Ergonomic Analysis of Personal Computer Workstation Environments in the Home

by

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ABSTRACT

The purpose of this study was to evaluate home computing workstations of an identified population to identify potential situations that could result in ergonomic issues. The use of a PC in the home could contribute to the probability of developing CTDs or CVS. To achieve this purpose, various objectives were developed that identified the characteristics of home computing workstations, identified and assessed the extent of potential ergonomic issue(s) for the individual(s) operating the PC at home, and compared the characteristics of home computing workstations with overall best practices of computing workstations. The tools used to evaluate the home computing workstations included an ergonomic survey, RULA assessment and ergonomic instrumentation. The researcher was able to identify potential situations that could result in ergonomic issues based on PC workstations in the home. It appears that home computing workstations have

the potential to lead to ergonomic issues consistent with those identified within an office work environment. The most significant characteristic of home PC workstations that was identified was the lack of an adjustable desk or workstation. The participants also experienced discomfort in the hands, eyes, back and shoulders while operating the PC in the home. With the results of this study, best practice of overall PC workstations were identified and recommended to reduce the potential development of CTDs or CVS by use of a PC in the home.

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Chapter 1: Introduction

Since their introduction in the 1980s, PCs have become powerful and extremely versatile tools that have revolutionized how people work, learn, communicate, and find entertainment (Encarta®, 2008). Many households in the United States now have PCs, thanks to affordable prices and software that has made PCs easy to use without special computer expertise (Encarta®, 2008). PCs can be used in the home, at work, or in the case of laptops, at any other desired location if permitted. PCs in the home can be very beneficial; work can be done outside of the workplace and children can do homework outside of school and libraries just to name a few.

Office environments with computer workstations have been found to contribute to ergonomic issues. "Ergonomic risk factors have been identified in the office workplace and are likely to be present in the telecommuters work situation" (Westin, 2000, p. 10). Office ergonomics consist of a workstation setup relative to an individual's posture, length of time in a position or doing a particular task, types of movements, or repetition of movements (Erstad, 2007). Many job surroundings, such as the work surface, lighting, noise level, and temperature are focuses of office ergonomics. Any device used to perform the job duties such as a computer mouse or scanning machines are focuses of office ergonomics as well (Erstad, 2007). Utilizing computers in the home is likely to create ergonomic issues consistent with those identified in the office workplace such as cumulative trauma disorders (CTDs) and computer vision syndrome (CVS). The most common example of a CTD is tendonitis, while carpal tunnel syndrome is a more rare and serious disorder (University Health Services, 2008). Eyestrain is an overall symptom of CVS (University Health Services, 2008).

Workstation design is an important factor of office ergonomics, which becomes an important factor in the home as well. Workstation design as well as the location of the workstation (or the location of the PC) can have an affect on your health with the onset of CTDs, repetitive stress injuries (RSIs), and CVS.

PCs (laptops or desktops) use in the home results in extensive use of a keyboard, monitor, and mouse. "The Occupational Safety and Health Administration and The National Institute of Occupational Safety and Health have identified repetition, posture, force and a combination of these risk factors in the office environment as risk factors that have the capability of causing cumulative trauma disorders (CTDs) or Work-Related Musculoskeletal Disorders (MSDs)" (Westin, 2000, p. 6). Improper position of the person's body in relation to the keyboard and monitor can lead to CTD symptoms or injuries (Westin, 2000). Furthermore, the position of the monitor in relation to the person's eyes can also result in inadequate or improper positions that can lead to CTD symptoms or injuries (Westin, 2000). CTDs accounted for 29% of all workplace injuries requiring time away from work in 2007 (Bureau of Labor Statistics, 2009). CVS is another factor that can possibly result from interaction with a computer display or its environment. Almost 80% of employees who use computers for more than two hours a day suffer from symptoms of CVS (Business Wire, 2006). According to the U.S. Bureau of Labor Statistics (1998), more than 75 million workers sit at computers every day (as cited in Torrey, 2003). More than 70% of these people are affected in some way by CVS (Torrey, 2008). The risk factors for these various disorders and syndrome can also be found in the home with the use of a personal computer. There are an alarming number of complaints from discomfort and injuries that result in becoming CTDs or RSIs in the

office workplace. According to OSHA, CTDs are the number one occupational illness, accounting for about 65% of all illnesses reported, and over 2 million compensation claims paid per year by private industry (Kalthofer, 2002). This can also be expected to occur in the home with the personal use of desktop or laptop computers.

Statement of the Problem

Home computing workstations have the potential to lead to ergonomic issues consistent with those identified within an office work environment. The locations of PCs in the home can vary from household to household. The workstation set-up in many homes may not be properly ergonomically designed. This could lead to the user developing CTD or CVS symptoms from the various risk factors that could be acquired when using a PC in the home environment.

Purpose of the Study

The purpose of this study was to evaluate home computing workstations of an identified population to identify potential situations that could result in ergonomic issues. The use of a PC in the home could contribute to the probability of developing CTDs or CVS.

Research Objectives

1. Identify the characteristics of home computing workstations.
2. Identify and assess the extent of potential ergonomic issue(s) for the individual(s) operating the PC at home.
3. Compare the characteristics of home computing workstations with overall best practices of computing workstations.

Importance of Study

PCs can greatly improve productivity in the workplace, allowing people to collaborate on tasks from different locations and easily share documents and information. Many people with a PC at home are able to telecommute, working from home over the Internet. Laptop PCs with wireless connections to the Internet allow people to work in virtually any environment when away from the office. PCs can help people to be self-employed (Encarta®, 2008). "The number of tele-workers has continued to increase by approximately 10% to 15% each year in the US and in many countries" (Gordon, 1999, pg. 4). This means that more and more people are working out of their homes and are using PCs. These statistics do not take into account the number of people who do not use PCs for work-related purposes.

PCs are also a recreational device for playing computer games, watching videos with web casting, downloading music, saving photographs, or cataloging records and books (Encarta®, 2008). With more and more people using PCs in their homes, the potential for more ergonomic injuries will arise.

Data from the research could provide more awareness to those individuals who use a laptop or desktop computer in the home of the ergonomic effects that are enhanced by location and overall workstation of the PC in the home. This could lead to more homes practicing better ergonomic techniques when using their PC.

Limitations of Study

1. The ability to observe actual PC usage and the ergonomic issues that arise in a home will be difficult. Home access may not be granted by any of the participants in the study.

2. Data will be collected by use of a survey, which will be constructed by the researcher. Survey data collection will only be as reliable as those who partake in the survey.

Definition of Terms

Computer Vision Syndrome- "The complex of eye and vision problems related to near work, which are experienced during or related to computer use. CVS is characterized by visual symptoms that result from interaction with a computer display or its environment. In most cases, symptoms occur because the visual demands of the task exceed the visual abilities of the individual to comfortably perform the task" (American Optometric Association, 2008, pg. 1).

Cumulative Trauma Disorder (CTDs)- "A disorder that can affect bones, muscles, tendons, nerves and other anatomical features. It develops when micro traumas, or minute injuries, occur repeatedly from over use or misappropriate use of a body part or external force applied to the body" (Adams, 2006, p.1). "Traumas occur when the body part is called on to work harder, stretch farther, impact more directly or otherwise function at a greater level then it is prepared for. The immediate impact may be minute, but when it occurs repeatedly the constant trauma cause damage" (Adams, 2006, pg. 1). Occupational Safety and Health Administration (OSHA) and the National Institute for Occupational Safety and Health (NIOSH) refer to CTDs as Work-Related Musculoskeletal Disorders (MSDs) (OSHA). CTDs is interchangeable with RSIs (repetitive stress injuries), for this study, CTDs will be the only term used.

Desktop- A personal computer that is designed to fit conveniently on top of a typical office desk.

Ergonomics- "The applied science of equipment design, as for the workplace, intended to maximize productivity by reducing operator fatigue and discomfort" (The American Heritage® Dictionary of the English Language, 4th Ed., 2000)

Laptop- "A portable computer small enough to use on one's lap" (The American Heritage® Dictionary of the English Language, 4th Ed., 2000)

Office Ergonomics- Focuses on the arrangement of the work environment to fit a person's needs while he/she is doing a job (Erstad, 2007)

Personal Computer (PC) – A computer, be it a desktop or laptop device, designed for use by a single person (Encarta®, 2008)

Telecommuter-"Interchangeble with tele-worker. An employee that works away from the office and in their home at least 1-3 days per week" (Westin, 2000, p. 12).

Video Display Terminal (VTDs)- consists of a display screen, a keyboard, and a central processing unit (OSHA 3092, 1997).

Workstation- "A desk with a computer or a computer terminal and keyboard" (The Oxford Pocket Dictionary of Current English. 2008)

Summary

PCs have become an important tool in many households in America. More and more people are beginning to work in their homes and PC usage is becoming a part of everyday life. Ergonomics problems that arise with computer use in the office workplace have also found their place in the home.

Chapter II: Review of Literature

The United States population is 303,824,646 (The World Factbook, 2008). A report conducted by hard drive manufacturer Seagate has found that 76% of Americans own a PC…(Gamasutra, 2005). According to the statistics, many people in the U.S. have laptops or desktops for their own personal use. These PCs are being used in the home either for work or recreational purposes. Regardless of what the PC is being used for, using a PC in the home has the potential of causing the development of CTDs or CVS. There are ergonomic considerations that can be implemented in the home to help reduce the possibility of developing CTDs or CVS as well as best practices that can be followed.

Ergonomically Designed Workstations.

Ergonomically correct workstations are workstations that promote the maximum level of comfort, safety, and efficiency for the user (Browne & Goodman, 1999). An ergonomically correct workstation consists of having proper seating, desk height, proper distance of computer monitor from the user's eyes, as well as environmental issues such as proper lighting, noise levels, ventilation, etc. (Browne & Goodman, 1999). Figure one illustrates the basics of an ergonomically correct workstation.

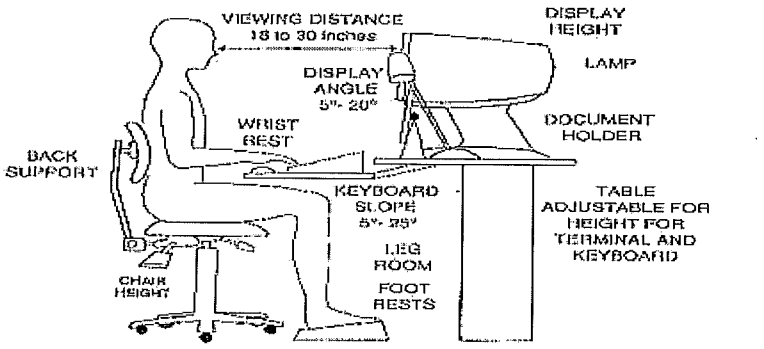

Diagram from "Ergonomics and VDT Use," flyer prepared by the Library of Congress Collections Services VDT Ergonomics Committee, 1991-92.

Figure 1. Illustration of an ergonomically correct workstation.

The top of the desktop computer monitor should be at eye level to the user (Rhodes, 2006). Grieco & Molteni (1999) stated that "the chair is the most important component, since it interacts with other components and significantly influences operator comfort" (p. 1784). Adjustable chairs are more practical; adjustable chairs can accommodate for numerous posture changes to meet the variability of the potential user... (Grieco & Molteni, 1999, p.1784). The second important component of the workstation is the desk. The height or work surface is the most discussed area of the workstation since an incorrect or improper height leads to the development of musculoskeletal problems and prevents the legs from being in an appropriate position (ANSI, 1988). In Tables 1 and 2, recommendations for chair adjustability and desk, VDT screen, and keyboard are given according to Greico and Molteni (1999).

Table 1

Recommendations for the Adjustability of Chair Components and Corresponding Anthropometric Parameters

	Recommended Dimensional Range (in.)	Corresponding anthropometric Parameters
Seat Height	15.4 - 20.5	Popliteal height
Seat Depth	15.4 - 21.7	Buttock popliteal length
Seat width without armrests	$\geq$ 18.5	Hip width
Seat width with armrests	$\geq$ 19.3	Hip width
Backrest height	12.6 - 19.7	Max kyphosis/seat plane height
Backrest width		
Lumbar region	$\geq$ 13	Minimum width lumbar lordosis
Thoracic Region	15	Maximum width at thoracic kyphosis
Armrest		
Height	6.3 - 9.1	Elbow height to seat plane
Depth	7.9 - 9.8	
Width	$\geq$ 2	

Table 2

Recommendations for Desk, VDT Screen, and Keyboard

	Recommended Dimensional Range (cm)
Desk	
Surface height	28.3 - 29.5
Surface width	59.1
Surface depth	35.4
Legroom	31.5
Depth at knee	31.5
Keyboard	
Slope	5°- 30°
Thickness	1.2-2
Screen height	35.4 - 43.3

Ergonomically designed workstations can help to prevent risk factors/injuries from computer use. Having adjustable items (chairs, desk, computer screen), allow for any operator to have a comfortable experience when using a PC in the home or at work. According to Pheasant & Haslegrave (2006), "If the dimensions of the workstation are inappropriate to the worker, the likelihood of discomfort increases." (as cited in Schumann, 2007, p. 11).

Computers Being Used in the Home

There are two types of computers being used in the home; laptops and/or desktops. Desktop computers have been used in the home as well as the office workplace for years. Ergonomic issues present within the office workplace are likely to occur with the use of a

desktop computer in the home. Laptop computers, however, have introduced new ergonomic issues which include the attachment of the monitor and keyboard. According to Harris and Sraker (1999), 60% of laptop users report associated musculoskeletal discomfort (as cited in Karwowski, 2001).

Laptop computers, or notebooks, are the choice for working and staying connected on the move (Ergo® in Demand, 2008). Laptops make it easier to access information quickly when away from the desk. However, laptop computers, although portable, have not been designed to be a substitute for a desktop computer (Ergo® in Demand, 2008). The popularity of the laptop however, has resulted in them being used that way for many consistent working hours (Ergo® in Demand, 2008). Due to the attachment of the monitor and the keyboard on a laptop, establishing a proper viewing and keyboarding position can be difficult. Incorrect set up creates the potential for developing any of numerous painful and inconvenient computer injuries such as CVS and CTDs (Ergo® in Demand, 2008). Extensive use of a desktop or laptop computer in the home without having proper ergonomic factors set (such as workstation design and location) can lead to the development of CTDs and/CVS.

Risk Factors and/or Injuries from Computer Use

CTDs results from forceful, awkward, and/or repetitive use of body parts, producing damaged muscles, tendons, and nerves (University Health Services, 2008). The most common example of a CTD is tendonitis, while carpal tunnel syndrome is a more rare and serious disorder (University Health Services, 2008). Although CTD is a broad term that includes several disorders, general symptoms of all CTDs includes tingling or loss of sensation in fingers, inability to grasp objects between thumb and fingers, decrease in the size of hand muscles, and pain in the wrist, elbow, shoulder, or neck (University Health Services, 2008).

Carpal tunnel syndrome (CTS) and thoracic outlet syndrome are two of the most disabling CTDs (University Health Services, 2008). "In CTS, repeated bending or use of the wrist and fingers results in the compression of the median nerve (runs along the palm side of the wrist) causing intermittent numbness, tingling, and pain in the side of the hand including the thumb through the inside of the ring finger. The hand's communication with the brain is disrupted and the fingers have difficulty sensing temperature and gripping objects" (University Health Services, 2008, pg. 15). Those suffering from CTS may also notice swelling of the hand and forearm. Pain and numbness in the fingers not only occur while typing, but also at night. If untreated, these symptoms can become chronic and permanently disabling, and may cause a change in one's lifestyle and career (University Health Services, 2008). CTS make up for more than 40% of computer-related CTDs (Condor, 1998).

Carpal tunnel syndrome is probably the most widely known CTD, but eyestrain is the most common (University Health Services, 2008). Studies have indicated that visual symptoms occur in 50-90% of VDT workers (American Optometric Association, 2008). Eyestrain is an overall symptom of CVS. If untreated, eyestrain or CVS can lead to general fatigue, increased myopia (nearsightedness), and a decrease in overall efficiency (University Health Services, 2008). Eyestrain can affect anyone, especially those who work at a computer for more than three hours a day. Some symptoms of eyestrain include; headache, dry eyes, blurred vision, eye fatigue, and changes in color perception (University Health Services, 2008).

The rise of computer use has resulted in an epidemic of injuries of the hands, arms, and shoulders (McDowell, 2000). According to OSHA, 1.8 million workers are affected by a musculoskeletal disorders (MSDs) each year (McDowell, 2000). A survey of computer workers show that eye and vision problems are the most frequently reported health-related problems,

generally occurring in 70-75% of computer workers (American Optometric Association©, 2008). With more and more people using PCs in their home, these numbers are likely to increase.

Type of Ergonomic Analysis

There are several ergonomic tools that can be utilized to identify and analyze risk factors related to performing a particular job or task. Some of these ergonomic tools can be used to determine the risk factors that occur from the use of a computer (either in the workplace or in the home), in relation to the body. One of these ergonomic tools includes:

Rapid Upper Limb Assessment

The RULA is an acronym for Rapid Upper Limb Assessment. The RULA, developed by McAtamney & Corlett (1993) is used as an initial tool to identify work related upper limb disorders (Appendix A). The RULA focuses on ergonomic risk factors of the arms, wrists, legs, neck, and trunk associated with a performed task. The assessment identifies risks by looking at posture, force, duration, and position of the arms, wrist, neck, trunk, and legs. Each area is scored to determine the level of risk for each specific body part; the level being high or low. All of the individual scores from each body part examined is combined in a final score. The final score of the RULA will range from 1-7 (1 being an acceptable posture and a 7 signifying that a change should be implemented); this will address the risks and identify the level at which they should be controlled.

Best Practices

"Work performed at video display terminals may require sitting still for considerable time and usually involves small frequent movements of the eyes, head, arms, and fingers" (OSHA 3092, 1997, p.5). Keeping a fixed posture over long periods of time results in muscle fatigue and can eventually lead to muscle pain and injury if this practice is not changed or corrected (OSHA

3092, 1997). There are various practices that can be followed to help reduce the development of CTDs or CVS from computer use. In the booklet, *Working Safely with Video Display Terminals* from OSHA (1997), proper work station design will reduce CTDs and vision problems associated with computer use when the following work practices are observed:

- "Ensure that the operator has a comfortable sitting position sufficiently flexible to reach, use, and observe the display screen, keyboard, and document.
- Provide posture support for the back, arms, legs, and feet as well as adjustable display screens and keyboards.
- Ensure that VDT tables or desks are vertically adjustable to allow for operator adjustment of the screen and keyboard.
- Ensure proper chair height and support to the lower region of the back.
- Ensure that document holders are used to allow the operator to position and view material without straining the eyes or neck, shoulder, and back muscles" (p. 9).

In the office environment, the workstation consists primarily of a workstation, chair, and computer equipment. Appropriate placement of these components will promote a neutral body position of the body, efficient performance, and a more comfortable and safe environment (OSHA, 2008). Computer workstations should provide as many adjustable features as possible (OSHA 3092, 1997). In the booklet, *Working Safely with Video Display Terminals* from OSHA (1997), tools on proper setup of an ergonomically correct workstation are listed below:

Workstation.

A well-designed and appropriately adjusted workstation will minimize awkward postures and exertions while operating on a computer workstation (OSHA, 2008). A well designed workstation will also provide adequate clearance for the legs and proper placement of computer

components and accessories (OSHA, 2008). According to Chengalur, Rodgers, & Bernard (2004), the following dimensions should be considered when selecting a workstation:

- Clearance under the work surface
- Work surface height
- Type of work surface
- Width and depth of work surface

Chengalur et al. (2004) provides further considerations when selecting a PC workstation in Tables 3 and 4:

Table 3

Clearance Dimensions Under the Work surface at a Seated Workstation (adapted from BSR/HFES 100 2002)

	Recommended Workstation	Other Considerations
Height clearance for thighs and lower legs	20-27 in. 28.5 in. for a nonadjustable work surface at the front edge 19.5-28 in. for an adjustable work surface	Shoe allowance has been added. ISO recommends 1.2 in.
Height clearance for knee height	19.6-25 in.	Shoe allowance has been added. ISO recommends 1.2 in.
Depth clearance for knees	17.5 in.	These dimensions allow for changes in posture
Width clearance for thighs	20.5 in.	Clothing and movement are added. ISO recommends 1 in. for medium clothing and 1.8 in. for movement.
Height clearances at foot level	4.5 in.	Shoe allowance has been added. ISO recommends 1.2 in.
Depth clearance at foot level	23.5 in.	

Table 4

Recommended Work Surface Height for Input Devices in a Seated Workstation (adapted from BSR/HFES 100 2002)

	Recommended Workstation	Other Considerations
Input device work surface Height for a seated workstation	22-28.5 in. for an adjustable work surface 28.5 in. for a nonadjustable work surface	Shoe allowance of 1.2 in. has been added and input device thickness of 1 in. subtracted from anthropometric dimensions. If using a fixed-height surface, a height-adjustable chair should be used and a footrest available.

OSHA (2008) provided further considerations on how to design an ergonomically correct workstation:

- Work surface depth should allow the monitor to be viewed at a distance of at least 20 inches.
- Additional space and depth may be achieved by using a corner rather than a straight run of the workstation.
- The location of frequently used items (mouse, phone, keyboard) should be placed and remain in the primary work zone of the workstation.

- The workstation should be adjustable. Clearance for the legs should generally be between 20-28 inches. There should be 2-3 inches from the top of the thighs and the underside of the workstation (CDC, 2000).
- There should be adequate clearance spots for operators to change working postures.

Chair.

Most workers in an office environment spend most of their time sitting to perform his/her job. The chair can be an important factor in preventing back pain as well as in improving employee performance in office work (OSHA 3092, 1997). A properly designed and adjustable chair that promotes comfort and efficiency is critical to help minimize risk factors associated with PC workstation environments (OSHA 3092, 1997). All adjustments should easily be made from the seated position (OSHA 3092, 1997).

- Chair Height

The "popliteal" height serves as an initial starting point for determining the proper height of the chair (OSHA 3092, 1997). The "popliteal" is the height from the floor to the point at the crease behind the knee (OSHA 3092, 1997). Proper chair height is achieved when the entire sole of the foot can rest flatly on the floor or on a footrest (OSHA 3092, 1997). The back of the knee should be slightly higher than the seat of the chair. This allows the blood to circulate freely in the legs and feet (OSHA 3092, 1997). O'Reilly, Finder, and Werrell (2007) furthermore state that the thighs should be approximately parallel to the floor and the angle of the knee joints are 90 degrees or slightly more (p. 23). The chair should have a five leg base with casters that will allow for easy movement on the floor (OSHA, 2008).

- Armrests

"Adjustable armrests may help to reduce loads in the back, neck, and shoulders that are created when the arms and hands are suspended over the keyboard" (Lim, Sauter, & Schnorr 1999, p.7). Armrests should be low and short enough to fit under work surfaces to allow users to get close enough to the work surface (OSHA 3092, 1997). Properly adjusted armrests should also be low enough so the shoulders are relaxed, high enough to support the lower arms, and close enough to support the lower arms while keeping them close to your body (OSHA, 2008). Armrests should be made of a soft material and have rounded edges (OSHA, 2008). Armrests should be 2-3 inches wide and should tilt without having to be manually readjusted (Chengalur et al., 2004).

- Backrest

A proper backrest should support the entire back including the lower region; the back rest, along with the seat, should allow for variations of the user's seating position (OSHA 3092, 1997). "A slightly reclining posture is not uncommon for VDT operators and can help to minimize the muscular effort of continuous sitting in an upright posture" (Lim et al., 1999, p.7). "A slightly protruding lumbar support is important in either the upright or reclining seat posture. Vertical adjustability of the back rest will help ensure proper positioning of the lumbar support" (Lim et al., 1999, p.7). The backrest should allow the user to recline at least 15 degrees from the vertical (OSHA, 2008).

- Seat pan Design

Size, shape, and angle should be considered in the design of the seat pan of the chair (OSHA 3092, 1997). The seat pan should be slightly concave with a softly padded, rounded, or "waterfall" edge; this type of seat pan design will assist in distributing the weight, as well as

possibly prevent the user from sliding forward in the chair (OSHA 3092, 1997). A seat pan that slopes slightly down at the back or one that has a forward tilt are options or angle design of the seat pan. These angles will produce less stress on the lower region (OSHA 3092, 1997).

VDT Design.

Most new VDTs have separate, adjustable keyboards and display screens that allow for the keyboard and display screen to be positioned appropriately for the employee (OSHA 3092, 1997). VDT operators may spend a considerable amount of time looking at the display, so having the keyboard and monitor properly placed on the workstation in relation to the user is very important (OSHA 3092, 1997). Placing the monitor in an appropriate position helps to reduce exposure to forceful positions, awkward postures, and overhead glare; this in turn helps to minimize such risk factors as eye strain, excessive fatigue, and neck and back pain (OSHA, 2008).

- Display Screen

Screens should have user controls for character brightness. Screens that adjust horizontally and vertically enable the operator to select the proper viewing angle for their use (OSHA 3092, 1997). The monitor angle should be adjusted to face the user's face; the bottom of the screen will be closer to the user than the top of the screen (O'Reilly et al. 2007). The topmost line of the screen should not be higher than the user's eyes (OSHA 3092, 1997). O'Reilly et al. (2007) also stated that the top of the monitor screen should not be higher than the user's eyes, but this height may be lowered to facilitate neutral neck position while viewing. O'Reilly et al. (2007) furthermore stated that "biomechanically it is less stressful to slightly bend the head forward than to tilt it backwards" (p. 13). The preferred viewing distance for VDTs ranges between 18 and 24 inches (OSHA 3092, 1997). To this distance must be added the depth of the

display itself. O'Reilly et al. (2007) stated that "the preferred eye-to-monitor viewing distance is typically between 20 and 30 inches, but the monitor can be positioned at any distance that facilitates seeing the screen and does not require maintaining an awkward posture" (p. 13). Legibility is also a primary consideration in selecting a display screen. Legibility factors to be considered include symbol size and design, contrast, and sharpness.

- Keyboard

The keyboard should be detachable and adjustable to ensure proper position, angle, and comfort for the operator (OSHA 3092, 1997). The angle of the keyboard should range from 0-15 degrees up at the back (Chengalur et al., 2004). Keyboards should be as thin as possible, less than 1.2-1.4 inches, measured at the home (middle) row (Chengalur et al., 2004). To ensure that the user's arms are kept in a comfortable position, a lower-than-normal work surface may be required; this can be achieved by installing a keyboard extender or tray (OSHA 3092, 1997). Keeping the forearms parallel to the floor and the elbows at the sides is the preferred working position for users of PC workstation environments; this allows for the hands to move easily over the keyboard (OSHA 3092, 1997). "It is generally believed that those loads on the shoulders and elbow flexors can be minimized by positioning the keyboard (home row) at elbow height or perhaps slightly lower" (Lim et al., 1999, p. 7). The wrist should be in line with the forearm and a padded and detachable wrist rest can be used to help keep the user's wrists and hands in a straight position while keying (OSHA 3092, 1997).

- Mouse

The mouse should be placed at the user's side with his/her arm close to the body for support; a straight line should be maintained between the hand and forearm (OSHA 3092, 1997). The mouse should be at the same level as the keyboard (O'Reilly et al. 2007).The upper arm

should not be elevated or extended while using the mouse. The top surface of the wrist should also be flat, not angled (OSHA 3092, 1997). A mouse pad or rest can be used to help maintain straight wrists.

Lighting.

Light should not be positioned or directed in a way so that it shines into the user's eyes while the user is looking at the display screen (OSHA 3092, 1997). Furthermore, lighting should be adequate for the user to see the text and the screen, but not so bright as to cause glare or discomfort (OSHA 3092, 1997).

- Contrast

Contrast is the difference in luminance or brightness between two areas (OSHA 3092, 1997). "To prevent the visual load caused by alternate light and dark areas, the difference in illuminance between the VDT display screen, horizontal work surface, and surrounding areas should be minimized" (OSHA 3092, 1997, p8).

- Glare

Glare is usually defined as a harsh, uncomfortably bright light (OSHA 3092, 1997). "Glare may be the result of direct light sources in the visual field (e.g., windows), or reflected light from polished surfaces (e.g., keyboards) or from more diffuse reflections which may reduce contrast (e.g., improper task lighting)" (OSHA 3092, 1997, p.8). Glare has the potential to cause annoyance, discomfort, or loss in visual performance and visibility to the user of the PC workstation (OSHA 3092, 1997). Walls and work surfaces visible around the screen should be painted a medium color and have a non-reflective finish to help reduce reflection from walls and work surfaces (OSHA 3092, 1997). Care should be taken, especially when workstations are installed within 20 feet of windows, to ensure that there is some method of blocking the sun's

light, such as blinds or curtains (OSHA 3092, 1997). In most cases, rearranging the workstation can help to reduce glare from the user's line of sight (OSHA 3092, 1997). The face of the display screen should be at right angles to windows and light sources (OSHA 3092, 1997). Glare should not be reduced by compromising the monitor's height, angle or location (O'Reilly et al. 2007, p.23).

Body Positions.

Along with having an ergonomically correct workstation to minimize the development of CTDs or CVS, positioning the body correctly in relation to the workstation is also important. Neutral body positioning is recommended when operating at a computer workstation. Neutral body positioning consist of having the body in a comfortable working position in which the joints are naturally aligned (OSHA, 2008). The risk of developing MSDs along with stress and strain on the muscles, tendons, and skeletal system are reduced when the body is kept in a neutral position while working (OSHA, 2008). The following are considerations from OSHA (2008) on how to maintain neutral positioning while operating on a computer workstation:

- The hands, wrists, and forearms are straight and roughly parallel to the floor.
- The head should always face forward and be in line with the body. The head should be kept level or bent slightly forward.
- Shoulders should be relaxed and the upper arms should hang normally on the side of the body.
- Elbows should be bent between 90-120 degrees and should remain close to the body.
- Feet should rest flatly on the floor or a footrest if the workstation cannot be adjusted.
- The back should have complete lumbar support when sitting vertical or leaning back slightly.

- Thighs and hips should be parallel to the floor and supported by a well padded seat.
- Knees should be at or around the same height as the hips with the feet slightly forward.

Laptop Computers

Laptop computers are not recommended as primary computers. A docking station is recommended to provide adjustability as well as neutral postures while using the laptop in the office or home (CDC, 2000). The following are ergonomic recommendations from the Centers of Disease Control and Prevention (2000) on how to use a laptop:

- Maintain a comfortable viewing area from the screen of about 18-30 inches.
- Keep the head and trunk in a neutral position.
- The screen should be angled so that it is perpendicular to the line of sight.
- The keyboard should be placed at elbow height, and the wrists should be kept straight while keying.
- An external mouse should be used instead of the small constricted touchpad or trackball.

Summary

Computer use in the home is becoming an everyday thing. There are many ergonomically correct workstations found in the office environment, but this may not be the case in the home. There are particular ergonomic measurements and characteristics that classify a workstation as a properly designed ergonomic workstation, as well as best practice criteria that can be utilized to promote an ergonomic workstation environment and reduce the development of CTDs or CVS. If workstations in the home are not designed properly, symptoms of CTD or CVS can develop and worsen over time if the situation is not corrected or if the symptoms aren't treated. Various ergonomic tools can be used to determine the risk factors associated with the use of computers in

the home, and these tools can provide insight into implementing changes to prevent risk factors and/or injuries from computer use.

Chapter III: Methodology

The purpose of this study was to evaluate home computing workstations of an identified population to identify potential situations that could result in ergonomic issues. The use of a PC in the home could contribute to the probability of developing CTDs or CVS.

The goals of this study were to:

1. Identify the characteristics of home computing workstations.
2. Identify and assess the extent of potential ergonomic issue(s) for the individual(s) operating the PC at home.
3. Compare the characteristics of home computing workstations with overall best practices of computing workstations.

The sections that will be addressed in this chapter include sample selection and description, instrumentation, procedures followed, data analysis and limitations.

Sample Selection and Description

Participants were chosen by occupation and department within The University of Wisconsin-Stout (UW-Stout). The participants will include the administrative assistants within the College of Management department at UW-Stout. The College of Management department at UW-Stout is small in size and will produce better results considering the in depth nature of the study. To promote involvement in the study, each participant received an initial email explaining the study and to ask if he/she would participate in the study.

After participation in the study was agreed upon by the participants, an ergonomic survey and consent form was physically given to each participant by the researcher. The survey was explained in its entirety as well as the consent form which only needed to be

signed if home access was granted from the participant; outside of the signed consent form if applicable, all other information collected from the participants was kept completely anonymous. Surveys were returned via inter-department mail through UW-Stout. All information collected was kept confidential and any personal information (for home visit purposes) was properly destroyed after this study.

Instrumentation

Various instrumentation tools were used to collect and analyze data for this study. This instrumentation includes:

- An ergonomic survey (Appendix B)

The ergonomic survey was constructed by the researcher and consisted of 38 questions addressing the PC workstation within the home.

- The Rapid Upper Limb Assessment (Appendix A). (McAtamney & Corlett, 1993).

The RULA is a survey method used for identifying work related upper limb disorders. The RULA will analyze positions of the body while operating the PC.

- Goniometer

Used to measure angles of the body while operating a PC

- Inclinometer

Used to measure the incline of the monitor

- Tape Measure

Used to measure the height of the overall workstation and its components

Procedures Followed

The use of the ergonomic survey served as the main source of data collection. After each participant agreed to participate in the study, the ergonomic survey was provided to all the participants to complete. The survey took approximately 20 minutes to complete and each participant received four days to complete the survey. The researcher's name was provided to each participant along with the location to mail the surveys to within UW-Stout after completion. Surveys were returned to the researcher and analyzed. Home visits were conducted to further analyze the PC workstation in the home if allowed by the participant. The RULA and ergonomic instrumentation were used to further analyze the actual home PC workstation of the participants.

Data Analysis

The PC workstation environments and its characteristics were analyzed via an ergonomic survey, RULA assessment (if applicable), and ergonomic instrumentation (if applicable). Potential ergonomic issues were identified and assessed using the ergonomic survey and RULA assessment. Posture, repetition, duration, and force will also be quantified using the RULA assessment. The RULA will further produce a score from 1-7 (1 being an acceptable posture and a 7 signifying that a change should be implemented) that will address if there are work related upper limb disorders identified and the level at which they should be controlled. Participants were physically observed by the researcher to complete the RULA assessment.

Descriptive statistics (total numbers, averages, percentages) will be used to discuss all data collected. All of the data acquired from the use of the ergonomic survey,

RULA (if applicable) and ergonomic instrumentation (if applicable) will be compared against the overall best practices of computing workstations.

Limitations

1. The ability to observe actual PC usage and the ergonomic issues that arise in a home will be difficult. Home access may not be granted by any of the participants in the study.
2. Data will be collected by use of a survey, which will be constructed by the researcher. Survey data collection will only be as reliable as those who partake in the survey.

Chapter IV: Results and Discussion

The purpose of this study was to evaluate home computing workstations of an identified population to identify potential situations that could result in ergonomic issues. The use of a PC in the home could contribute to the probability of developing CTDs or CVS.

The objectives of this study were to:

1. Identify the characteristics of home computing workstations.
2. Identify and assess the extent of potential ergonomic issue(s) for the individual(s) operating the PC at home.
3. Compare the characteristics of home computing workstations with overall best practices of computing workstations.

Summary of Methods

Information was collected by use of an anonymous ergonomic survey and a standardized ergonomic assessment (RULA). Ergonomic instrumentation was also used to collect measurements and further analyze the PC workstation. The RULA and other measurements were only performed if home access was granted. The ergonomic instrumentation was used to collect height measurements of the workstation as well as angles of the subject while operating the PC. The RULA furthered analyzed positions of the body while operating the PC. The population consisted of administrative assistants (those who primarily work with computers) in the College of Management department at The University of Wisconsin-Stout.

Research Objective #1

To identify the characteristics of home computing workstations, an ergonomic survey was constructed by the researcher and consisted of 38 questions addressing the PC workstation within the home (See Appendix B). The survey was distributed to the nine administrative assistants in the College of Management Department at UW-Stout. The survey identified various characteristics related to the actual PC, workstation, chair, monitor, environment, and any discomfort experienced while operating a PC in the home. There was an 89% (8 participants) response rate for the ergonomic survey. Also, ergonomic instrumentation was used to further analyze the actual home PC workstation of those participants who agreed to participate in a home visit.

Survey Results

The first survey question asked if there was a PC being used in the home and if the PC being used was a laptop, desktop, or both. If both were used, the PC used most was indicated and used to answering the remaining questions of the survey (reflected in Figure 2). Figure 2 illustrates the type of PC being used in the home:

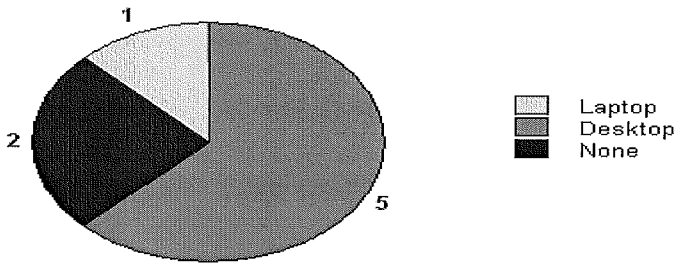

Figure 2: Type of PC Being Used in the Home

The following are the results of the remaining survey questions pertaining to PC workstation characteristics:

- 1/4 of the participants did not use a PC in the home

- 1/6 of the participants did not have a permanent location in the home for their PC (ex. an office); PC was mainly used in living room,
- 2/3 of the participants did not have an adjustable desk in their home,
- All of the participants indicated that the keyboard was placed directly in front of them while typing,
- 1/6 of the participants could not adjust the keyboard from being flat on the work surface to a tilt,
- 1/3 of the participants did not keep their wrists in a neutral (straight) position while typing
- The average time spent on the PC a day from all the participants was 2.58 hours (range = 7 hours, median = 1.5 hours, mode = 1 hour),
- All of the participants indicated that there was enough legroom for their feet to be planted flat on the floor or on a footrest,
- 1/6 of the participants found themselves reaching for items (ex. telephone, mouse, etc.),
- All of the participants had chairs that were adjustable by height; 2/3 of the chairs had adjustable backrests and 1/2 of the chairs had an adjustable seat pan,
- 1/3 of the participants were unaware of the backrest adjustability and 1/2 of the participants were unaware of the seat pan adjustability of the chair,
- 5/6 of the participants had chairs that provided adequate lumbar support; 1/6 of the participants was unaware of the lumbar support of the chair,
- 5/6 of the chairs had adjustable armrests,
- 2/3 of the monitors were adjustable by height; 1/2 were adjustable by tilt;

- The top of 2/3 of the monitors were at or slightly below eye level as the participant operated the PC,
- All of the PCs had brightness and contrast control,
- 5/6 of the participants avoided glare and reflections on the monitor,
- 5/6 of the participants had adequate lighting where the PC was being used,
- 5/6 of the participants indicated that there was a window where their PC was being used, and 1/3 of the participants indicated that the window sometimes caused a glare on the monitor,
- 5/6 of the participants indicated that he/she takes breaks in between operating on the PC for long periods of time.

Ergonomic Instrumentation Measurements

The following table (See Table 5) lists the measurements of the PC home workstations analyzed via an actual visit to the participant's home (in accordance with the participant) by the researcher. One-third of the participants were willing to allow home access to the researcher to collect height measurements of the workstation as well as angles of the participant while operating the PC. One individual utilized a laptop computer in the home, and the other individual utilized a desktop computer.

Table 5

Measurements of the PC Workstation in the Home

	Laptop	Desktop
Chair height (from seat pan to floor)	19 in.	20 in.
Chair height (from top of backrest to floor)	38 in.	42 in.
Incline of backrest	108°	107°
Back of knees to seat pan	3.5 in.	1 in., minimal clearance
Desk height	29 in.	30.5 in.
Keyboard tray to floor	24 in.	26 in.
Keyboard away from user	7 in.	7 in.
Bottom of keyboard tray to top of thighs	1.5 in.	3 in.
Eyes from monitor	32.5 in.	26 in.
Top of monitor to work surface	13 in.	21.5 in.
Incline of monitor	102°	89°
Angle of arms (while typing)	149°	115°
Angle of legs	73°	81°
Placement of feet	Feet not flat; one foot resting on chair legs; no footrest	Feet flat or crossed

Research Objective #2

To identify and assess the extent of potential ergonomic issue(s) for the individual(s) operating the PC at home, an ergonomic survey was used as well as the RULA. Participants were physically observed by the researcher to complete the RULA assessment.

Rapid Upper Limb Assessment

The RULA (See Appendix A) was performed on one-third of the participants; the participants that allowed home access to the researcher. The RULA furthered analyzed positions of the body while operating the PC. The RULA produced four levels of scoring for the final score:

- 1 or 2 = acceptable posture,
- 3 or 4 = further investigation, change may be needed
- 5 or 6 = further investigation, change soon
- 7 = investigate and implement change

The results of the RULA are as follows:

Table 6

RULA Scores

	Laptop	Desktop
Arm & Wrist analysis		
Step 1: Upper arm position	2	2
Step 2: Lower arm position	1	2
Step 3: Wrist position	1	1
Step 4: Wrist twist	1	1
Step 5: Posture	2	2
Step 6: Muscle	1	1
Step 7: Force/load	0	0
Step 8: Wrist & Arm score	3	3
Neck, trunk, & leg analysis		
Step 9: Neck position	1	1
Step 10: Trunk position	1	2
Step 11: Legs	2	1
Step 12: Posture	3	2
Step 13: Muscle	1	1
Step 14: Force/load	0	0
Step 15: Neck, trunk, & leg score	4	3
Final score	**4**	**3**

Ergonomic Issues

The final questions of the ergonomic survey asked the participants if he/she experienced any discomfort while operating the PC. If discomfort was experienced, the participants were asked where he/she experienced the discomfort. The following areas of the body were questioned:

- Hands

- Wrists
- Arms
- Shoulders
- Neck
- Back
- Legs
- Eyes

The participants were also asked to provide a brief description of the discomfort that was experienced. One-half of the participants indicated that he/she experienced no discomfort while operating on the PC. The other half of the participants experienced discomfort in the eyes, back, shoulders, and hands while operating the PC in the home. Table 7 lists the descriptions of the discomfort experienced:

Table 7

Discomfort Experienced While Operating PC in Home

Discomfort Areas	Description
Hands	Numbing of fingers
Eyes	Tired eyes
	Eyestrain
Back	Not sitting properly; need to readjust chair
Shoulders	

Research Objective #3

The characteristics of the home computing workstations were compared with the overall best practices of computing workstations. Tables 8-10 compares home PC workstations with the overall best practices of computing workstations:

Table 8

Best Practice vs. Home PC Workstation: Workstation and Chair

	Best Practice	Laptop	Desktop
Workstation height	22 – 28.5 in. (adjustable) 28.5 in. (nonadjustable) 2 – 3 in. for thigh clearance	29 in. (nonadjustable) 1.5 in.	30.5 in. (nonadjustable) 3 in.
Chair height	"Popliteal" height serves as an initial starting point for determining the proper height of the chair	19 in. (from seat pan to floor) 38 in. (from top of backrest to floor)	20 in. (from seatpan to floor) 42 in. (from top of backrest to floor)
Armrest	Low and short to fit under workstation; rounded edges and 2-3 in. wide; adjustable	Nonadjustable	No armrests and/or nonadjustable
Backrest	Should allow user to recline at least 15° from the vertical; should support the entire back	108° (18° from vertical)	107° (17° from vertical)

Table 9

Best Practices vs. Home PC Workstation: VDT Design

	Best Practice	Laptop	Desktop
Display screen	Viewing distance should range between 18-30 inches; top of monitor screen should not be higher than the user's eyes	Nonadjustable by height; 32.5 in. (eyes from monitor)	Nonadjustable by tilt and/or height; 26 in. (eyes from monitor); top of monitor at or slightly below eye level
Keyboard	Should be detachable and adjustable; angle should range from 0-15 degrees up the back; wrist should be in line with the forearm	Keyboard detachable and adjustable; keyboard placed directly in front of user	Nonadjustable; wrists sometimes kept in a neutral position while typing
Mouse	Should be at the same level as keyboard; top surface of wrist should be flat		

Table 10

Best Practice vs. Home PC Workstation: Environment and Body Positions

	Best Practice	Laptop	Desktop
Lighting	Should not be positioned to shine in the user's eyes; lighting should be adequate to view screen and not cause glare	Adequate lighting	Lighting may or may not be sufficient
Contrast	Difference in illuminance should be minimized	Contrast minimized	Contrast minimized
Glare	Face of display screen should be at right angles to windows and light sources	Window sometimes causes glare on display screen	Window sometimes causes glare on display screen
Hands, wrists, & arms	Hands, wrists, and forearms should be straight and parallel to floor	Wrists kept straight while typing	Wrists sometimes not kept straight while typing
Elbows	Elbows bent between 90-120 degrees	Arms at 149°	Arms at 115°
Feet	Feet should rest flatly on floor or footrest (if workstation nonadjustable)	Feet not flat; resting on chair legs	Feet sometimes flat or crossed
Back	Back should have complete lumbar support	Not sitting properly in chair	Complete lumbar support

Discussion

It appears that home computing workstations have the potential to lead to ergonomic issues consistent with those identified within an office work environment. Survey results indicated that some of the home PC workstation environments are consistent with the best ergonomic practices for overall PC workstations. However, survey results, along with the RULA and ergonomic instrumentation, indicated that some of the home PC workstation environments were not properly ergonomically designed and the variation of PC location within the home can lead to the user developing CTD or CVS symptoms.

The characteristics of home PC workstations indicated that desktop computers were used more in the home than a laptop. However, there were homes that did not use a computer at all. There were permanent locations in the home for the PC to be used, i.e. an office, however, one participant indicated that the PC being used in his/her home did not have a permanent location, and was mainly used in the living room. The most significant characteristic of home PC workstations that was identified was the lack of an adjustable desk or workstation.

The researcher was also able to identify and assess the extent of potential ergonomic issue(s) for the individual(s) operating the PC at home by use of the various ergonomic tools. The participants experienced discomfort in the hands, eyes, back and shoulders (See Table 7). This discomfort consisted of numbing fingers, eyestrain, tired eyes, and back pain due to not sitting properly in the chair. Numbing fingers, or a loss of sensation in the fingers, is one of many symptoms associated with CTDs along with pain in the shoulders. Tired or fatigued eyes and eyestrain are overall symptoms of CVS.

Home PC workstations environments did possess some of the characteristics or considerations consistent with the overall best practices of computer workstations. Some of these include adequate lighting, minimizing contrast, keeping the monitor at or above the user's eye level, maintaining acceptable thigh clearance from the workstation, and an acceptable recline of the backrest (See Tables 8-10). However, some practices in the home were not consistent with the overall best practices of computer workstations (See Tables 8-10).

Chapter V: Summary, Conclusions and Recommendations

The purpose of this study was to evaluate home computing workstations of an identified population to identify potential situations that could result in ergonomic issues. The use of a PC in the home could contribute to the probability of developing CTDs or CVS.

The objectives of this study were to:

1. Identify the characteristics of home computing workstations.
2. Identify and assess the extent of potential ergonomic issue(s) for the individual(s) operating the PC at home.
3. Compare the characteristics of home computing workstations with overall best practices of computing workstations.

The sections that will be addressed in this chapter include the summary, conclusions, recommendations, and area of further research.

Summary

The following sections will be included in the summary: restatement of the problem, methods and procedures, and major findings.

Restatement of the Problem

Home computing workstations have the potential to lead to ergonomic issues consistent with those identified within an office work environment. The locations of PCs in the home can vary from household to household. The workstation set-up in many homes may not be properly ergonomically designed. This could lead to the user developing CTD or CVS symptoms from the various risk factors that could be acquired when using a PC in the home environment.

Methods and Procedures

Information was collected by use of an anonymous ergonomic survey and a standardized ergonomic assessment (RULA). Ergonomic instrumentation was also used to collect measurements and further analyze the PC workstation. The RULA and other measurements were only performed if home access was granted. The ergonomic instrumentation was used to collect height measurements of the workstation as well as angles of the subject while operating the PC. The RULA furthered analyzed positions of the body while operating the PC. The population consisted of administrative assistants (those who primarily work with computers) in the College of Management department at The University of Wisconsin-Stout.

Major Findings

Characteristics of home PC workstations were identified amongst the identified population used for this study. The most significant characteristic of the home PC workstations that was identified was the lack of an adjustable desk or workstation. Two-thirds of the participants did not have an adjustable desk in their home. In addition, the researcher identified and assessed the extent of potential ergonomic issue(s) for the individual(s) operating a PC in the home. One-half of the participants experienced discomfort in the hands, eyes, back, and shoulders (See Table 7). This discomfort consisted of numbing fingers, eyestrain, tired eyes, and back pain.

Many home PC workstation environments of the identified population did possess some of the characteristics or considerations consistent with those of overall best practices for computer workstations. However, some practices in the home were not consistent with the overall best practices for computer workstations.

Conclusions

- Based on the ergonomic survey, RULA, and ergonomic instrumentation, home PC workstations of the individuals within this study have the potential to lead to ergonomic issues consistent with those identified within an office environment.
- Based on the ergonomic survey, a lack of an adjustable desk or workstation in the home is typical amongst the individuals within the identified population of this study. As indicated by OSHA 3092 (1997), computer workstations should provide as many adjustable features as possible. Furthermore, as stated by OSHA (2008), a well-designed and appropriately adjusted workstation will minimize awkward postures and exertions while operating on a computer workstation.
- Based on the ergonomic survey, experiencing discomfort while operating a PC in the home is bound to occur with half of the individuals within the identified population of this study. This discomfort is consistent with the overall symptoms associated with CTDs and CVS.
- Based on the data analyzed, it appears that home PC workstation environments of the identified population are not properly ergonomically designed and completely consistent with the overall best practices of computer workstations. Implementing the considerations of overall best practices for PC workstations in the home, could minimize the possibility of developing CTDs or CVS and result in more homes practicing better ergonomic techniques when using their PC.

Recommendations

- Many office environments implement ergonomic programs that promote proper and effective ergonomic techniques while operating a PC in the office. These techniques should be adopted from the workplace and used in the home. More home PC workstations will become properly ergonomically designed and risk factors of developing CTDs or CVS from PC usage in the home will be reduced.
- Adjustable furniture (workstation/desk, chair, monitors) should be utilized in the home to allow for adjustability in body and working postures of the user. This will allow for different areas of the body to work and rest to reduce overuse of a body part resulting in discomfort.
- Body angles (arms and legs) should be kept at a 90 degree angle to promote comfort and adequate circulation through the body.
- Home PC users should not operate the PC for long periods of time. Breaks should be taken often to allow the individual to stretch, walk around, and relax muscles in the body.
- Alternating tasks/jobs while operating on the PC with non PC related work will help to reduce the development of CTDs or CVS. Switching from keyboarding/typing to writing a document for example will reduce the repetitiveness of keyboard use that can cause discomfort in the fingers and wrists. Alternating tasks will also allow for other body parts to function and for others to rest.
- Home PC users should be aware and knowledgeable of office ergonomics and the overall best practices of computer workstations. Without the proper knowledge,

the risks and hazards that occur from improperly designed workstations cannot be identified and abated. Home PC users should utilize some form of ergonomic training to adequately identify any risks from computer use and the discomfort (CVS or CTDs) that may arise.

Area of Further Research

The researcher recommends the following topics that should be studied further to help reduce those ergonomic issues found in the office workplace to occur in the home when operating a PC:

- Focus on one particular PC (laptop or desktop) to determine the frequency and severity of ergonomic risk factors occurring from the use of a laptop or desktop in the home. Laptop computers introduced new ergonomic issues with the attachment of the keyboard and monitor and may result in more frequent or severe ergonomic issues when compared to desktop computers.
- Explore home PC users' perception of office ergonomics and its application in the home. This will portray an individual's understanding of ergonomics to determine if he/she has the knowledge to properly ergonomically design the PC workstation in the home.
- Expand the identified population to include more than just individuals who primarily use a computer at work. Most individuals have and utilize a PC in the home and do not primarily work on computers at their job.
- Explore the office environment of the identified population (administrative assistants within the College of Management at UW-Stout) to determine if there is an ergonomics program in place at the individual's place of employment. This

could reveal the knowledge of office ergonomics amongst the individuals and these practices could be implemented in the home.

- Conduct an accident/incident analysis of UW-Stout accident reports of ergonomic injuries related to computer use to quantify the potential need for the employer to address any ergonomic related issues in more detail.

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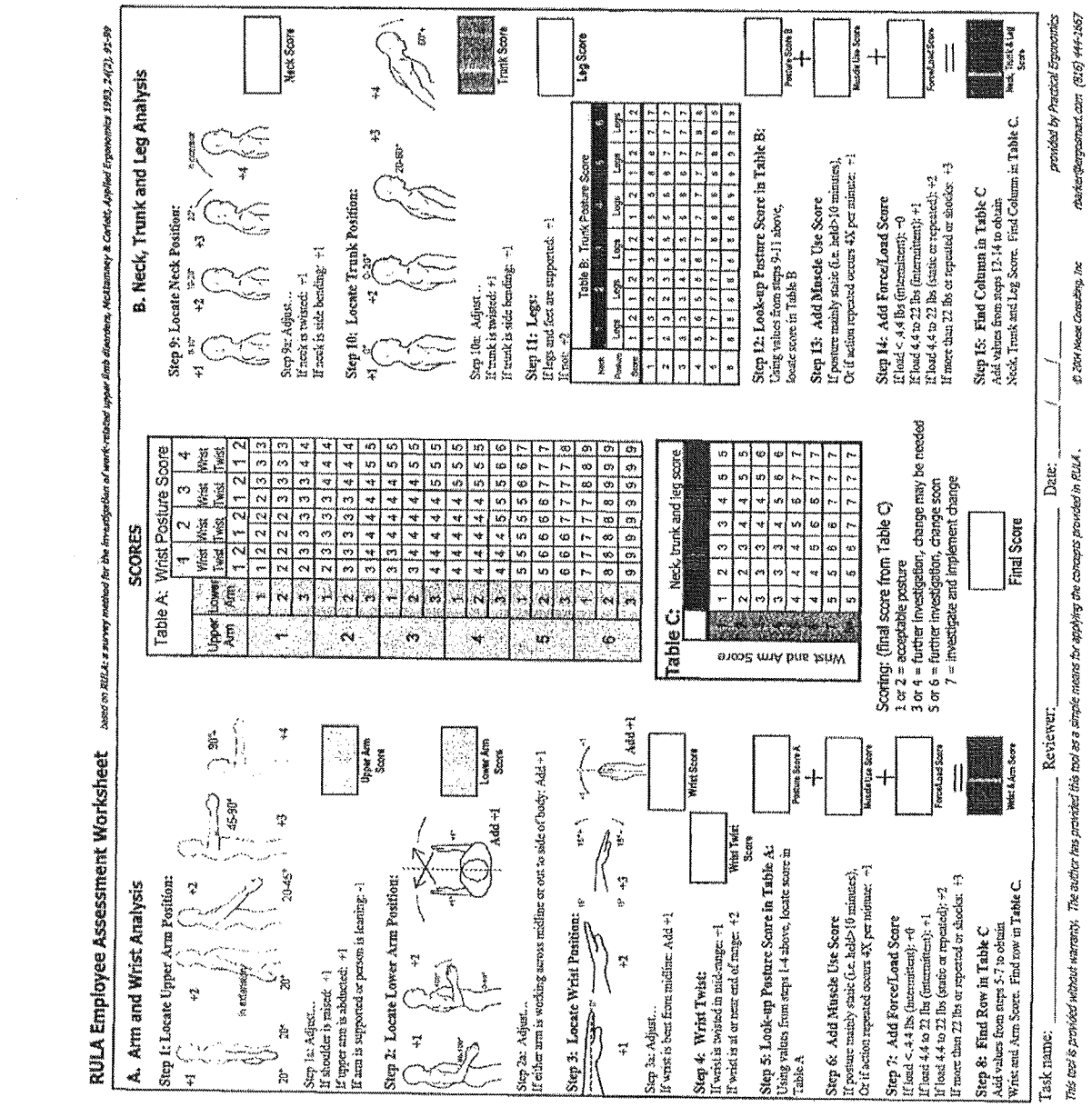
Appendix A: Rapid Upper Limb Assessment



Appendix B: Ergonomic Survey

This research has been approved by the UW-Stout IRB as required by the Code of Federal Regulations Title 45 Part 46.

Ergonomic Analysis of Personal Computer Workstation Environments in the Home

Survey Questions

Computer

1. Is there a PC being used in the home?

    If yes, is the PC being used in the home a laptop, desktop, or both?

    If both are used in the home, which is used most?

2. Is the keyboard placed directly in front of you?

3. Does the keyboard adjust from being flat on the work surface to a tilt?

4. Are the wrists kept in a neutral position (straight) while typing?

5. How many hours do you spend on your PC a day?

Workstation

1. Is there a permanent location in your home for your PC? (ex. an office)

    If no, where is your PC located or mainly used?

2. Is there a desk being used while the PC is being operated?

    Is the desk adjustable?

3. Is there enough legroom for your feet to be planted flat on the floor or on a footrest?

4. Do you find yourself reaching for items? (ex. telephone, mouse, etc.)

Chair

1. Is the chair adjustable by:
    Height?

    Backrest?

    Seat pan?

2. Does the chair provide adequate lumbar support?

3. Does the chair have armrests?

Adapted from NIOSH's Elements of Ergonomics Programs
NIOSH Publication No. 97-117; March 1997

If yes, are the armrests adjustable?

Monitor

1. Is the monitor adjustable by:
   Height?

   Tilt?

2. Is the top of the monitor at or slightly below eye level?

3. Does the monitor have brightness and contrast control?

4. Are glare and reflections avoided?

Environment

1. Is there adequate lighting where your PC is being used?

2. Is there a window where your PC is being used?

   If yes, does it cause a glare on the monitor?

Discomfort

1. Do you have any discomfort in your body while operating the PC?
   If yes, do you experience discomfort in:
   Hands?

   Wrists?

   Arms?

   Shoulders?

   Neck?

   Back?

   Legs?

   Eyes?

2. Can you give a brief description of the discomfort you experience?

3. Do you take breaks in between operating on the PC for long periods of time?

Home Visit

1. Are you willing to allow me to visit your home to observe the PC workstation environment for further assessment? **All information will be kept anonymous**