students having similar hardware configuration or platforms (for example, Windows or Macintosh), this reduced the burden of providing training over a variety of platforms or software packages.

Table 2: Surveyed U.S. Higher Education Institutions with Computer Requirements, by Enrollment Size and Type *

Number of Enrolled Students	Public	Private
Fewer than 1999	4	22
Between 2000-4999	4	24
Between 5000-19,999	28	19
More than 20,000	33	5
Total	69	70

* Information gathered from publicly available University websites

Computer Configuration and Training

Successful technology integration techniques are a recurring theme in education research. Computers have been shown to be useful tools in education, but only in the wake of proper planning, which includes appropriate training for faculty and students. Most, if not all, of the institutions requiring computer purchase also included an introductory usage program with workshops on how to use the hardware and software. However, an ergonomics component was generally not evident in the description of these training sessions. The training programs focused on how to use the software, but did not look beyond that to provide training on healthy computing or computer ergonomics.

The computer configurations, as seen in Figure 1, have progressively changed from traditional desktop PCs, to laptop PCs, and in some locations towards the emerging tablet PC. The laptop and tablet PCs offer more mobility than the desktop PCs, affording students the option to bring their computers to class. Figure 1 summarizes the type of computer required, and the availability of ergonomics or healthy computing programs. As seen in the figure, very few programs include ergonomics. Of those that offer ergonomics information, the information appeared to be directed to employees and not to students.

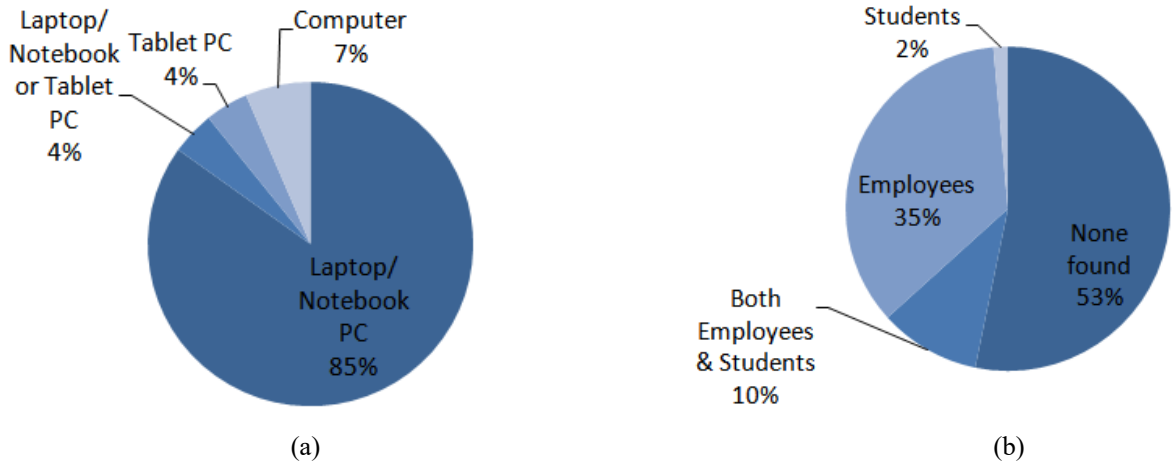

Figure 1: U.S. Higher Education Institutions with a Computer Requirement: (a) Configuration Types* and (b) Ergonomics Program Availability*

* Information gathered from publicly available University websites

COLLEGE STUDENTS AND MSDS

There is a long history of research on the topic of typing-related (and then computer-use-related) musculoskeletal discomfort in working populations. More recently, attention has begun to focus on MSDs in college students and associations with their increasing use of computers, as well as their earlier exposure to computers than that of prior generations of students. Alexander was one of the first to recognize the potential for future workers (students) to enter the workforce injured and/or with little knowledge of links between computer use and MSDs, and so conducted one of the earliest surveys of students' knowledge of computer ergonomics [Alexander, 15]. Although there were weaknesses in the study, in general it revealed that students had little knowledge about computer ergonomics. Subsequent research has provided information about the prevalence of MSDs in students, effects of MSDs on student functioning, and risk factor exposure, through surveys, observational field studies, and laboratory-based studies. These studies show that risk factor exposure and MSD prevalence in college students has some important similarities to the office workers' experience.

Repetition, Duration, and Symptoms

Amick and colleagues have published a number of studies aimed at improving the understanding of students' use of computers, risk factors they are exposed to when using PCs, and the effects of this use. In a cross-sectional survey, Hupert et al. found that 10% of a sample of undergraduates reported experiencing upper extremity pain within an hour of starting to use a computer (on any given day) [Hupert, 16]. In a small, prospective study, Chang et al. found an increase in musculoskeletal symptoms with measured daily computer use that exceeded 3-3.5 hrs, in a group of male students; no such relationship was found for the group of female subjects [Chang, 17].

Research from another group of researchers compared computer usage in college students and professional workers. The results showed that total reported computer use by graduate students (33.7 hours per week) was similar to that of professional workers (35.7 hours per week) [Noack-Cooper, 18]. Also, the propensity for continuously working at the computer (meaning the lack of breaks) correlated with the reported discomfort among the students. The

similarities between the professional workers and college students computing hours, as well as reported discomfort, suggests the need to implement some type of ergonomics intervention for the college student population.

Posture and Symptoms

In a survey of graduate and undergraduate students, 30% of respondents who used desktop PCs and 18% who used notebook PCs (NPCs) reported assuming awkward or uncomfortable postures "quite often" or "almost always" [Noack, 8]. Further, there was a significant statistical relationship amongst desktop PC users between frequency of assuming awkward postures and reporting of frequent discomfort associated with computer use ($p=0.013$). Amongst notebook PC users, the association was almost significant ($p=0.06$). To verify self-reported posture data, other researchers have directly observed college students while using computers [Menendez, 19, Tullar, 20]. During three periods lasting one week each, researchers found that greater than 75% of the students assumed postures associated with causing musculoskeletal disorders [Tullar, 20]. Examples included "arms not along side during keying or mousing; lower back not supported; not having chair accessories; computer monitor not adjustable; mouse being too high or low; hand/wrist/forearm in contact with the desk edge; lack of wrist support; and keyboard not being adjustable". When applying RULA to assess student postures when using computers, Menéndez et al. found scores averaging around 5.5, which indicate a need for change soon, per the developers of RULA [Menendez, 19, McAtamney, 21]. Lifetime prevalence for experiencing symptoms during or after computer work was 86% in these study participants [Menendez, 19].

Not only are college students experiencing discomfort, but the discomfort is limiting their functionality. Katz et al. have shown that many activities that students need to perform on a daily basis can be affected by upper extremity discomfort associated with using computers [Katz, 22]. In one study 70% of female students and 30% of male students reported recently experiencing upper extremity symptoms with computing; similar percentages of students scored above 0 on the researchers' Student Functional Limitation Scale, which assesses the student's ability to perform academic or extra-curricular activities [Jenkins, 23]. Interestingly, the percentage of females reporting discomfort and functional limitations was somewhat greater in this study than in a prior study that employed the same methodology, which may be a consequence of increased computer use even within this short time frame [Hupert, 16]. Compared to the 2004 study, a greater percentage of both males and females reported seeing medical attention for their computer-use-related discomfort in the 2007 study.

ERGONOMICS AWARENESS

Ergonomics programs in the workplace take a variety of forms. Workplaces may distribute pamphlets or require employees to attend training presentations. Other programs are more interactive, with self-help web sites which guide the user on how to set-up a computer workstation for better posture, and with tips on healthy computing, such as taking breaks.

When examining the various college websites, the availability of these programs often did not seem as though it would be obvious to students, and in many cases also not obvious to employees. It may be that safety concerns within higher education institutions are still primarily focused on traditional areas of laboratory safety, environmental health, chemical safety, etc., and that office ergonomics has yet to be recognized as important to employee health. It may also be that the institutions' concerns for student safety are primarily focused on areas such as crime prevention and more traditional health concerns (flu outbreaks, sports injuries, etc.). However, given the ubiquitous exposure to computers experienced by both employees and students, and the prevalence of computer-related discomfort amongst both worker and student populations, colleges should be encouraged to look beyond their traditional health and safety concerns towards including ergonomics in that mix.

Education and Mobile Computing

Students report that computers are essential to their academic work and personal lives, to the point that "it is hard to imagine functioning as a student without using a computer" [Cortés, 24]. That may mean that, as a preventive measure, advising a reduction in time spent using a computer is unrealistic, and that other avenues of risk factor reduction should be suggested. In particular, those that focus on patterns of use and the physical interaction of the student and his/her computer may be more readily adopted.

A desktop computer, with a separated monitor and keyboard, allows for adjustability of these elements, relative to the user, for a healthier computing set-up. NPCs, while affording a wider range of postures to users (from sitting at a desk to lying on the floor), provide very limited adjustability when operated as stand-alone units. For example,

NPC users can not alter the height of the screen to prevent neck and shoulder muscle tension, without adversely affecting the keyboard location and negatively affecting the upper extremities. Studies show marked differences in posture and muscle activity when working with a desktop PC and an NPC [Saito, 25, Szeto, 26]. Sommerich found that individuals who used an NPC as a stand-alone device reported more frequent and widespread discomfort than those who utilized the NPC with peripheral devices [Sommerich, 27]. For longer computer usage duration, solutions for laptop users include the use of a docking station, an external mouse, keyboard, and/or monitor [Price, 28, Sommerich, 29]. These peripherals can modify a laptop computer into a more adjustable desktop hybrid. During travel or more mobile computing tasks, some of these modifications are limited in application. However, using an external mouse, keyboard, monitor and/or docking station as often as possible and taking appropriate breaks are easily implemented interventions and should be part of every laptop user's healthy computing habits.

Tablet PC (TPC) usage is particularly understudied with regards to musculoskeletal discomfort in users, with the exception of some studies of K-12 students [Sommerich, 13, 30, 31, Straker, 32]. It is possible that TPCs would not be associated with discomfort because they offer additional versatility in interaction for users. The computer can be used in the notebook or the slate configuration. However, Sommerich et al. reported the prevalence of musculoskeletal discomfort associated with TPCs ranged from about 28-70%, depending on body part, in a group of high school juniors and seniors who participated in a 24/7 access TPC program [Sommerich, 31]. In elementary students the postures and muscle activity of the tablet PC user group were higher than the desktop user group, implying a higher risk for MSD [Straker, 32].

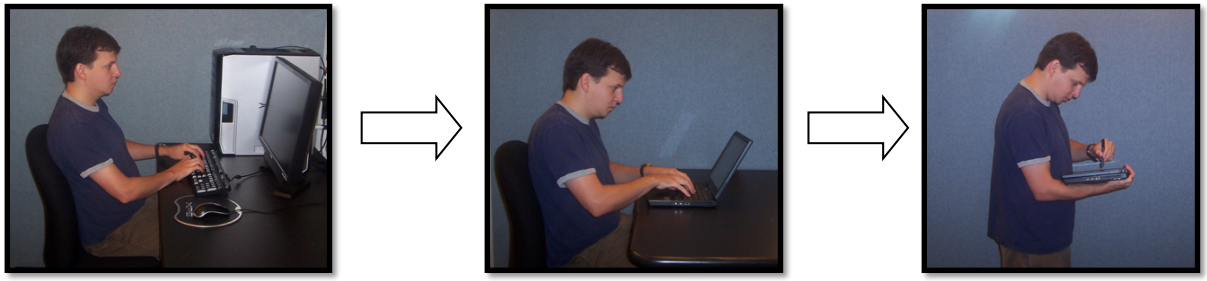

Figure 2: The changing configurations of computers: desktop PC, laptop/notebook PC, and tablet PC

Intervention Success

It is appropriate to study the musculoskeletal discomfort/disorder risk factors to which student computer users are exposed, in order to determine the best means for reducing those exposures and, thereby the associated discomfort/disorder. While the available literature is mixed on the success of interventions aimed at reducing physical discomfort associated with computer use, some studies have shown some limited success for workstation adjustment [Aarås, 33], some alternative keyboard designs [Tittiranonda, 34], rest breaks [Galinsky, 35], and arm support [Rempel, 36].

Participatory ergonomics intervention methods have been shown to be effective in other occupational settings [Hignett, 37]. The benefits of a participatory ergonomics program are that the participants drive the changes and are therefore more likely to propose solutions they may be open to trying and maintaining. In two studies involving students (college – [Robertson, 38]; high school – [Korkmaz, 39]), participants demonstrated increased knowledge about computer-related ergonomics at the end of the study. However, recruitment (low participation) was a problem in both studies. Therefore, this methodology needs further tailoring if it is to be effective in educational environments.

DISCUSSION

In the fall of 2005 U.S. higher education institutions enrolled 17,487,475 students. The projected enrollment in degree-granting institutions in 2011 is 19,105,000 [Digest of Education Statistics, 40]. The rising number of institutions implementing computer requirements, and the level of integration into the institution, are potentially increasing student exposure to computers. As seen in this review, laptop or tablet PCs are most often required which, based on their design, potentially impose greater ergonomic risks.

Aspects of student life create a more diverse computing environment, different from traditional computer user populations (work-related). Many college students belong to a mobile computing population, taking their computers with them to class, to the library, home, and, given the campus-wide wireless network at many institutions, can even stop briefly to check email on the steps of a building or standing in a hallway. Their mobility can offer reduced duration in one particular position when using the computer; however the lack of a workstation set-up increases the likelihood of poor posture while computing. Poor posture, duration of computer use and reported discomfort as a result of computer usage indicates that college students, however different from office workers who use computers, are exposed to some of the same risk factors that may increase the risk of musculoskeletal disorders.

We have to assume that the earlier students adopt healthy computing habits the better. It is more likely that without intervention, through ergonomics programs or healthy computing initiatives, college students will enter the workforce with musculoskeletal discomfort that is linked to computer use, as well as a lack of awareness of how to reduce their exposure to computer-use-related risk factors. Intervention measures, long a part of the workplace, now need to progress into the educational environment. Pilot programs have been tested in a few colleges, but their application is uneven and not widespread. The next step is disseminating this information to all colleges, to highlight the need for, and provide guidelines to, implementing ergonomics training along with the computer requirement.

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