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A comparison of mouse wrist supports during computer mouse function

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A COMPARISON OF MOUSE WRIST SUPPORTS DURING COMPUTER MOUSE FUNCTION

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ABSTRACT

A COMPARISON OF MOUSE WRIST SUPPORTS DURING COMPUTER MOUSE FUNCTION

by Lisa Voge-Levin

Eighteen computer operators were monitored to determine the effect of two mouse supports on wrist posture. A mixed-factor design with three independent variables, Support Use (PRESENT and ABSENT), Support Type (SoftSpot™ and Gel-eez®), and Support Experience (experienced and non-experienced) was used. Participants performed typical mouse tasks for 20 minutes. Data were collected for wrist posture, points of contact, grip style, and subjective ratings. The results showed that overall, using a mouse support did not result in more time spent in neutral wrist extension or flexion postures. There was evidence of a long-term effect whereby the experienced users developed better mousing postures in neutral wrist extension. Participants spent more time in neutral ulnar deviation with a mouse support PRESENT. Contact stress appears significant at the volar wrist and distal forearm with support PRESENT or ABSENT. Participants rated the mouse supports as more comfortable, less fatiguing, and producing less pressure.

ACKNOWLEDGEMENTS

I dedicate this manuscript to my mother, Margaret, and the memory of my father, Lyle. They acknowledged my unique abilities (as one of nine children!), encouraged me to take chances, and respected my choices. I am forever grateful to them.

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CHAPTER 1

INTRODUCTION

In the last 15 years, work-related musculoskeletal disorders of the upper extremities have become a growing concern for Video Display Terminal (VDT) users, as well as the medical and ergonomic communities. Upper Extremity Cumulative Trauma Disorders (UE CTDs) accounted for 4% of all workers' compensation claims in 1995, compared to less than 1% in 1986. The Bureau of Labor Statistics has indicated that Upper Extremity Cumulative Trauma Disorders are one of the fastest growing occupational-related disorders in the industry (Brogmus, Sorock, & Webster, 1996).

A number of authors have investigated the relationship between workplace factors and work-related musculoskeletal disorders of the upper extremities (Berqvist, Wolgast, Nilsson, & Voss, 1995b; Faucett & Rempel, 1996; Hales, Sauter, Peterson, Fine, Putz-Anderson, Schleifer, Ochs, & Bernard, 1994; Rossingnol, Morse, Summers, & Pagnotto, 1987; Sauter, Schleifer, & Knutson, 1991; Stock, 1991). The physical factors associated with the development of Upper Extremity Cumulative Trauma Disorders in computer operators include awkward postures, repetition, mechanical or contact stress on soft tissue, and intense activity over prolonged periods of time (Armstrong, 1986).

The number of Video Display Terminal operators using the computer mouse has increased dramatically with the transition in computer software and operating systems from being text-driven software (e. g., DOS-based environment) to being graphically based (e.g., Windows-based environment). Along with changes in software, there have been the introduction and explosion of users on the World Wide Web, a primarily mouse-driven operation.

Johnson, Hewes, Dropkin, and Rempel (1993) used video analysis to compare patterns of hand activity during mouse function in order to identify how mouse use patterns vary between common software applications. Computer mouse use accounted for 30% of the time while performing word processing tasks, 40% of the time for database and spreadsheet activities, and 65% of the time for graphics and drawing tasks.

Simultaneous with increased mouse use has been an increase in Upper Extremity Cumulative Trauma Disorders related to mouse use. Armstrong, Martin, Rempel, and Johnson (1995) identified contact stress against the wrist, and postural stresses such as wrist deviation, flexion, and hyperextension as just a few of the physical risk factors related to computer mouse use. Pascarelli and Kella (1993) further described deleterious effects of extreme positions of the wrist. Any exaggerated positions of the wrist can cause increased friction and shearing of the flexor tendons, especially when coupled with repetitive and intense forearm muscle use. Extreme wrist postures have been strongly associated with the development of Upper Extremity Cumulative Trauma Disorders (Armstrong, 1986).

CHAPTER 2

LITERATURE REVIEW

Upper Extremity Supports

The most current edition (1988) of the American National Standards Institute's (ANSI) American National Standard for the Human Factors Engineering of the Video Display Terminal Workstations reports that palm and wrist supports are accessories designed to hold up the hands and forearms at the keyboard. The ANSI standard acknowledges that current research does not clearly indicate or specify, in detail, the need for accessories such as wrist supports. There is no discussion of wrist supports precisely for mouse use in the current ANSI standards.

Carter and Banister (1994), in their review of musculoskeletal problems of Video Display Terminal (VDT) workers, conceded that there are no clear guidelines for the use of forearm and wrist supports. However, they acknowledged that many VDT operators use palm supports in order to rest the forearm and wrist. The authors agree with the theoretical basis of the design of palm supports, which is to decrease the load on the upper spine while keyboarding. Various investigators have researched the pros and cons of wrist supports for keyboarding, with contradictory results (Bergvist et al., 1995b; Carter & Banister, 1994; Fernstrom, Ericson, & Malker, 1994; Grandjean, Hunting & Piederman, 1983; Hagglund & Jacobs, 1996; Hedge, McCrobie, Land, Morimoto, & Rodriguez, 1995; Hedge & Powers, 1995; Horie, Hargens, & Rempel, 1993; Nakaseko, Grandjean, Hunting, & Geirer, 1985; Rose, 1991).

To date, there have been few published ergonomic recommendations explicitly for mouse use. Armstrong et al. (1995) reported the greatest stress concentrations on the wrist and forearm tissues may come from the edges of the work surface as the mouse is being used. The authors recommended work surfaces designed with rounded edges as a method to decrease contact stress. They advised training in techniques to minimize the force of exertions, and suggested incorporating rest breaks. A wrist support is theoretically designed to be used to rest upon during or after a hand and forearm movement.

Mouse wrist supports, as an ergonomic accessory, have become a standard item for computer users, as noted in the plethora of ergonomic accessory catalogues. Sellars and Roth, authors of the book. Zap! How Your Computer Can Hurt You and What You Can Do About It (1994), suggested a wrist support for keyboard users in order to keep the wrists and hands parallel to the floor. They recommended that wrist supports be thick and padded, and be placed at a parallel height to the keyboard.

Designers and manufacturers of mouse supports assume that the height of the mouse support should be equal to the height of the keyboard, as noted in the numerous combination keyboard and mouse supports (e. g., 3M's gel keyboard and mouse support).

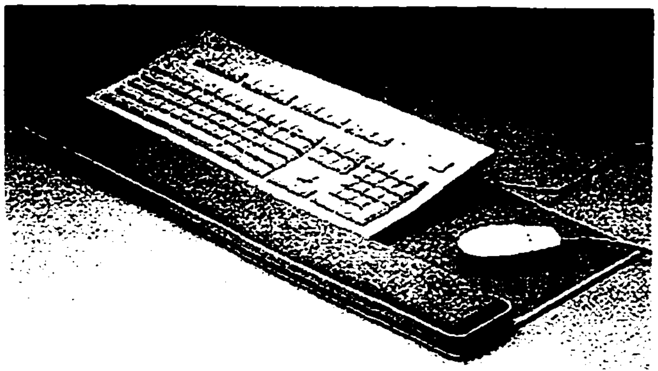

Figure 1. 3M™ gel-filled wrist rest for keyboard and mouse WR512.

Note. Photo courtesy of www.3m.com/market/omc/om_html/cws_html/r512.html (November 4, 1998).

AliMed™, an ergonomic products company, sells a variety of different height wrist supports for keyboards and mice. The AliMed™ brochure suggests the wrist support height should be equivalent to the keyboard height in order to achieve the desired neutral wrist posture. The catalogue does not specifically address recommendations for the height of the mouse wrist support.

To date, there are no published guidelines regarding the height for mouse supports and very little research to support the application of mouse wrist supports. Only one study, by Damann and Kroemer (1995), researched the effects of wrist posture and the operational use of one type of mouse wrist support. The authors found a mouse wrist support was beneficial for unloading the muscles of the shoulder and minimizing awkward postures of the wrist.

In the following section, a glossary of terms to aid the reader in understanding the terms used in the study is provided.

Definition of Terms

The following terms are defined to clarify their meaning for the purpose of this research:

Carpal Tunnel Syndrome: Compression of the median nerve at the wrist.

Computer mouse: A pointing device used to select commands for control of the computer and to move objects from one location to another.

Cumulative Trauma Disorders (CTDs): A disorder of the soft tissues due to repeated, forceful, and awkward movements of the body over a period of time. Other names associated with this disorder are Work-Related Musculoskeletal Disorders, Repetitive Strain Injury, and Repetitive Motion Injuries (Ranney, 1993).

Distal Ulnar Nerve Neuropathy: A disorder characterized by compression of the ulnar nerve at the wrist (known as Guyon's Canal).

"*Dragging*": The mouse user holds the mouse button down while moving the mouse (Johnson, Smutz, Tal, & Rempel, 1994).

Fixed wrist mouse support: A wrist support that is stationary.

Forearm support: A platform for the entire forearm (elbow to wrist), used with mouse or keying movements, used to decrease the muscular activity or load of the shoulder.

Hypo thenar eminence: The fleshy prominence on the palm, below the little finger.

Mobile wrist mouse support: A wrist support that is movable.

"*Point and click*": The mouse user positions the cursor over a selected location on the screen and pushes the control button.

Radial deviation: The act of bending the wrist toward the thumb side of the hand.

Ulnar deviation: The act of bending the wrist toward the little finger side of the hand.

Wrist extension: The act of bending the wrist up.

Wrist flexion: The act of bending the wrist down.

Wrist support: Platform for the wrist; prevents sharp edge of table from digging into the tissue of the wrist; raises and straightens the wrist in reference to the keyboard or mouse.

Mouse Use and Upper Extremity Cumulative Trauma Disorders

Recently, increased use of the mouse has been linked with an increase in the development of Upper Extremity Cumulative Trauma Disorders. Compared to studies of computer keyboard use and the link to UE CTDs, there have been relatively few prospective or investigative studies specific to computer mouse use and the occurrence of Upper Extremity Cumulative Trauma Disorders.

Looking at workers' compensation claims out of the Liberty Mutual Group from 1986 to 1993, Fogelman and Brogmus (1995) investigated the physical effects of increased mouse use on computer operators. Results indicated 6.1% of all claims in 1993 were computer use claims, with a rapid rise in the rate of computer mouse-related claims. The authors stated in their analysis that the body parts injured most frequently in the computer mouse claims involved not only the wrist, but the hand, lower arm, and upper arm. Even though the claims for Upper Extremity Cumulative Trauma Disorders are few, the numbers of claims are growing in the area of computer use and, specifically, computer mouse usage.

According to Karlqvist, Hagberg, and Selin (1994), long periods of strenuous mouse use resulted in awkward postures of the wrist, elbow, and shoulder. From a physiological perspective, Johnson, Smutz, Tal, and Rempel (1994) analyzed the fingertip forces during computer mouse operation in order to identify the potential relationship between mouse usage and musculoskeletal fatigue and injury. They found a significant elevation in fingertip forces and sustained fingertip loading. They concluded that mouse dragging operations placed the operators' forearm tendons and muscles under great biomechanical stress.

Hagberg (1995) investigated 751 computer mouse operators for the existence of a specific "computer mouse syndrome." His study compared intense mouse users (greater than 10 hours a week) with non-intense mouse users (less than 2 hours a week). Results demonstrated no major differences between intense and non-intense mouse users. For both groups, the location of symptoms was the shoulder scapula region, wrist, hand, and fingers. The symptoms in the scapula and shoulder region were due to static muscle loading. The symptoms from the wrist were due to extreme positions of the wrist, specifically ulnar deviation with mouse use. The pain in the hand and fingers was due to extensor tendon inflammation represented by the strain from using the mouse for clicking and dragging operations. In conclusion, Hagberg supports the idea that computer mouse use may cause symptoms in many parts of the body, but cautions against the term "mouse-arm" syndrome.

Recent literature (Fogelman & Brogmus, 1995; Hagberg, 1995; Johnson et al., 1993; Karlqvist et al., 1994) depicts the growing concern over mouse-related injuries and increased workers' compensation claims regardless of whether or not a specific syndrome for mouse use has been coined. The symptoms and body parts affected are similar to those described in the literature regarding computer keyboard injuries. However, the number of studies focusing on computer mouse use and Upper Extremity Cumulative Trauma Disorders remains limited.

Risk Factors Associated with Mouse Use

The most common risk factors associated with mouse input devices that can lead to upper limb musculoskeletal disorders are repetition, force, contact stress, and postural stress (Armstrong et al., 1995).

Armstrong et al. (1995) reported the sides of the fingers, the base of the palm, and the elbow are more vulnerable to the injurious effects of contact stress due to the close proximity of underlying nerves in these areas. With small surface areas, there is a greater magnitude of force being applied to the soft tissues. The base of the palm has a small surface area. The authors reported greater stress concentrations applied to the base of the palm were coming from the edges of the work surface. The authors recommended providing rounded edges on work surfaces as a method to minimize contact stress to the palm.

Distal ulnar nerve neuropathies (compression of the distal ulnar nerve at the wrist) due to contact stresses are not uncommon when computer mouse technique is primarily a wrist-based movement. For example, Davie, Katifi, Ridley, and Swash (1991) reported one case of distal ulnar neuropathy on an individual who performed intense computer keyboard and mouse use while completing his doctoral thesis. Resting his extended right hand on the hard surface of a table caused direct pressure on the hypothenar eminence and wrist. The authors concluded that a foam mat to rest the wrist on may have prevented pressure on the volar surface of the wrist, thus preventing the distal ulnar neuropathy.

Another case, cited by Friedland and St. John (1984), described an injury to the hypothenar eminence resulting from contact stress. They reported on an individual who played video games for one month and developed distal ulnar nerve neuropathy from resting his extended wrist on the surface of the machine.

Contact stress is a common risk factor for the development of cumulative trauma disorders, as the external pressure on underlying nerves and soft tissue lead to ischemia and neurovascular changes that can adversely affect the sensory and motor capabilities of the upper extremities.

Non-neutral postures are identified as stressful postures of the wrist and strongly associated with the development of Upper Extremity Cumulative Trauma Disorders (Armstrong, 1986). Armstrong et al. (1995) identified the most prevalent postural stresses related to computer mouse use as wrist deviation, wrist flexion and hyperextension, forearm rotation, and extreme reaching. Wrist radial and ulnar deviation control the side-to-side movements of the mouse, which manipulate the distance the cursor moves on the screen. The height of the mouse with respect to the elbow determines flexion and extension of the wrist. The authors suggested the mouse be located near elbow height to decrease excessive wrist flexion and extension.

Karlqvist et al. (1994) examined postures of the upper extremity in 12 computer mouse users and 12 nonmouse users during a word processing task. The authors found ulnar wrist deviation to be greater than 15°, 64 % of the time for mouse users. The participants reported discomfort in the whole arm after working with a computer mouse for 2 hours.

The literature on risk factors associated with mouse use concurs on the probable causes of computer mouse injuries. The causes frequently cited are contact stress and force applied to the underlying nerves in the palm and wrist, and non-neutral postures of the wrist. Methods to decrease these risk factors include a foam mat and rounded edges to rest the wrist on, as well as consideration of mouse height with respect to the elbow. A mouse wrist support addresses all three of these recommendations.

Wrist Supports for Keyboard Use: Pros and Cons

Pros

Numerous researchers advocate the employment of wrist supports with computer keyboard function (Bergvist et al., 1995a; Carter & Banister, 1994; Grandjean et al., 1983; Hagglund & Jacobs, 1996; Nakaseko et al., 1985; Rose, 1991). Berqvist et al. (1995a) contemplated upper body musculature problems with relationship to the ergonomic and organizational factors of keyboard users. The authors found the participants (n = 260) in the study with non-neutral or extreme hand positions recorded arm and hand discomfort. The discomfort was due to the non-use of lower arm supports and high profile keyboards.

Carter and Banister (1994), in a review of musculoskeletal problems related to Video Display Terminal use, theorized that a palm rest for keyboard users would reduce the static muscular load on the trapezius muscles of the shoulder. They inferred that wrist rests and forearm supports might be more appropriate for intermittent typing tasks. The authors described a good palm rest dimension for keyboarding as 5 cm wide, padded with a rounded edge in the front, and suggested it be detachable to accommodate a variety of hand sizes.

Grandjean et al. (1983) reported increased comfort with the use of forearm-wrist supports in 80% of the participants in their study (n = 68). Grandjean and his colleagues observed the resting behaviors of their subjects' forearms and hands when the subjects were supplied with or without a forearm-wrist support. Interestingly, 80% of the participants rested their forearms or wrists when a support was given to them. If no support was supplied, 50% of the subjects rested their forearms or wrists on the desk surface.

Hagglund and Jacobs (1996) examined wrist motions of 20 computer users typing with a wrist support and/or forearm supports, to computer users without any form of wrist or forearm support. The researchers referred to research claims that wrist extension greater than 15° and ulnar deviation greater than 20° can be predisposing factors in developing Upper Extremity Cumulative Trauma Disorders. The researchers assumed that wrist extension and ulnar deviation would decrease when using a wrist rest or forearm support, and expected the greatest change when using both types of supports. Results indicated that all four wrist motions remained under 20° of motion during the treatment conditions that utilized some form of wrist rest or forearm support.

While researching split keyboard designs with the use of large or small forearm and wrist supports, Nakaseko et al. (1985) discovered a large forearm support was associated with a greater sense of relaxation by the participants. Four strain gauges outfitted on the forearm supports measured Newtons (N) of force applied to the supports from the forearms of the participants (n = 31). Interestingly, concerning the size of wrist supports, Nakaseko et al.'s studies clearly indicated a distinctly lower pressure score with the small supports (average 19 N). Rose (1991) found a significant decrease in finger forces when an arm was supported by a wrist support (n = 60).

In summary, the aforementioned researchers agreed on the benefits of wrist supports for keyboard operators. Their research supported the benefits of using a wrist support for decreasing static muscle load, increasing comfort, and decreasing awkward wrist postures. A logical analogy would support the use of wrist supports for computer mouse users.

Cons

There are some researchers who hold contradictory opinions regarding the efficacy of wrist supports (Fernstrom et al., 1994; Hedge et al., 1995; Hedge & Powers, 1995; Horie et al., 1993). In an electro-myographic study of the forearm and shoulder muscles utilizing five different types of keyboards, Fernstrom et al. (1994) found no significant differences in muscle activity with or without the use of a palm rest. A few problems related to this study were that participants (n = 8) had never used a palm rest before, and the testing time per condition was limited to 10 minutes.

Hedge and Powers (1995) looked at full motion arm supports which allow each arm to rest in a mobile cradle that supports the arm weight for all horizontal movements. Using video motion analysis to measure postural changes in 12 participants, the results indicated no improvement in wrist postures with the use of forearm supports. In a larger field study, Hedge et al. (1995) compared the effects of wrist supports, keyboard trays, and negative slope keyboard trays on musculoskeletal discomfort during keyboard tasks (n = 38, 26% with an Upper Extremity Cumulative Trauma Disorder). Sixteen participants in the experimental group and 7 participants in the control group used a padded wrist rest. The height of the wrist rests varied from 1.8 cm (0.75 inches) to 2.5 cm (1 inch), with a maximum depth from front to back of 3 cm (1.2 inches). The investigators concluded that there were no significant differences in wrist extension or ulnar deviation when using a wrist support.

One of the first experimental studies looking at Carpal Tunnel Pressure (CTP), and the use of wrist rests showed that CTP does not diminish with the use of a wrist rest. Horie et al. (1993) inserted pressure transducing catheters into 7 human subjects' wrists, in order to measure the pressure in the carpal tunnel. Average CTP during typing with a wrist rest was 31.4 mm Hg, which was similar to typing with the wrists on the desk (31.3 mm Hg). The authors postulated the higher Carpal Tunnel Pressure was due to the external pressure on the palm from the wrist rest.

In summary, this group of authors claimed that keyboard wrist supports of various designs did not demonstrate any benefit in reducing muscle contraction, decreasing wrist deviation, or minimizing Carpal Tunnel Pressure.

The group of researchers in support of using a wrist support cited benefits of reduced static muscle load, increased comfort, and decreased awkward wrist postures. In sharp contrast are the group of researchers disclaiming any benefits from using a wrist support in terms of reduced muscle load, pressure, or awkward postures.

Wrist Supports and Mouse Use

There is one published report on the use of wrist rests strictly for mouse use. Damann and Kroemer (1995) investigated the effects of surface height and the use of mouse wrist supports on wrist posture. Eight males and eight female participants volunteered for the experiment. Fourteen of the participants were very experienced mouse users. None of the participants had a history of diagnosed cumulative trauma disorders, and all participants met a performance consistency standard subsequent to participation in the study.

The 16 subjects performed a randomly assigned mouse-only pointing task at four different surface heights, with or without a wrist support (a total of eight conditions). The keyboard and mouse were placed on an adjustable table, with the keyboard directly in front of the monitor, and the mouse and mouse pad were located to the immediate right of the keyboard. Participants sat in an adjustable chair and remained at a constant height throughout all conditions, while the four mouse heights varied by raising and lowering the adjustable table. A wrist monitor attached to the participant's right hand, wrist, and forearm measured the four dependent variables of wrist flexion and extension and radial and ulnar deviation. Movement time and accuracy data were also collected.

The study used a repeated measure's design with four within-subjects factors of mouse height, support, distance between targets, and target width. Mouse height and support were counterbalanced. The four levels of mouse height were 100% (mouse height equal to seated elbow height), 120%, 140%, and 80%. Wrist support was either PRESENT or ABSENT. A standard mouse pad (24 cm x 20 cm) of foam covered in an anti-static cloth was the ABSENT condition. An additional foam block (24 cm x 9 cm x 2 cm) on the same mouse pad constituted the PRESENT condition.

Results of the study suggested the use of wrist supports decreased wrist extension and radial deviation. while wrist flexion increased slightly. The authors explained that with a support, the wrist is positioned at a level relatively equal to the height of the mouse, therefore reducing wrist extension; whereas, without a support, users tend to extend their elbows and place the heel of the hand on the mouse pad, with the fingers and palm draped over the top of the mouse, thus producing wrist extension.

At least part of the effectiveness of a mouse support may be the unloading of the shoulder muscles, as the wrist and distal end of the forearm rest on the support. The unconscious relaxation of the shoulder and elbow may contribute to the effectiveness of the mouse support.

Damann and Kroemer (1995) concluded that a wrist mouse support is advisable. The optimal mouse pad surface height should be at seated elbow height, or 20% higher or lower. Results of the study indicated that surface height of the mouse support at 140% of seated elbow height produced the greatest wrist flexion and ulnar deviation. The Damann and Kroemer study did not, however, look at the elbow or shoulder in relationship to mouse use.

Mouse Wrist Support Product Review

There are two types of mouse wrist supports. The fixed mouse wrist support is stationary; once placed on the work surface, it stays in place. The mobile mouse wrist support was designed to move in unison with the mouse user, as s/he manipulates the mouse.

The design of fixed mouse supports varies in size, height, and texture. The manufacturer's claims promoting mouse wrist supports include:

1. Reduces pressure points.
2. Greater comfort for your wrist.
3. The wrist is placed in an ergonomically correct angle.
4. A soothing and comfortable support.
5. Helps prevent Carpal Tunnel Syndrome.
6. Minimizes wrist pressure while maintaining optimal palm or wrist support.
7. Maintains a neutral wrist position while using a mouse.
8. Helps reduce the risk of injuries by supporting the wrist while using a mouse.

Specifically, a sample of the fixed mouse supports currently available and their claims are provided below.

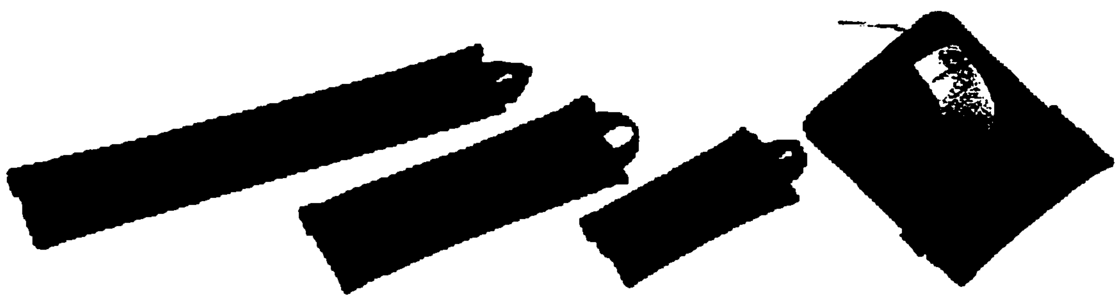

Figure 2. Gel-eez™ mouse support.

Note. Photo courtesy of www.caselogic.com/infinity/newsroom/html/gem/html (November 4, 1998).

The manufacturers of the Gel-eez™ claim a reduction in fatigue and discomfort while using the Gel-eez™ and diminished chances of developing a repetitive strain injury.

Figure 3. SoftSpot® mousepad wrist support.

Note. Photo courtesy of www.softspot.com (November 4, 1998).

The manufacturers of the SoftSpot® mousepad claim a natural, neutral position and a reduction in stress on the wrists and forearms. They claim their product distributes weight which improves circulation and decreases pressure points.

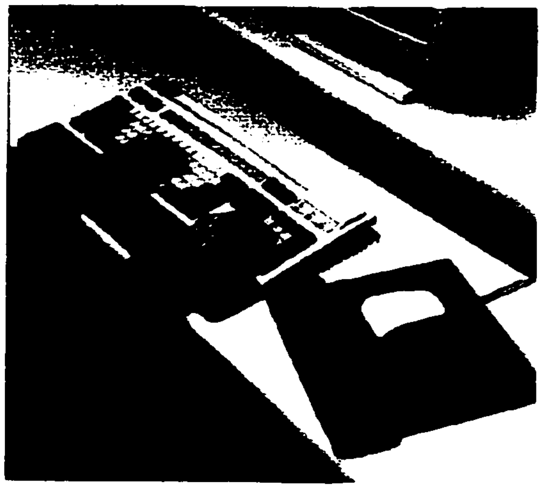

Figure 4. WristAssist™ mouse support.

Note. Photo courtesy of www.wristassist.com (November 6, 1998).

The manufacturers of the WristAssist™ claim their product is an inexpensive way to keep mouse users' wrists in neutral alignment. They claim the foam density was selected by ergonomists for its blend of support and feel.

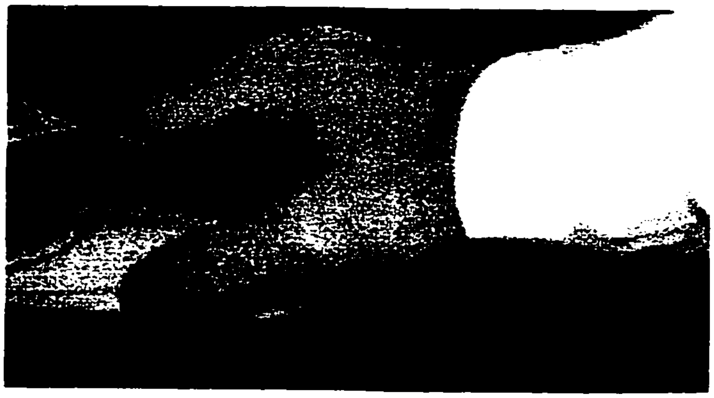

Figure 5. Wrist Rester™ mouse support.

Note. Photo courtesy of www.wristrester.com (November 7, 1998).

The manufacturers of the Wrist Rester™ claim their product elevates the wrists and provides comfort.

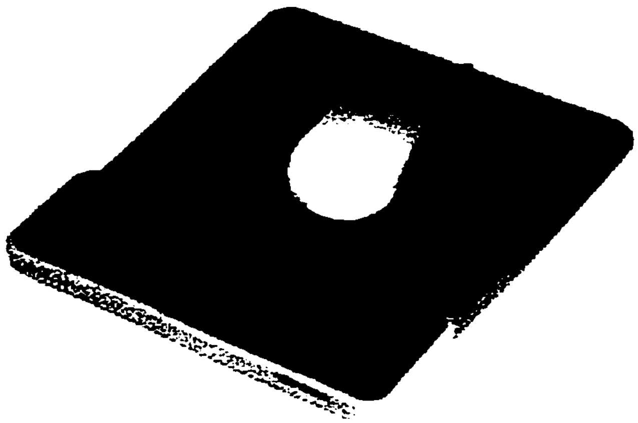

Figure 6. 3M™ gel-filled wrist rest.

Note. Photo courtesy of www.3m.com/market/omc/om_html/cws_html/r512.html (November 4, 1998).

The manufacturers of the 3M™ wrist rest claim their product helps relieve wrist strain and discomfort and is ergonomically designed to encourage proper wrist alignment during use of a keyboard, mouse, or trackball. They claim the 3M gel filling eliminates pressure points and comfortably supports the wrists and palms.

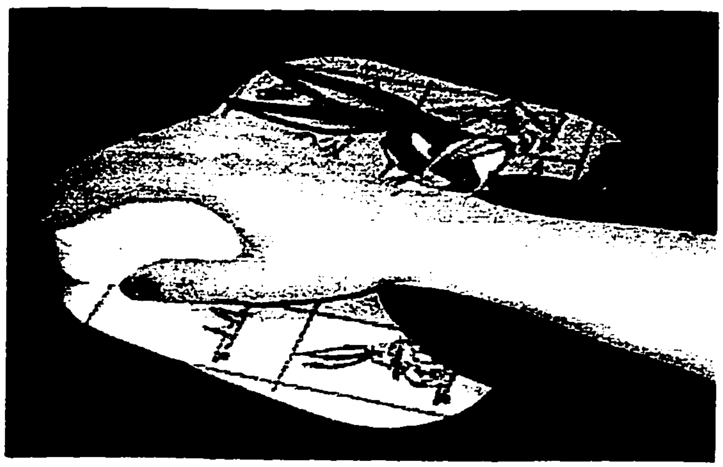

Figure 7. Flolite wrist rest.

Note. Photo courtesy of www.flolite.com/al2000.html (November 4, 1998).

The manufacturers of the Flolite wrist rest claim their product is designed to provide comfort, support, and increased dexterity for the users of a computer mouse. They claim the fluid-filled pad, when used properly, can reduce the movements which cause repetitive stress syndrome.

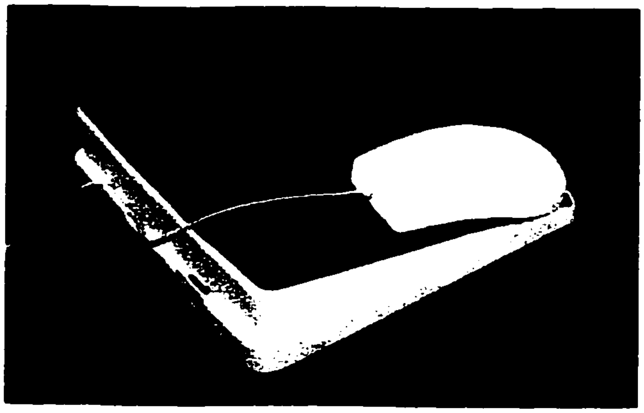

Figure 8. Mouse escalator.

Note. Photo courtesy of www.4amouse.com (November 4, 1998).

The manufacturers of the mouse escalator claim their product puts the wrists in a natural position rather than an arched position over the mouse. They claim their product improves mousing and reduces pressure, strain, and pain.

Summary

A review of the literature provided a mixed view of the benefits of a wrist support. With the exception of one study, most of the research to date has investigated the use of wrist supports during keyboard tasks, but not during mouse tasks.

The manufacturers' claims that a wrist support provides neutral alignment, reduces wrist strain, and reduces fatigue and discomfort has some support in the research. Hagglund and Jacobs (1996) reported wrist motions remained under 20° of motion when some form of wrist rest or forearm support was utilized. Berqvist et al. (1995a) found the participants in their study reported arm and hand discomfort due to the lack of arm supports. Armstrong et al. (1995) recommended rounded edges on work surfaces as a method to minimize contact stress.

Davie et al. (1991) concluded resting the wrist on a foam mat may prevent pressure on the volar surface of the wrist. Grandjean et al. (1983) reported participants in their study described increased comfort with the use of forearm-wrist supports. Nakaseko et al. (1985) participants reported a greater sense of relaxation associated with forearm supports.

Problem Statement

In stark contrast to the reported research mentioned above, there are reports based on scientific research disproving the benefits of wrist supports. Fernstrom et al. (1994) found no significant differences in muscle activity with or without the use of a palm rest. Hedge and Powers (1995) concluded there were no significant differences in wrist extension or ulnar deviation when using a wrist support. Horie et al. (1993) showed that Carpal Tunnel Pressure does not diminish with the use of a wrist rest.

Damann and Kroemer's (1995) study investigating the effects of a mouse wrist support on wrist posture concluded that the use of mouse wrist support is advantageous, as it decreases wrist extension and radial deviation.

The literature accounts for numerous, yet contradicting studies on the benefits of wrist supports for keyboard users. Only one single study, published to date, explored the use of a wrist support during computer mouse function. There exists little guidance in the ergonomic literature regarding the beneficial design aspects of mouse wrist supports. Therefore, a study looking at the use and design features of mouse wrist supports was undertaken.

Research Objectives

Only one study, by Damann and Kroemer (1995), researched the effects of a mouse wrist support on wrist posture during mouse function. Keyboard operators are using wrist supports, and it is logical to assume that mouse users are employing mouse wrist supports as well. From the literature, one can assume that the recommendations that apply to the keyboard regarding wrist supports also apply to the mouse. The mouse wrist supports available to the consumer vary in their design and function. There exists little guidance in the ergonomic literature regarding the potential beneficial aspects of mouse wrist supports. Therefore, an investigation was undertaken to determine what mouse wrist supports were available to the consumer, and if they met the claims stated by the manufacturers.

The objectives of this study were to (a) identify commonly used mouse wrist supports and document the benefits as stated by the manufacturers' claims; (b) observe and quantify wrist postures while using two common mouse supports; (c) compare the objective data and subjective reports of the SoftSpot® and Gel-eez™ mouse wrist supports with the manufacturer's claims; and (d) provide design guidelines regarding how the wrist can be supported during computer mouse function.

Results of the study will add to the ergonomic literature in providing guidelines to ergonomic professionals when making recommendations to clients regarding mouse wrist supports. The industrial design community may also benefit from this study, by providing some insights into the design and functional use of mouse wrist supports.

Hopefully, this initial exploration of mouse wrist supports will encourage other researchers in the field of ergonomics to do further research on the relationship of wrist posture and mouse wrist supports.

The study was a three-factor mixed design. The with-in subjects independent variable was Support Use (PRESENT or ABSENT). The between-subjects independent variables were Support Type (Gel-eez™ vs. SoftSpot®) and Support Experience (experienced vs. non-experienced).

Four dependent variables were measured including (a) wrist range of motion (percentage of time spent in neutral and awkward wrist postures), (b) points of contact, (c) grip and pinch style, and (d) subjective responses pertaining to comfort, fatigue, precision, speed, and pressure. There were 18 computer operators in the study who participated in a mouse-based task for the two conditions (mouse wrist rest PRESENT or ABSENT). It is hypothesized that:

1. Based on Damann and Kroemer's (1995) study, there will be a significant difference in wrist ROM (percentage of time spent in neutral wrist postures) for the factors Support Use (PRESENT or ABSENT). Use of mouse wrist supports will produce a greater percentage of time spent in neutral wrist postures for both experienced and non-experienced mouse wrist support users. There will be no significant difference in wrist ROM for the factors Support Type (Gel-eez™ vs. SoftSpot®) and Support Experience

(experienced vs. non-experienced). The null hypothesis for this study is that the factors will not have an effect.

2. There will be no significant difference in points of contact of the upper extremity during mouse use for the factors Support Use (PRESENT or ABSENT), Support Type (Gel-eez™ vs. SoftSpot®), and Support Experience (experienced vs. non-experienced).

3. There will be no significant difference in grip or pinch style for the factors Support Use (PRESENT or ABSENT), Support Type (Gel-eez™ vs. SoftSpot®), and Support Experience (experienced vs. non-experienced).

4. There will be no significant difference in subjective responses pertaining to comfort, fatigue, accuracy, speed, and pressure with the use of a mouse support PRESENT relative to the mouse support ABSENT for the factors Support Type (Gel-eez™ vs. SoftSpot®) and Support Experience (experienced vs. non-experienced).

CHAPTER 3

METHODS

Participants

Participants consisted of 18 adult volunteers (10 females and 8 males) between the ages of 23 and 52 years (M = 33.5 years). Participants for the study were recruited from local businesses from a posted flyer (see Appendix A). Due to an inability to attract additional volunteer participants, some of the participants were paid a nominal fee of $20.00 to $40.00. The researcher does not expect any change in motivation since this was a postural study. Participants were screened by a questionnaire (see Appendix B) prior to participation in the study.

Participant Screening

When an individual responded to the flyer, (see AppendixA), s/he was screened using a Participant Screening Tool (see Appendix B). The introduction to the screening tool stated the purpose of the study, which ascertained significant issues of use patterns of the selected mouse wrist supports. Criteria for participant selection included:

1. All participants had a minimum of one year of PC experience and used a standard mouse.

2. Participants used the right hand during computer mouse use.

3. Participants used either the Gel-eez™ or SoftSpot® mouse wrist support for a minimum of 3 months, or none at all.

4. Placement of the mouse (in relation to the elbow) was at or near the same height.

5. There was no recent history of diagnosed upper extremity repetitive strain injury in the last year.

6. Participants had experience playing Solitaire, and had the computer program Excel on their computer.

The first 18 participants who volunteered and passed the screening requirements were accepted for the study.

Apparatus

The Mouse Wrist Supports

A product survey was undertaken to determine some commonly used fixed wrist supports specifically intended for computer mouse use. Considering the information gathered from local retail stores and distributors, two models were selected. The two mouse wrist supports represent a modest range in the genre of fixed mouse supports with regard to materials and dimensions.

The two mouse wrist supports selected for the study were the Gel-eez™ wrist rest from Case Logic and the SoftSpot® mousepad wrist support from Envirogen International, Inc.

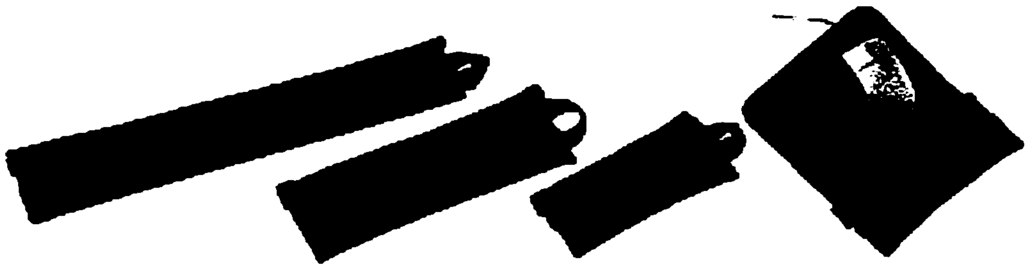

Figure 9. Mouse Support A, the Gel-eez™ wrist rest.

Note. Photo courtesy of www.caselogic.com/infinity/newsroom/html/gem/html (November 4, 1998).

The Gel-eez™ wrist rest consisted of a standard mouse pad (20 cm W x 24 cm L), with the addition of a (20 cm W x 8 cm L x 2.5 cm H) non-toxic gel pad. The manufacturers of the Gel-eez™ claimed that the dual chambers conform to the wrist shape for maximum comfort and can help reduce the risk of repetitive stress injuries. It is a fluid-filled support designed to reduce pressure points and provide greater comfort for the wrist.

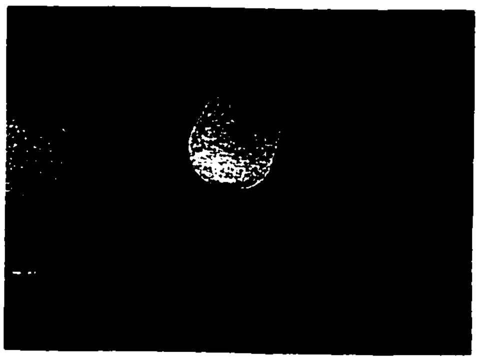

Figure 10. Mouse Support B, the SoftSpot® mousepad wrist support.

The SoftSpot® wrist support consisted of an oblong shaped base (19 cm W x 33 cm L), with the addition of a (13.5 cm W x 12 cm L x 3.5 cm H) polyurethane pad made of Therasoft®. The manufacturers claimed that the Softspot® design ensured a neutral position and eased strain on the wrists and forearms. They claimed the Therasoft® pad distributed weight, eliminated pressure points, and improved circulation. The standard mouse pad measured 20 cm W x 24 cm L x 1 cm H.

Greenleaf Medical WristSystem™

All participants wore the Greenleaf WristSensor glove containing dual axis sensors that detected wrist movements (see Appendix C). The Greenleaf Data Recorder was the means of communication between the glove and the computer program.

The dynamic right wrist positions of flexion, extension, radial deviation, and ulnar deviation were recorded using the portable Greenleaf Medical WristSystem™ (see Appendix C) and Movement Analysis Software (MAS) model 4.1. Wrist movements were recorded at 6 Hz. When plotting the data, the Greenleaf Medical WristSystem™ MAS software represented wrist extension as a positive number and flexion as a negative number. Similarly, ulnar deviation was represented by a positive value and radial deviation by a negative value. Data was recorded for each participant's four wrist motions during the two test conditions (with and without a wrist support). Each test condition lasted 15 to 20 minutes.

Computer Workstation

The computer workstation used for testing was the participant's own office workstation, consisting of a table or a desk, a chair, and a computer system. No adjustments were made to the participant's workstation.

The type of mice used for the study were standard Logitech and Microsoft mice used by Dell, IBM, HP, and Compaq computer companies.

Experimental Design

The design of the study was a three-factor mixed design. The with-in subjects independent variable was the use of a mouse wrist support, PRESENT or ABSENT. The between-subjects independent variables were type of mouse wrist support (Gel-eez™ vs. SoftSpot®) and mouse rest experience (experienced vs. non-experienced).

There were four experimental groups. Group 1 consisted of 6 participants with experience using the SoftSpot® mousepad wrist support. Group 2 consisted of 6 participants with experience using the Gel-eez™ wrist rest. Two control groups consisted of 3 individuals each, who did not have experience using any type of mouse wrist support. Group 3 tested with the SoftSpot®, and Group 4 tested with the Gel-eez™. Due to the difficulty in finding willing participants, there were unequal group sizes.

The dependent variables included (a) wrist range of motion, (b) points of contact, (c) grip and pinch style, and (d) subjective responses pertaining to comfort, fatigue, precision, speed, and pressure.

Wrist Range of Motion

This measurement represented the percentage of time spent in each of the four wrist postures including (a) wrist flexion, (b) wrist extension, (c) wrist radial deviation, and (d) wrist ulnar deviation.

Data representing the percentage of time the wrist deviated from neutral was collected from the Greenleaf MAS system and categorized into 10 levels. The "neutral zone" as described by Hedge et al. (1995) was used as a model for this study. Any wrist postures outside the neutral zone were deemed as awkward wrist motions when using a wrist support (Hedge et al., 1995), and a risk factor for developing Upper Extremity Cumulative Trauma Disorders (UECTD). For purposes of this study, wrist posture was categorized into (a) neutral zone as defined as wrist extension of 0° to 15° and wrist ulnar deviation, wrist radial deviation, and wrist flexion of 0° to 20°; (b) moderate awkward posture as defined as wrist extension of 15° to 30°, wrist flexion of 20° to 40°, and 20+° for ulnar and radial deviation; and (c) extreme awkward postures as defined as wrist extension of 30+° and wrist flexion of 40+°.

Points of Contact of the Upper Extremity

The investigator recorded upper extremity points of contact during computer mouse function, noting where the participant anchored his/her upper extremity during the task conditions. The points of contact included (a) the volar wrist, (b) the distal forearm (the distal one-third of the forearm), (c) the mid-forearm (the middle third of the forearm), (d) the proximal forearm (the proximal third of the forearm), and (e) the elbow. Visual observation by the investigator was documented during the first 5 and last 5 minutes of the Solitaire testing session, as well as throughout the other mouse tasks.

Grip and Pinch

This analysis included observation by the researcher of the subject's right upper extremity grip and pinch prehension style while manually manipulating the mouse. The four possible pinch and grip styles included (a) thumb-finger palm grip: thumb pad opposes the palmar pad or one finger (or the pads of several fingers) near the tips; (b) thumb and two-finger grip (writing grip): thumb and two fingers (often the forefinger and index finger) oppose each other at or next to the tips; (c) thumb-fingertips enclosure (disk grip): thumb pad and the pads of three or four fingers oppose each other near the tips (object grasped does not touch the palm); and (d) finger-palm enclosure: most or all of the inner surface of the hand is in contact with the object while enclosing it. Figures 11 through 14 are from Kroemer (1986).

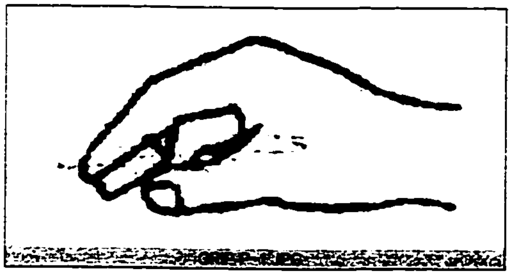

Figure 11. Thumb-finger palm grip.

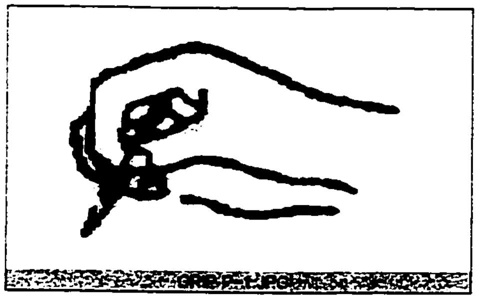

Figure 12. Thumb and two-finger grip (writing grip).

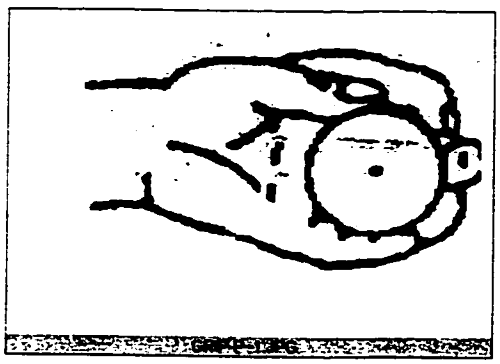

Figure 13. Thumb-fingertips enclosure (disk grip).

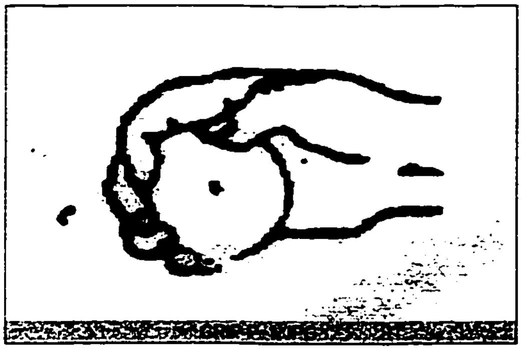

Figure 14. Finger-palm enclosure.

Subjective Evaluation of the Perceived Benefits from the Mouse Wrist Support

A questionnaire was designed by the researcher to identify possible benefits achieved from the two mouse wrist supports tested (see Appendix D). After the testing condition was completed, a 7-point Likert scale ranging from (1) much worse to (7) much better was used to measure subjective responses for the use of a support PRESENT, relative to the use of the support ABSENT. The physiological and performance factors included (a) comfort, (b) fatigue from use, (c) mousing accuracy and precision, (d) mousing speed, and (e) pressure exerted on the wrist.

Procedures

Introduction of the Task

All participants were tested in their own offices. To maintain a natural context, participants were encouraged to adopt their typical workstation postures. Participants were verbally introduced to the purpose of the study. They were requested to read and sign a written consent form (see Appendix E), prior to participating in the study. Each participant was assigned a Participant Identification Number (PIN) to ensure anonymity.

Fitting and Calibrating the Greenleaf WristSystem™

The investigator fitted each participant with the proper sized (small, medium, or large) right-hand glove. A new file was then opened on the Greenleaf computer program and calibrations were performed in the four specified wrist positions according to the Movement Analysis Model 4.1 Protocol. The default wrist positions consisted of 60° of flexion and extension, 30° of ulnar deviation, and 20° of radial deviation. When a participant could not obtain any of the default wrist angles, the investigator changed the value in the program to the participant's maximum range. The same investigator performed all calibrations. Wrist posture was measured at a rate of 6 Hz. The investigator informed the participants that they could move their hands as usual, while wearing the glove, but they should try not to move or adjust the glove.

Test Conditions

There were two test conditions. The PRESENT condition consisted of the participant using a mouse support, either the Gel-eez™ or the SoftSpot®. The ABSENT condition consisted of the participant using a standard mouse pad provided by the investigator.

Practice Session

Before initiation of data recording for both the PRESENT and ABSENT conditions, participants were given a 5-minute practice session while wearing the wrist system.

Static Body Posture

A 20-second initial measurement on the Greenleaf WristSystem™ was taken to observe the static resting wrist posture for both PRESENT and ABSENT conditions. Prior to initiation of data recording for both conditions, a 35 mm picture was taken of the participant's overall static body posture. A second picture of the participant's hand grasping the mouse, as if s/he was ready to begin using the mouse was taken also.

The Task

Before the initiation of the task and data collection, all participants were instructed to use the mouse as normally as possible in both testing conditions. The 15- to 20-minute task for each condition consisted of a timed 12-minute computer game of Solitaire and 5 to 8 minutes of custom designed mouse tasks developed by Interface Analysis Associates. Data was collected throughout all the task conditions.

The mouse tasks required the following cursor movements and mouse functions to perform:

1. Solitaire: This task involved vertical, horizontal, and diagonal cursor movements with point and click, point and double click, and click and drag functions throughout the screen.

2. Clicker: This task involved point and click mouse functions with cursor movements throughout the screen (see Appendix F).

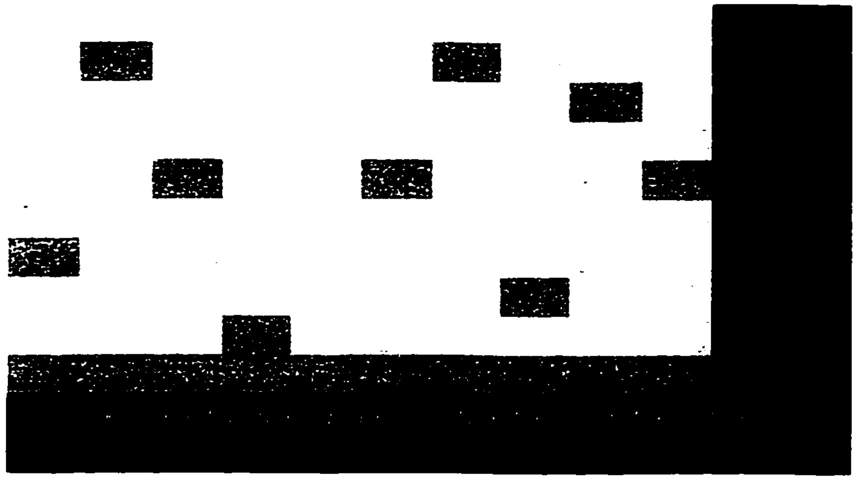

Figure 15. Mouse task clicker.

3. Dragster: This task involved point and click, vertical and diagonal click, and drag mouse functions with cursor movements ranging from the bottom of the screen to the upper half of the screen (see Appendix G).

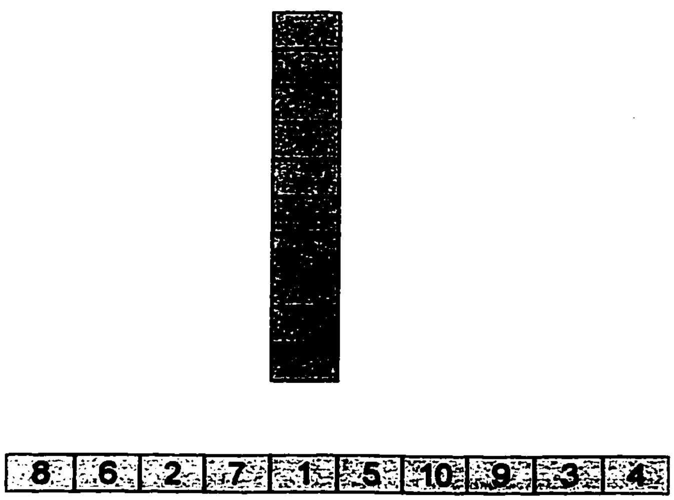

Figure 16. Mouse task dragster.

4. Scroller: This task involved point and click and click and drag mouse functions with the cursor movement in both vertical and horizontal directions, with scrolling on the right side of the screen (see Appendix H).

8	11	42	19	24	5	36	A	A	1	4	5	4	1	4	5
12	17	4	5	4	11	42	A	A	3	8	11	19	17	36	53
18	25	8	11	8	17	4	5	4	5	12	17	5	19	42	61
24	35	12	17	12	25	8	11	8	7	18	25	11	23	54	1
-13	0	18	25	18	35	12	17	12	11	24	35	17	31	36	17
36	53	24	35	24	0	18	25	18	13	30	0	25	18	42	19
12	61	30	0	-13	53	24	35	24	17	36	53	3	8	4	5
18	66	36	53	36	61	30	0	-13	19	42	61	5	12	8	11
24	70	42	61	42	66	36	53	36	23	54	1	36	53	36	17
-13	102	A	A	54	70	42	61	42	31	68	3	24	43	24	25
36	30	A	A	72	102	54	77	54	37	78	5	4	9	4	35
18	42	60	42	53	95	68	99	68	41	42	7	8	20	28	0
24	11	35	11	35	46	78	115	78	1	4	11	12	30	42	53
-13	23	11	23	-12	12	118	159	118	3	8	13	18	42	60	61
36	78	1	3	8	11	118	159	118	5	12	17	35	17	13	30
42	96	138	5	12	17	30	0	-13	7	18	19	0	19	17	36
54	24	11	7	18	25	36	53	36	11	24	23	13	5	19	42
68	-13	13	11	24	35	42	A	A	13	30	31	17	11	23	54
78	36	17	13	30	0	54	A	A	17	36	37	19	17	31	36

Figure 17. Mouse task scroller coaster.

5. Vertical Drag: This task involved point and click, vertical click and drag mouse functions, and cursor movements from the top of the screen down to the bottom of the screen (see Appendix I).

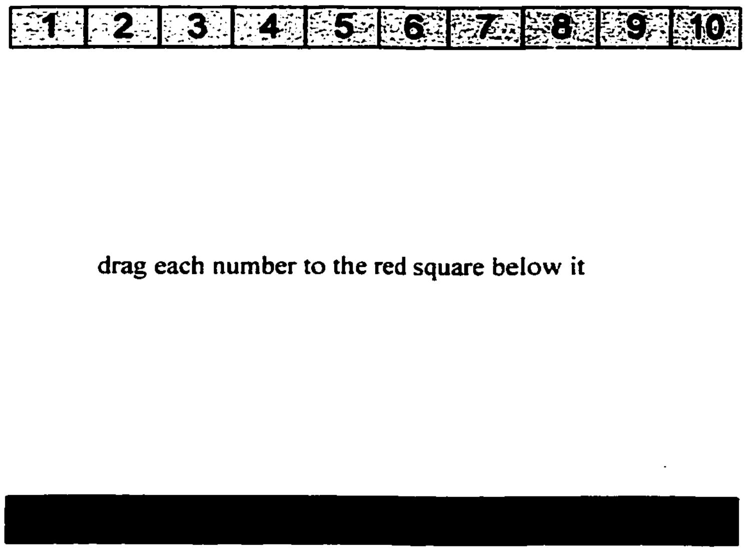

Figure 18. Mouse task vertical drag.

Both conditions were tested on the same day. Each participant was given a 5-minute break between the two testing conditions for recovery time. The order of testing conditions for support type (Gel-eez™ and SoftSpot®) was counterbalanced.

Table 1

Counterbalancing of Test Conditions for Support Type (SoftSpot® and Gel-eez™)

Users	SoftSpot®	Gel-eez™	Standard Mouse Pad
Experienced SoftSpot®			
Participant 1	Condition 1		Condition 2
Participant 2	Condition 2		Condition 1
Participant 3	Condition 1		Condition 2
Participant 4	Condition 2		Condition 1
Participant 5	Condition 1		Condition 2
Participant 6	Condition 2		Condition 1
Experienced Gel-eez™			
Participant 1		Condition 1	Condition 2
Participant 2		Condition 2	Condition 1
Participant 3		Condition 1	Condition 2
Participant 4		Condition 2	Condition 1
Participant 5		Condition 1	Condition 2
Participant 6		Condition 2	Condition 1
No Experience SoftSpot®			
Participant 1	Condition 2		Condition 1
Participant 2	Condition 1		Condition 2

(table continues)

Users	SoftSpot®	Gel-eez™	Standard Mouse Pad
Participant 3	Condition 2		Condition 1
No Experience Gel-eez™			
Participant 1		Condition 1	Condition 2
Participant 2		Condition 2	Condition 1
Participant 3		Condition 1	Condition 2

Post-Test Survey

A Post-Test Survey (see Appendix D) was provided to each participant at the end of the entire test procedure. Participants were asked to rate their mouse support relative to not using a mouse support on physiological and performance issues using a 7-point Likert scale. Finally, users were asked to define the best and worst features of their mouse support, and give suggestions for future improvements of the design of mouse supports.

CHAPTER 4

RESULTS

Analysis of Data for Wrist ROM

The range of motion measurements for wrist extension, flexion, ulnar deviation, and radial deviation was measured during computer mouse use. The percentage of time spent in predefined neutral and awkward posture zones was analyzed for all four test groups, in both testing conditions (support PRESENT and ABSENT). Awkward wrist postures are considered a risk factor for developing Upper Extremity Cumulative Trauma Disorders.

A mixed factors analysis of variance (ANOVA) with one within factor (support use) and two between factors (experience and support type) was used to test the dependent variable of wrist posture. Data were compiled for the following combined tasks: (a) static body posture, (b) Solitaire, (c) Clicker, (d) Dragster, (e) Scroller, and (f) Vertical Drag.

Statistical analyses conducted using the SPSS 10.0 software program for Microsoft Windows included analyses of the following factors: (a) support use (PRESENT and ABSENT), (b) support type (SoftSpot® and Gel-eez™) and (c) support experience (experience and no experience) for the following categories. An alpha level of .05 was used for all statistical tests.

1. Analysis of time spent in wrist extension: (a) neutral wrist extension 0° to 15°, (b) moderate wrist extension 15° to 30°, and (c) extreme wrist extension 30+°.

2. Analysis of time spent in wrist flexion: (a) neutral wrist flexion 0° to 20°, (b) moderate wrist flexion 20° to 40°, and (c) extreme wrist flexion 40+°.

3. Analysis of time spent in wrist ulnar deviation: (a) neutral wrist ulnar deviation 0° to 20° and (b) moderate wrist ulnar deviation 20+°.

4. Analysis of time spent in wrist radial deviation: (a) neutral wrist radial deviation 0° to 20° and (b) moderate wrist radial deviation 20+°.

5. Analysis of the interaction between the three factors: (a) support experience, (b) support use, and (c) support type for each category of ROM.

Wrist Extension

There was a significant main effect for Support Experience for postures in the neutral wrist extension range (0° to 15°), $F(1, 14) = 8.73$, $p < .05$. There was a significant collapsed over experience effect for the factor Support Experience, for the neutral wrist extension range (0° to 15°), $F(1, 14) = 8.73$, $p < .05$. The experienced participants of both the Gel-eez™ and the SoftSpot® spent significantly more time (M = 56.19 % time, SD = 30.47) in the 0° to 15° range than the non-experienced support users (M = 18.15% time, SD = 22.69), whether they were using the support or not.

No other interactions or main effects were revealed for the neutral wrist extension range (0° to 15°).

No statistically significant findings were revealed for any of the main effects or interactions for the moderate wrist extension (15° to 30°). When comparing the PRESENT support condition, the experienced and non-experienced SoftSpot® users spent 34% and 13% (respectively) of the time in moderate wrist extension (15° to 30°)

postures. The experienced and non-experienced Gel-eez™ users spent 24% and 31% (respectively) of the time in moderate wrist extension (15° to 30°) postures. It should be noted that the non-experienced Gel-eez™ users spent more time in the moderate wrist extension category than either the neutral (0° to 15°) or extreme (30+°) category. When comparing the ABSENT support condition, the experienced and non-experienced SoftSpot® users spent 30% and 15% of the time (respectively) in moderate wrist extension (15° to 30°) postures. The experienced and non-experienced Gel-eez™ users spent 35% and 11% of the time (respectively) in moderate wrist extension (15° to 30°) postures.

No statistically significant findings were revealed for any of the main effects or interactions for the extreme wrist extension (30+°) category. When comparing the PRESENT support condition, the experienced and non-experienced SoftSpot® users spent 1% and 0% (respectively) of the time in extreme wrist extension (30+°) postures. The experienced and non-experienced Gel-eez™ users spent 1% and 2% (respectively) of the time in extreme wrist extension (30+°) postures. When comparing the ABSENT support condition, the experienced and non-experienced SoftSpot® users spent 8% and 0% of the time (respectively) in extreme wrist extension (30+°) postures. The experienced and non-experienced Gel-eez™ users spent 7% and 23% of the time (respectively) in extreme wrist extension (30+°) postures. It should be noted that the non-experienced Gel-eez™ users spent more time in the extreme wrist extension category than either the neutral or moderate category.

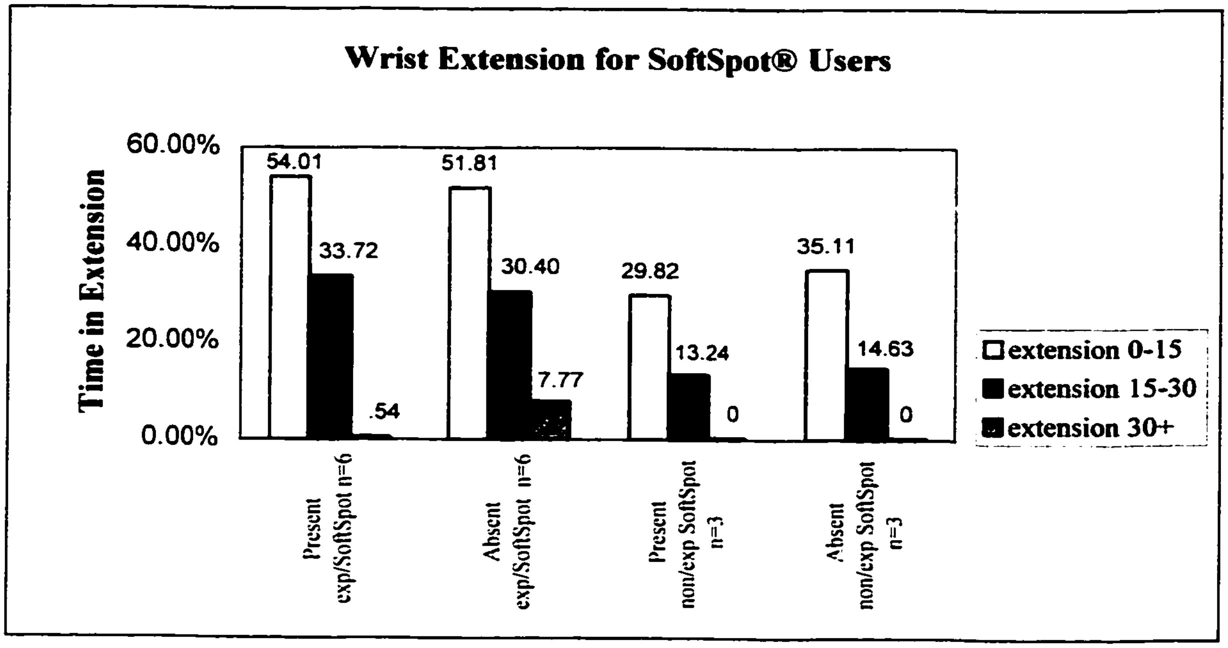

Figure 19. Percentage of time spent in wrist extension for SoftSpot® users.

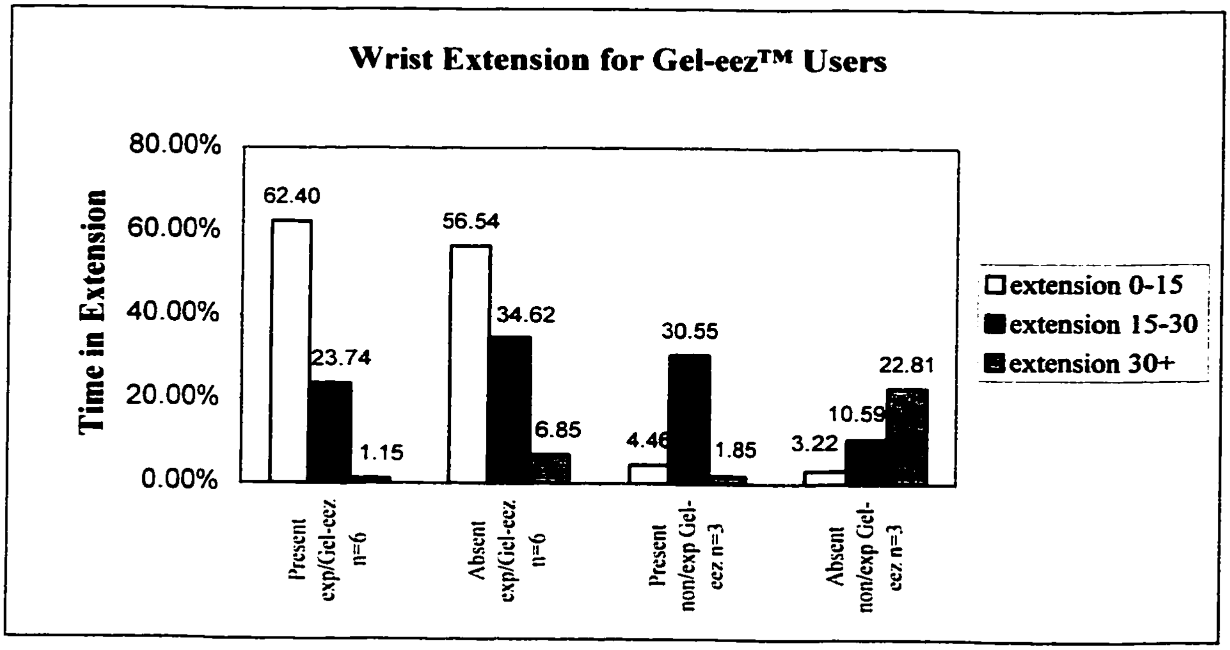

Figure 20. Percentage of time spent in wrist extension for Gel-eez™ users.

Wrist Flexion

There was a significant main effect for Support Experience, for postures in the neutral wrist flexion range (0° to 15°), $F(1, 14) = 8.73$, $p < .05$. The collapsed experience there was a significant effect for the factor Support Experience, for the neutral wrist extension range (0° to 15°), $F(1, 14) = 8.73$, $p < .05$. The experienced participants of both the Gel-eez™ and the SoftSpot® spent significantly more time ($M = 56.19$, $SD = 30.47$) in the 0° to 15° range than the non-experienced support users ($M = 18.15$, $SD = 22.69$), whether using the support or not during the study.

No statistically significant findings were revealed for main effects or interactions for the moderate wrist flexion range (20° to 40°), or the extreme wrist flexion (40+°) range. All four groups spent less than 1% of the time in the moderate wrist flexion range (20° to 40°), and no time in the extreme wrist flexion range (40+°) for the PRESENT and ABSENT support conditions.

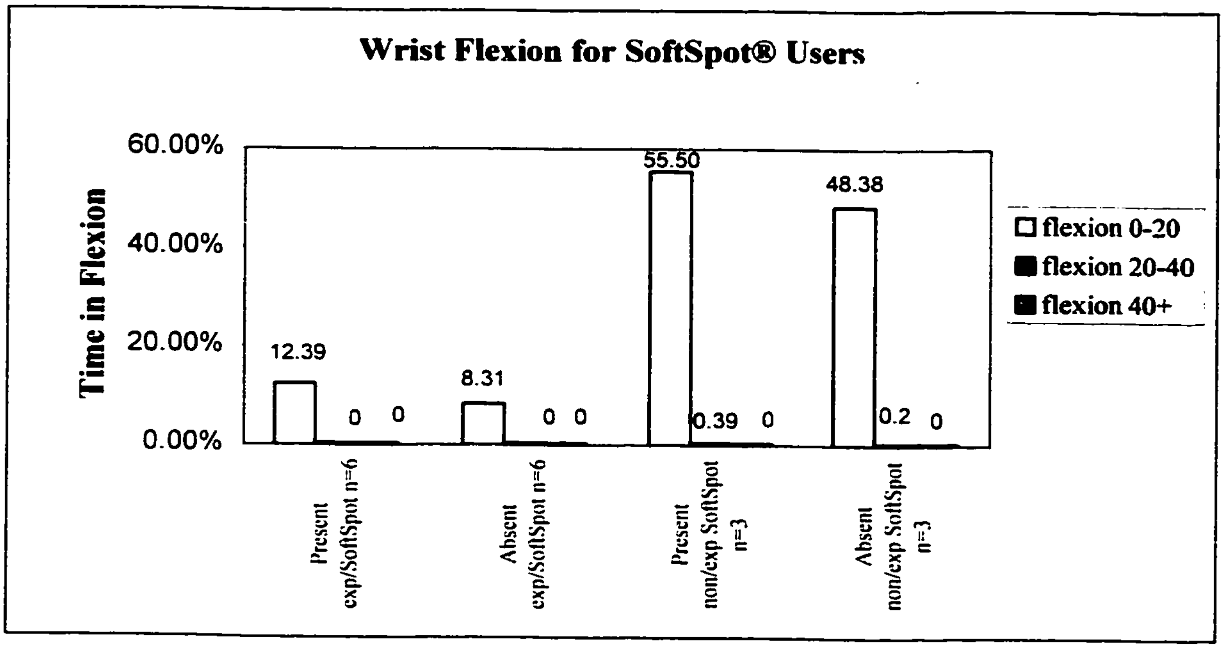

Figure 21. Percentage of time spent in wrist flexion for SoftSpot® users.

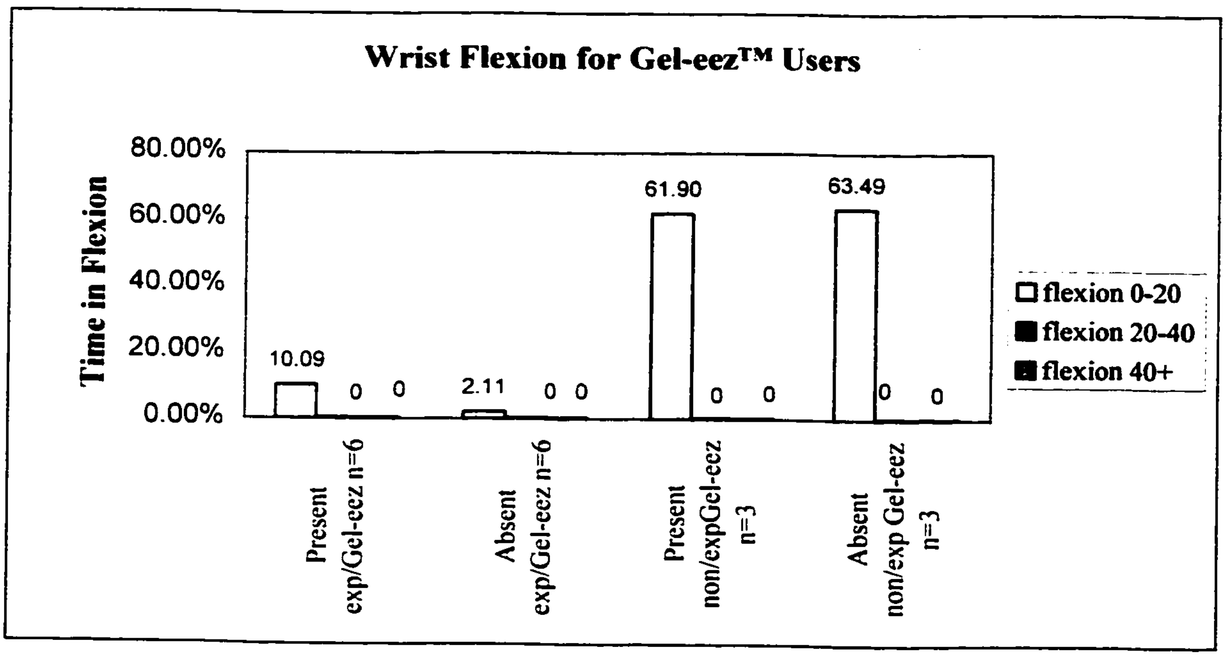

Figure 22. Percentage of time spent in wrist flexion for Gel-eez™ users.

Wrist Ulnar Deviation

There was a statistically significant main effect for Support Use for time spent in neutral wrist ulnar deviation (0° to 20°), $\underline{F}(1, 14) = 15.54$, $p < .05$. All participants (Gel-eez™ or SoftSpot® users) spent a higher percentage of time in neutral wrist ulnar deviation postures with the support PRESENT ($\underline{M}$ = 63.48 % time), compared to when the support was ABSENT ($\underline{M}$ = 27.15 % time).

The experienced and the non-experienced SoftSpot® users spent 59% and 71% (respectively) of the time in a neutral wrist ulnar deviation posture (0° to 20°), when the support was PRESENT, compared to 23% and 32% (respectively) when the support was ABSENT. The experienced and the non-experienced Gel-eez™ users spent 83% and 26% (respectively) of the time in a neutral wrist ulnar deviation postures (0° to 20°), when the support was PRESENT, compared to 41% and 3% (respectively) when the support was ABSENT.

No statistically significant findings were revealed for the interaction effects for time spent in neutral wrist ulnar deviation (0° to 20°). However, close inspection of the data revealed that the interaction between Support Type and Experience was marginally significant, $\underline{F}(1, 14) = 3.75$, $p < .07$. The plot of this crossover interaction, shown in Figure 23, reveals that the experienced group spent more time ($\underline{M}$ = 62.0 % time) in neutral wrist ulnar deviation postures (0° to 20°) than the non-experienced (collapsed) group ($\underline{M}$ = 14.2 % time) when using the Gel-eez™ support, but that the non-experienced group spent more time ($\underline{M}$ = 51.7 % time) in neutral wrist ulnar deviation postures (0° to 20°) than the experienced group ($\underline{M}$ = 41.6 % time) when using the Softspot® support.

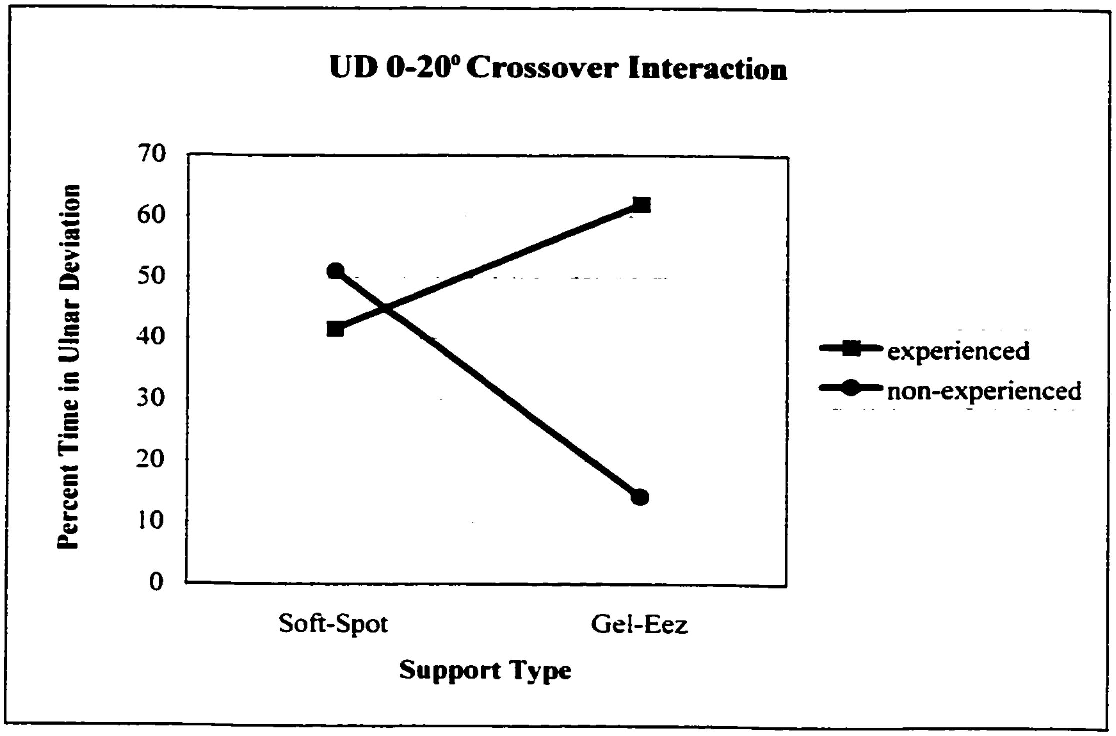

Figure 23. Crossover interaction of ulnar deviation 0° to 20°.

There was a significant Support Use main effect for the moderate wrist ulnar deviation range (20+°), $F(1, 14) = 15.01$, $p < .02$. It was found that all participants spent significantly more time in the 20°+ range when the support was ABSENT (M = 71.70% time, SD = 34.77) than when the support was PRESENT (M = 34.93 % time, SD = 38.50).

The experienced and the non-experienced SoftSpot® users spent 74% and 68% (respectively) of the time in a moderate wrist ulnar deviation posture (20+°), when the support was ABSENT, compared to 40% and 25% (respectively) when the support was PRESENT. The experienced and the non-experienced Gel-eez™ users spent 59% and 97% (respectively) of the time in a moderate wrist ulnar deviation postures (20+°), when the support was ABSENT, compared to 16% and 72% (respectively) when the support was PRESENT.

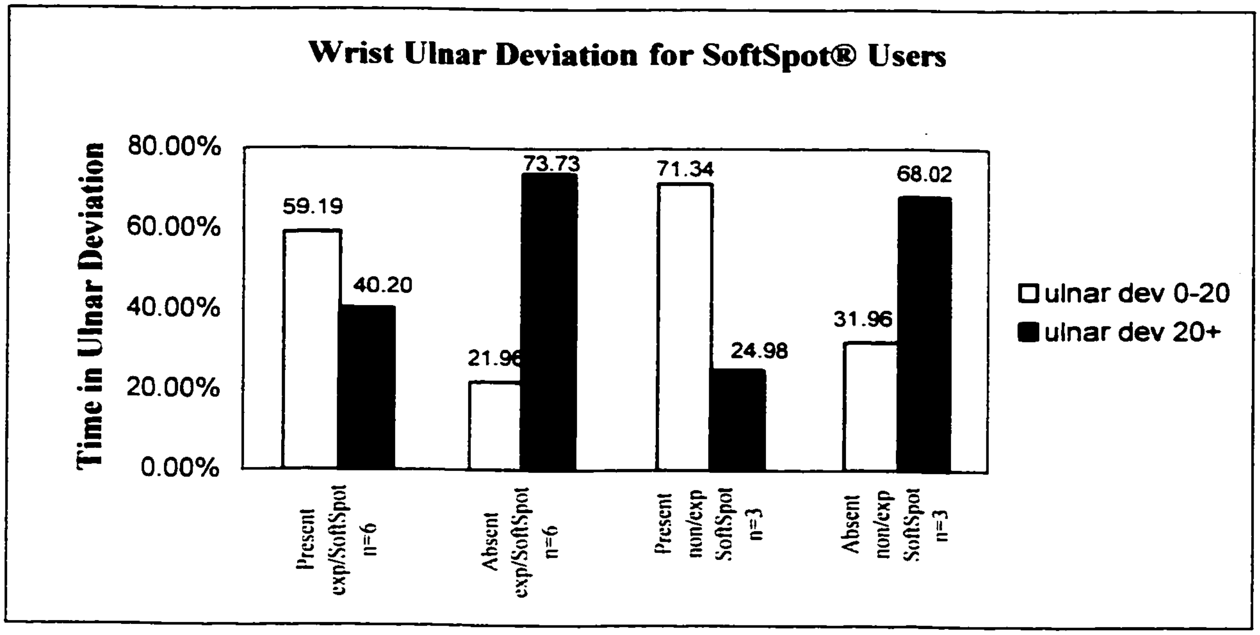

Figure 24. Percentage of time spent in wrist ulnar deviation for SoftSpot® users.

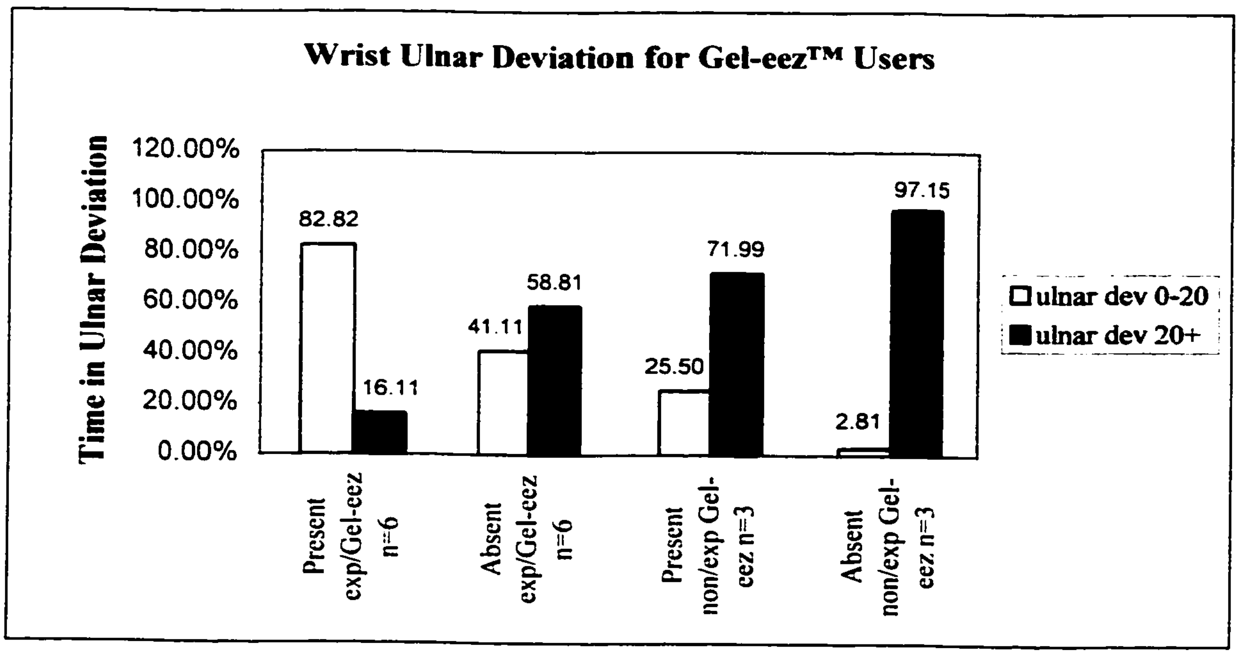

Figure 25. Percentage of time spent in wrist ulnar deviation for Gel-eez™ users.

Wrist Radial Deviation

No statistically significant findings were revealed for any of the main effects or interactions for time spent in neutral (0° to 20°) or moderate (20+°) wrist radial deviation ranges for the factors Support Use, Support Type, and Support Experience. All four groups spent less than 4% of the time in the neutral wrist radial deviation range (0° to 20°) and no time in the moderate radial deviation range (40+°), for the PRESENT and ABSENT support conditions.

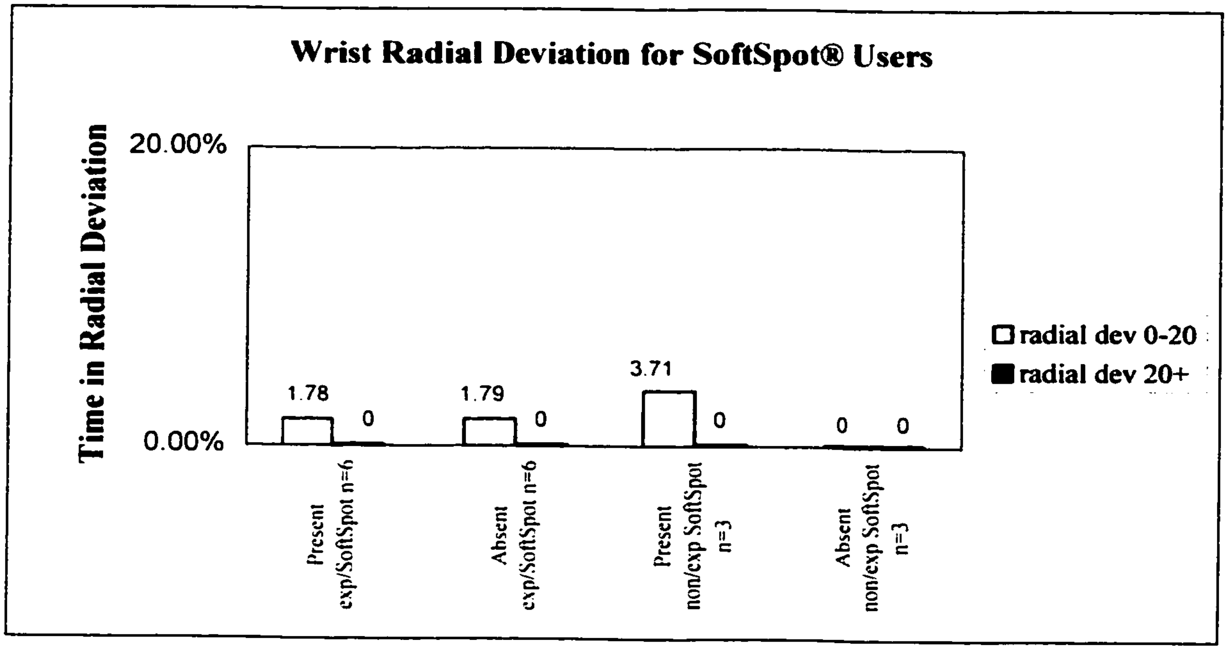

Figure 26. Percentage of time spent in wrist radial deviation for SoftSpot® users.

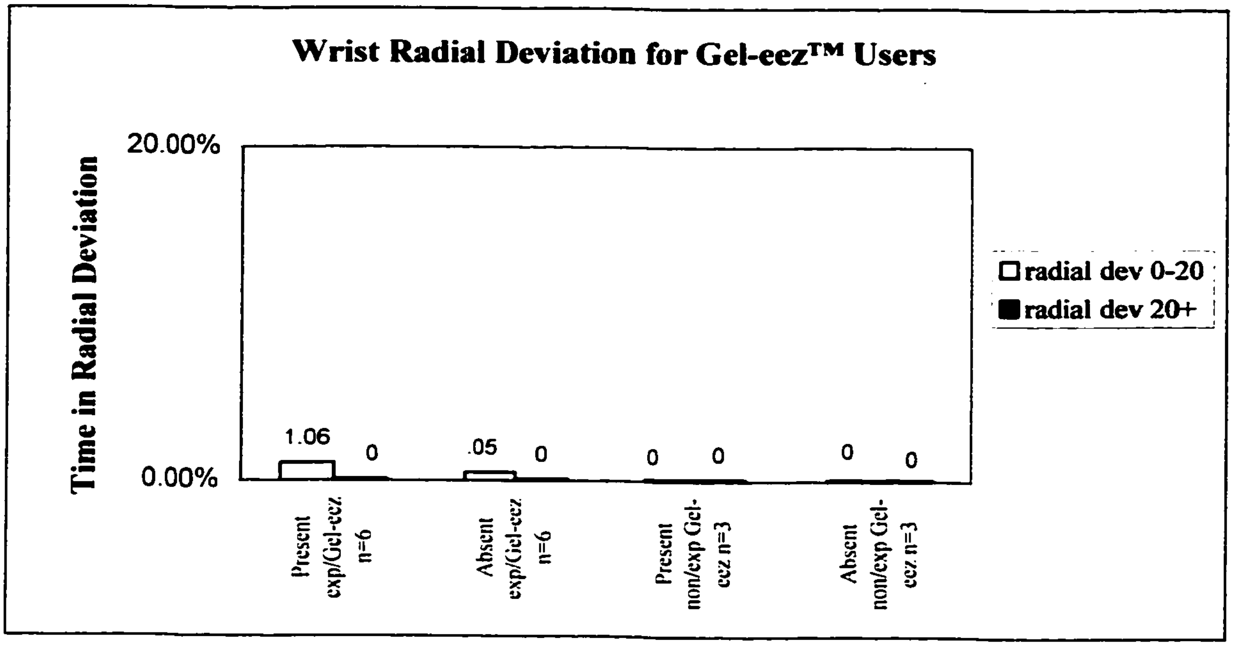

Figure 27. Percentage of time spent in wrist radial deviation for Gel-eez™ users.

Analysis of Data for Points of Contact

Points of contact of the right upper extremity included (a) the volar wrist, (b) the distal forearm, (c) the mid forearm, (d) the proximal forearm, and (e) the elbow. The number of points of contact for each participant was analyzed using descriptive statistics for Support Use (PRESENT and ABSENT), Support Type (SoftSpot® and Gel-eez™), and Support Experience (experienced and non-experienced users). There were 5 possible points for each participant during the five computer tasks, combined to make one representative number for each category of point of contact.

Points of contact at the elbow and volar wrist are considered risk factors for developing Repetitive Strain Injuries, as these structures are more vulnerable to the injurious effects of contact stress as reported by Armstrong et al. (1995).

In the support PRESENT or ABSENT conditions, all of the experienced SoftSpot® (Group 1, n = 6) users, 30 out of 30 possible (100%), demonstrated volar wrist and distal forearm points of contact, and 10 out of 30 (33%) elbow points of contact were observed during both test conditions. During the PRESENT condition, 13 out of 30 (43%) mid-forearm points of contact were observed on the Softspot® wrist support. This is in comparison to the ABSENT condition where there were no mid-forearm points of contact.

Table 2

Summary of Individual Points of Contact for Each Group, Support PRESENT and ABSENT

	Support Present				Support Absent			
	Exp/ SoftSpot® n = 6	No Exp/ SoftSpot® n = 3	Exp/ Gel-eez™ n = 6	No Exp/ Gel-eez™ n = 3	Exp/ SoftSpot® n = 6	No Exp/ SoftSpot® n = 3	Exp/ Gel-eez™ n = 6	No Exp/ Geleez™ n = 3
Volar Wrist	30/30	13/15	30/30	13/15	30/30	15/15	28/30	15/15
Distal Forearm	30/30	12/15	29/30	10/15	29/30	3/15	18/30	10/15
Mid-Forearm	13/30	2/15	5/30	2/15	0/30	5/15	5/30	7/15
Proximal Forearm	2/30	1/15	3/30	6/15	1/30	8/15	6/30	7/15
Elbow	10/30	1/15	5/30	4/15	10/30	8/15	5/30	2/15
Total	85/150	30/75	72/150	35/75	70/150	41/75	62/150	41/75

Note. Scores equal the number of points of contact for each segment of the wrist and arm, out of the total possible.

Similarly, when calculating individual points of contact for the non-experienced SoftSpot® users (Group 3, n = 3), there was a greater number of distal forearm points of contact, 12 out of 15 (80%), when the support was PRESENT, as compared to the ABSENT condition where 3 out of 15 (20%) distal forearm points of contact were observed. For both proximal forearm and elbow, there was a greater number of points of contact observed, 8 out of 15 (53%), when the support was ABSENT, as compared to when the support was PRESENT, where 1 out of 15 (6%) proximal forearm and elbow points of contact were observed.

For the experienced Gel-eez™ (Group 2, n = 6) wrist rest users, 30 out of 30 (100%) volar wrist points of contact were observed when the support was PRESENT or ABSENT. Fewer elbow points of contact were observed, 5 out of 30 (17%), during both test conditions. The only difference between the two test conditions was the greater number of distal forearm points of contact, 29 out of 30 (97%), when the Gel-eez™ support was PRESENT, as compared to the ABSENT condition where 18 out of 30 (60%) distal forearm points of contact were observed.

For the non-experienced Gel-eez™ wrist support users (Group 4, n = 3), 15 out of 15 (100%) volar wrist points of contact were observed when the support was PRESENT or ABSENT. Fewer elbow points of contact, 4 out of 15 (26%), were observed when the support was PRESENT, and only 2 out of 15 (13%) elbow points of contact were observed when the support was ABSENT. There were no other differences between test conditions.

In summary, when analyzing the categories of total points of contact for each participant for the factors, Support Use, Support Type, and Support Experience, there was a greater number of total points of contact in the PRESENT condition for experienced SoftSpot® and Gel-eez™ users. Non-experienced SoftSpot® and Gel-eez™ users had a greater number of total points of contact in the ABSENT condition (see Table 3).

When analyzing specific areas of potential risk, frequency of contact stress at the volar wrist was predominant, greater than 87% in both the PRESENT and ABSENT conditions (see Table 2) for both Support Type and Support Experience factors. This demonstrates a greater risk for volar wrist contact stress whether using a mouse support or not, regardless of experience. When analyzing frequency of contact stress at the distal forearm for Support Type and Support Experience factors, all groups were observed to have distal forearm contact greater than 67% when the support was PRESENT. There were slightly fewer (> 60%) points of contact at the distal forearm when the support was ABSENT, for the experienced SoftSpot® users and all Gel-eez™ users. Only the non-experienced SoftSpot® users demonstrated minimal contact stress (20%) when the support was ABSENT. This demonstrates a greater risk for distal forearm contact stress when a mouse support is PRESENT, regardless of experience. It also demonstrates a greater risk of distal forearm contact stress when a mouse support is ABSENT for all groups except the non-experienced SoftSpot® users.

The frequency of elbow contact was less than 33% for the PRESENT and ABSENT conditions for experienced SoftSpot® and Gel-eez™ users and non-experienced Gel-eez™ users. This demonstrates a low risk for contact stress at the elbow for these groups, whether using a mouse support or not. In contrast, the non-experienced SoftSpot® users demonstrated 8 out of 15 (53%) points of contact at the elbow for the ABSENT condition, compared to 2 out of 15 (13%) points of contact for the PRESENT condition. This demonstrates a higher risk for contact stress at the elbow for the non-experienced SoftSpot® users when not using a mouse support, and lower risk of elbow contact stress when using a SoftSpot® support.

Table 3

Summary of Total Points of Contact for Each Group, Support PRESENT and ABSENT

Users	Support Present	Support Absent	Total
Experienced SoftSpot®	85/150	70/150	155/300
Non-Exp/SoftSpot®	30/75	41/75	71/150
Experienced Gel-eez™	72/150	62/150	134/300
Non-Exp/Gel-eez™	35/75	41/75	76/150
Total	222/450	214/450	436/900

Note. Scores equal the number of points of contact out of the total possible.

Analysis of Data for Grip and Pinch

The four possible pinch and grip styles included (a) thumb-finger palm grip, (b) thumb and two-finger grip, (c) thumb-fingertip enclosure, and (d) finger-palm enclosure. The number of times a participant assumed one of the four predetermined types of pinch or grip was calculated for each participant in the four groups, in the two test conditions. There were 5 possible points for each participant during the five computer tasks. Pinch and grip data was analyzed using descriptive statistics for Support Use (PRESENT and ABSENT), Support Type (SoftSpot® and Gel-eez™), and Support Experience (experienced and non-experienced users).

Table 4

Summary of Grip and Pinch Styles for Each Group, Support PRESENT and Support ABSENT

	Support Present				Support Absent			
	Exp/ SoftSpot®	No Exp/ SoftSpot®	Exp/ Gel-eez™	No Exp/ Gel-eez™	Exp/ SoftSpot®	No Exp/ SoftSpot®	Exp/ Gel-eez™	No Exp/ Geleez™
Thumb/Finger Palm	0/30	0/15	0/30	0/15	0/30	0/15	0/30	0/15
Thumb/Two-Finger	0/30	0/15	0/30	0/15	0/30	0/15	0/30	0/15
Thumb/Fingertips Enclosure	20/30	15/15	26/30	10/15	4/30	10/15	14/30	8/15
Finger-Palm Enclosure	10/30	0/15	4/30	5/15	26/30	5/15	16/30	7/15
Total	30	15	30	15	30	15	30	15

Note. Scores equal the number of times a type of grip or pinch was assumed, out of a total possible.

None of the participants demonstrated the thumb-finger palm grip or the thumb and two-finger grip, during the PRESENT or ABSENT test conditions.

The experienced Softspot® users (Group 1, n = 6) demonstrated a greater number of thumb-fingertips enclosure type grips, 20 out of 30 possible (67%), for the support PRESENT condition, and fewer when the support was ABSENT, 4 out of 30 (13%). There was a transition in grip and pinch styles with the support ABSENT. There were a greater number of finger-palm enclosure type grips, 26 out of 30 (87%), and fewer thumb-fingertips enclosure type grips, 10 out of 30 (33%).

The non-experienced SoftSpot® users (Group 3, n = 3) all demonstrated a thumb-fingertips enclosure type grip, 15 out of 15 (100%) with the support PRESENT. There were slightly fewer when the Softspot® was ABSENT, 10 out of 15 (67%), and 5 out of 15 (33%) finger-palm enclosure type grips.

The experienced Gel-eez™ users (Group 2, n= 6) also demonstrated a greater number of thumb-fingertips enclosure type grips. 26 out of 30 (87%), for the support PRESENT condition, and 14 out of 30 (47%), when the support was ABSENT. Again there was a transition in grip and pinch styles with the support ABSENT. There were a greater number of finger-palm enclosure type grips, 16 out of 30 (53%), and fewer thumb-fingertips enclosure type grips, 4 out of 30 (13%).

The non-experienced Gel-eez™ users (Group 4, n = 3) demonstrated minimal difference in the type of pinch and grip for either the PRESENT or ABSENT conditions. Ten out of 15 (66%) demonstrated thumb finger-tips enclosure type grips, compared to 8 out of 15 (53%), when the support was ABSENT. When the support was PRESENT, 5 out of 15 (33%) used a finger palm enclosure type grip, compared to 7 out of 15 (47%), when the support was ABSENT.

In summary, when analyzing the four grip and pinch styles for each participant for the factors Support Use, Support Type, and Support Experience, the predominance of the thumb fingertips enclosure type grip emerged (79% across all groups) for the support PRESENT condition. Only the experienced support users (SoftSpot® and Gel-eez™) demonstrated a clear transition in grip and pinch style, from a thumb fingertips enclosure when the support was PRESENT, to a finger-palm enclosure when the support was ABSENT. When the support was ABSENT, there was more variability in grip and pinch styles for the non-experienced users (see Table 4).

Analysis of Subjective Data Regarding Perceived Benefits From Using a Mouse Support Relative to Not Using a Mouse Support

Post-test subjective ratings were collected from all 18 participants on the perceived benefits from the use of the Gel-eez™ or SoftSpot® mouse supports PRESENT, relative to the mouse support ABSENT. Physiological and performance factors of (a) comfort, (b) fatigue, (c) accuracy and precision, (d) speed, and (e) pressure on the wrist were queried using a 7-point Likert scale. Ratings were categorized from much worse (1) to much better (7). Subjective data were analyzed using descriptive statistics for Support Use (PRESENT and ABSENT), Support Type (SoftSpot® and Gel-eez™), and Support Experience (experienced and non-experienced users). A score of 5 to 7 indicated much better, a score of 4 indicated no real differences, and a score of 1 to 3 indicated much worse in subjective ratings for the use of a support PRESENT relative to the use of the support ABSENT.

Table 5

Raw Data of Frequency Distribution of Subjective Ratings for Experienced SoftSpot® Users, n = 6

	Worse 1	2	3	4	5	6	Better 7	Weighted Average
Comfort				1	1	4		5.5
Fatigue			1	1	3	1		4.5
Accuracy				4	1	1		4.5
Speed		1		3	1	1		4.1
Pressure		1		1	2	1	1	4.8

Table 6

Raw Data of Frequency Distribution of Subjective Ratings for Non-Experienced SoftSpot® Users, n = 3

	Worse 1	2	3	4	5	6	Better 7	Weighted Average
Comfort	1	1					1	3.3
Fatigue	1				2			3.6
Accuracy			2	1				3.3
Speed		1	1	1				3.0
Pressure	1		1				1	3.6

Table 7

Raw Data of Frequency Distribution of Subjective Ratings for Experienced Gel-eez™ Users, n = 6

	Worse 1	2	3	4	5	6	Better 7	Weighted Average
Comfort					3	2	1	5.6
Fatigue				2	1	2	1	5.3
Accuracy				3	3			4.5
Speed				3	2	1		4.6
Pressure					2	3	1	5.8

Table 8

Raw Data of Frequency Distribution of Subjective Ratings for Non-Experienced Gel-eez™ Users, n = 3

	Worse 1	2	3	4	5	6	Better 7	Weighted Average
Comfort				1	1	1		5.0
Fatigue				1	1	1		5.0
Accuracy				2	1			4.3
Speed				3				4.0
Pressure				1	1	1		5.0

Comfort

Experienced Softspot® users ($\underline{M}$ = 5.5), experienced Gel-eez™ users ($\underline{M}$ = 5.6), and non-experienced Gel-eez™ users ($\underline{M}$ = 5.0) all reported much better comfort levels from the use of mouse supports. The non-experienced Softspot® users reported much worse comfort levels ($\underline{M}$ = 3.3).

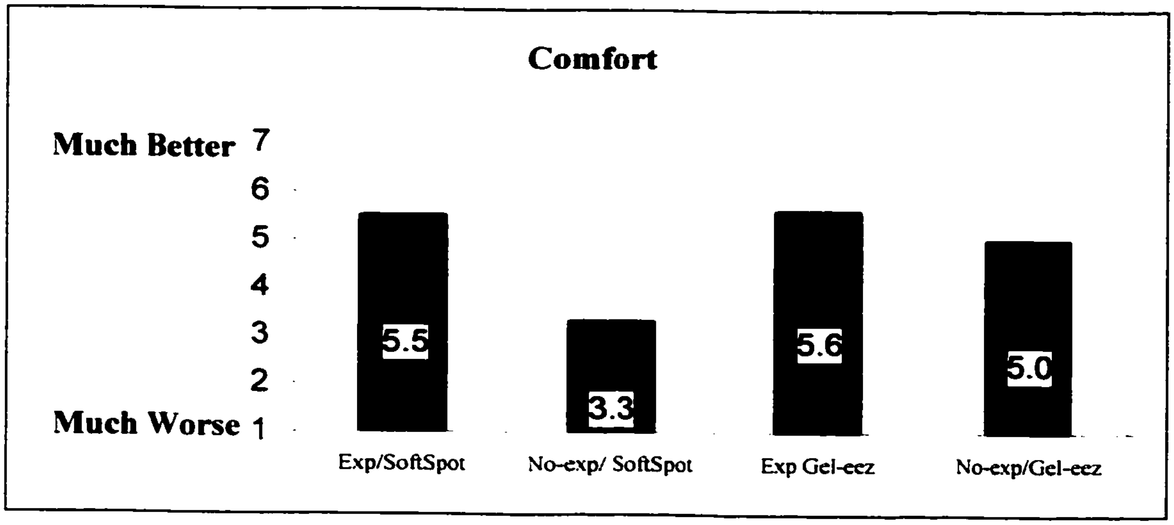

Figure 28. Mean subjective ratings for comfort with a mouse support PRESENT relative to the mouse support ABSENT.

Fatigue

Experienced Gel-eez™ users (M = 5.3) and non-experienced Gel-eez™ users reported reduced levels of fatigue from the mouse support (M = 5.0). Experienced Softspot® users (M = 4.5). reported the same level of fatigue with the use of a mouse support relative to not using a mouse support. The non-experienced Softspot® users reported much worse fatigue levels (M = 3.6).

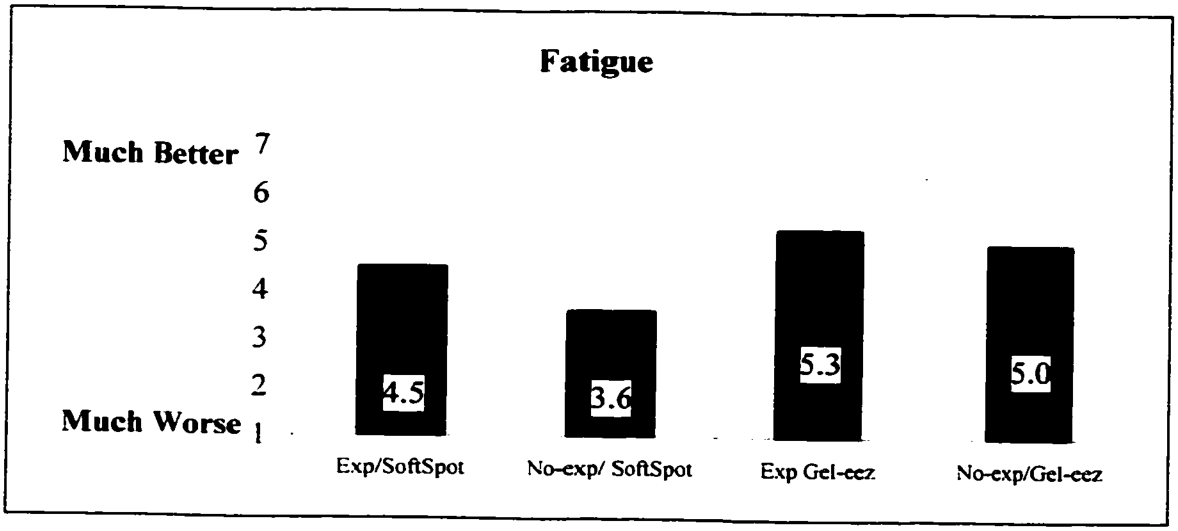

Figure 29. Mean subjective ratings for fatigue with a mouse support PRESENT relative to the mouse support ABSENT.

Accuracy

Experienced Softspot® users (M = 4.5), experienced Gel-eez™ users (M = 4.5), and non-experienced Gel-eez™ users (M = 4.3) reported no difference in accuracy from the use of a mouse support relative to not using a mouse support. The non-experienced Softspot® users reported much worse accuracy (M = 3.3).

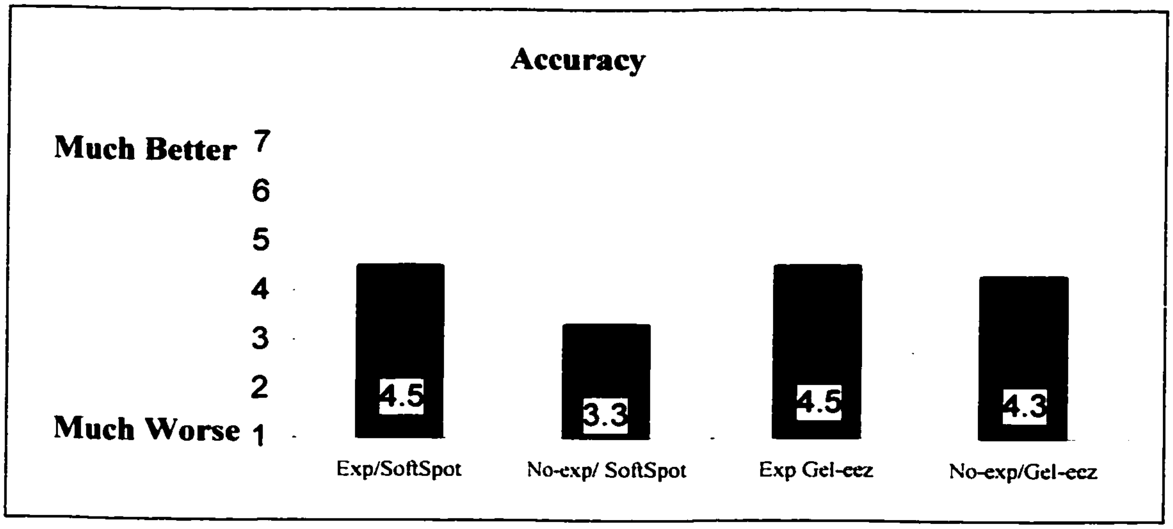

Figure 30. Mean subjective ratings for accuracy with a mouse support PRESENT relative to the mouse support ABSENT.

Speed

The experienced Softspot® users (M = 4.1), experienced Gel-eez™ users (M = 4.6), and the non-experienced Gel-eez™ users (M = 4.0) reported no difference in speed with the use of a mouse support relative to not using a mouse support. The non-experienced Softspot® users reported much worse speed (M = 3.0) with the use of a mouse support relative to not using a mouse support.

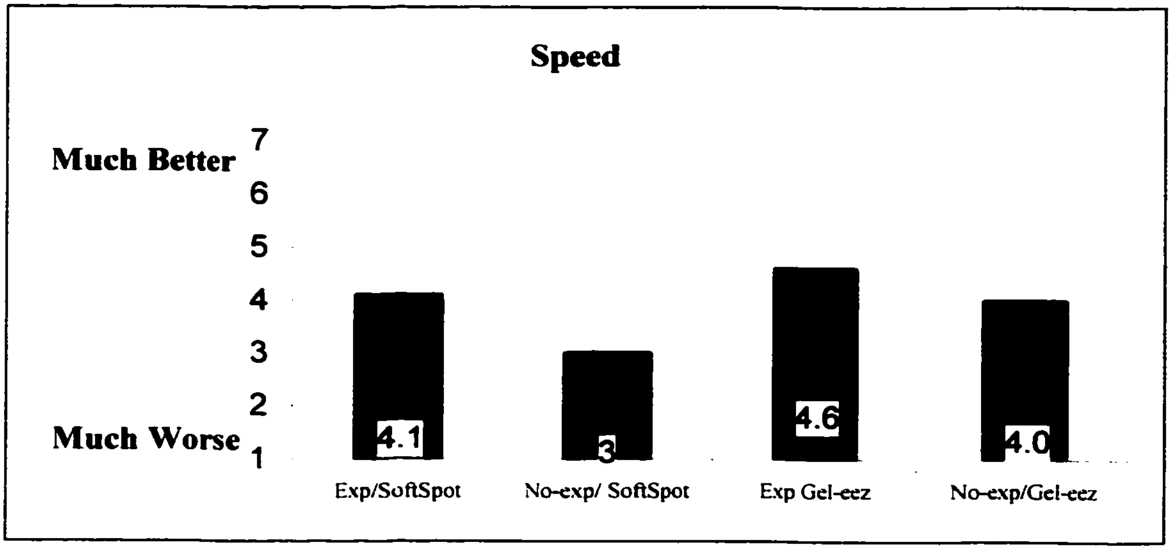

Figure 31. Mean subjective ratings for speed with a mouse support PRESENT relative to the mouse support ABSENT.

Pressure

The experienced Gel-eez™ users (M = 5.8) and the non-experienced Gel-eez™ users (M = 5.0) reported much reduced pressure when using a mouse support relative to not using a mouse support. The experienced Softspot® users (M = 4.8) reported no difference in pressure with the use of a mouse support relative to not using a mouse support. The non-experienced Softspot® users reported much worse pressure (M = 3.6).

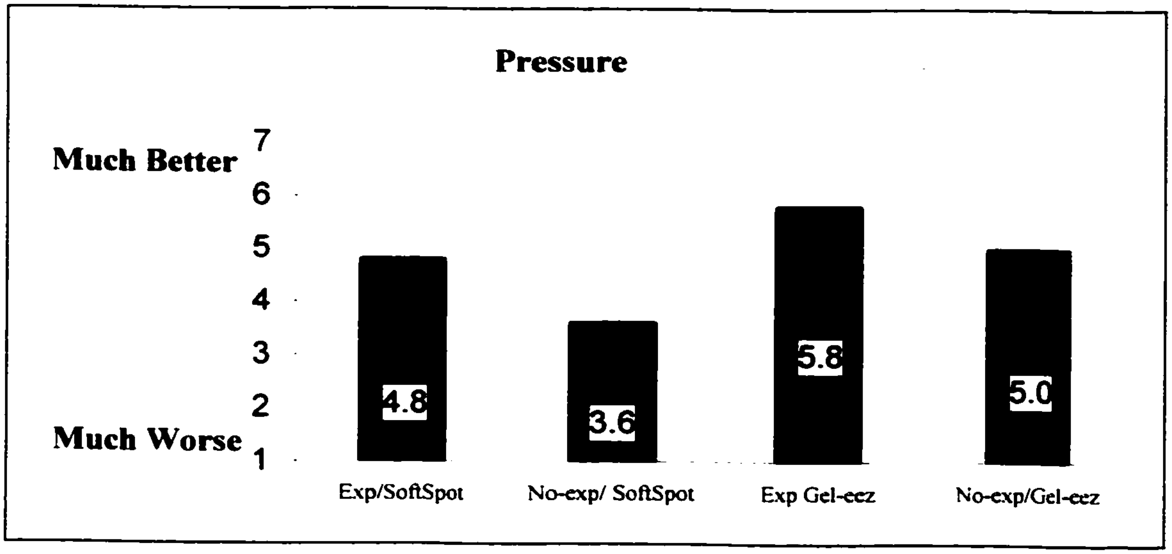

Figure 32. Mean subjective ratings for pressure with a mouse support PRESENT relative to the support ABSENT.

In summary, when analyzing subjective ratings for the factors Support Use, Support Type, and Support Experience, the experienced Softspot® users' mean scores suggest perceived improvement in the area of comfort only with the use of a mouse support relative to not using a support. The non-experienced Softspot® users' mean scores suggest the users found the use of the support to be much worse for comfort, fatigue, accuracy, speed, and pressure, relative to not using a support. Both experienced and non-experienced Gel-eez™ users' mean scores suggest perceived improvement in areas of comfort, fatigue, and pressure with the use of a mouse support relative to not using a mouse support.

Mouse Support Design Recommendations

Finally, some questions were posed to the 12 experienced Gel-eez™ and Softspot® mouse support users to explore participant recommendations for changes in the design of the mouse wrist supports.

Best Features of the SoftSpot® Mouse Support

When asked what were the BEST features of the mouse support, SoftSpot® users responded with:

1. It is comfortable. x3

2. It is colorful.

3. The pad is soft. x3

4. It has a smooth surface.

Gel-eez™ users responded with:

1. The gel support prevents my wrist from "dipping," and it provides great support.

2. It is comfortable because it conforms, is malleable, and can be heated or cooled.

3. It has a soft contour in a resting position.

4. It is flexible, and a feeling of squishiness. x2

Worst Features of the SoftSpot® Mouse Support

When asked what were the WORST features of the mouse support, SoftSpot® users responded with:

1. It is a bit too high and too large for my arm.

2. I need to tilt my hand to move the mouse.

3. The mouse pad is too short.

4. It takes up a lot of room on the desk.

Gel-eez™ users responded with:

1. The support is too narrow, and as it gets old, the gel congeals.

2. The support gets dirty easily.

3. The gel occasionally is not supportive enough.

Met Expectations

When asked if the mouse support did what it was expected it to do, Soft Spot® users responded with:

1. Yes, by all six participants.

Further explanation of the question yielded the following comment:

1. The support provided wrist support and was comfortable to use.

Gel-eez™ users responded with:

1. Yes, by all six participants.

Further explanation of the question yielded the following comments:

1. The mouse support makes one feel less fatigued after long hours at the computer.

2. It reduces fatigue and improves comfort.

3. It reduces strain on my wrists.

4. I expected mild relief in my wrists.

5. It allows the mouse to move more fluidly.

Suggested Improvements

When asked how would you improve the mouse support if you could, Soft-Spot® users responded with:

1. Make it smaller, not so wide.

2. Make it with a softer pad, of Jell-O-like quality.

3. Make it a little wider.

Gel-eez™ users responded with:

1. Make it wider and make one for the trackball too.

2. Make the inflation adjustable.

3. Keep it from sliding around.

4. Use firmer gel.

5. Make smaller sizes for different work surfaces.

CHAPTER 5

DISCUSSION AND CONCLUSIONS

Only one study to date, by Damann and Kroemer (1995), researched the effects of a mouse wrist support on wrist posture during mouse function. From the literature, one can assume that the recommendations that apply to the keyboard regarding wrist supports also apply to the mouse. The mouse wrist supports available to the consumer vary in their design and function. There has been no research to date about the design needs from the mouse support user's perspective.

The objective of this study was to (a) identify commonly used mouse wrist supports and document the benefits as stated by the manufacturers' claims; (b) observe and quantify wrist postures while using two common mouse supports (the SoftSpot® and Gel-eez™); (c) compare the objective data and subjective reports of the tested SoftSpot® and Gel-eez™ mouse wrist supports with the manufacturer's claim; and (d) provide design guidelines regarding how the wrist can be supported during computer mouse function.

The study was a three-factor mixed design. The with-in subjects' independent variable was use of a mouse wrist support, PRESENT or ABSENT. The between-subjects' independent variables were type of mouse wrist support (Gel-eez™ vs. SoftSpot®) and mouse rest experience (experienced vs. non-experienced). It was hypothesized that:

1. Based on Damann and Kroemer's (1995) study, there will be a significant difference in wrist ROM (percentage of time spent in neutral wrist postures) for the factors Support

Use (PRESENT or ABSENT). Use of mouse wrist supports will produce a greater percentage of time spent in neutral wrist postures. There will be no significant difference in wrist ROM for the factors Support Type (Gel-eez™ vs. SoftSpot®) and Support Experience (experienced vs. non-experienced).

2. There will be no significant difference in points of contact of the upper extremity during mouse use for the factors Support Use (PRESENT or ABSENT), Support Type (Gel-eez™ vs. SoftSpot®), and Support Experience (experienced vs. non-experienced).

3. There will be no significant difference in grip or pinch style for the factors Support Use (PRESENT or ABSENT), Support Type (Gel-eez™ vs. SoftSpot®), and Support Experience (experienced vs. non-experienced).

4. There will be no significant difference in subjective responses pertaining to comfort, fatigue, accuracy, speed, and pressure with the use of a mouse support PRESENT relative to the mouse support ABSENT, for the factors Support Type (Gel-eez™ vs. SoftSpot®) and Support Experience (experienced vs. non-experienced).

Wrist Extension

The hypothesis stating that there would be a significant difference in time spent in neutral wrist posture while using a mouse support was not supported for wrist extension. Overall, the use of a mouse support did not result in statistically significant time in neutral wrist extension. In fact, although not statistically significant, the non-experienced Gel-eez™ users spent more time (35%) in neutral wrist extension with the support ABSENT, compared to (30%) with the support PRESENT.

The hypothesis that there would be no significant difference in wrist extension for the factor Support Experience (experienced vs. non-experienced) was not supported. Experienced users of the Softspot® and the Gel-eez™ spent statistically significant more time in neutral zones for wrist extension (0° to 15°), than the non-experienced users, whether the support was PRESENT or ABSENT. This may be due to a "training" or "bracing" effect on the experienced users, from using a mouse support over a prolonged period of time. The experienced users may be exhibiting a muscle memory phenomena that maintains the neutral wrist position, whether or not there is a support PRESENT, similar to the way the body holds a limb in a set position after wearing a brace for an extended period of time.

Like keyboard wrist rests, mouse supports are designed to reduce wrist extension. For this measure, an interesting and profound effect was revealed. The presence or absence of a wrist support did not seem to alter posture to a great extent, in the short-term context such as in this study. However, there was evidence of a long-term effect, whereby the experienced users developed better mousing postures in terms of neutral wrist extension. Neutral wrist posture was maintained with the support PRESENT or when it was temporarily removed.

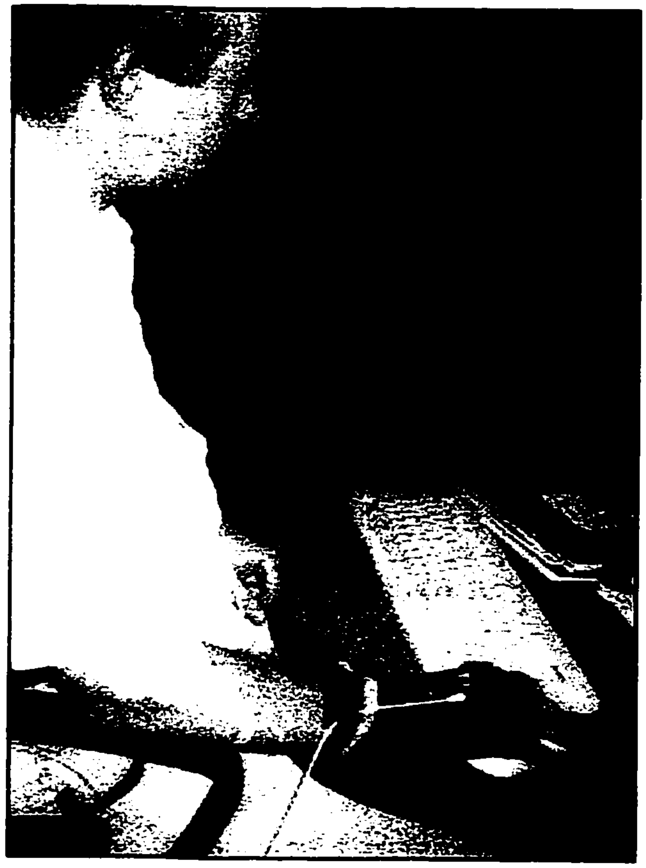

Figure 33. Neutral wrist extension posture with a mouse support.

Figure 34. Neutral wrist extension without a mouse support.

When comparing time spent in all three categories of extension for Support Use, Support Experience, and Support Type, the experienced users of both the SoftSpot® and the Gel-eez™ spent more time in neutral wrist extension with the support PRESENT, than without. The experienced Softspot® users spent 54% of the time in neutral wrist extension postures (0° to 15°), with the support PRESENT, and 52% of the time with wrist support ABSENT. The experienced Gel-eez™ users spent 62% of the time in neutral wrist extension postures (0° to 15°), with the support PRESENT, and 57% of the time with the support ABSENT. However, it was not a statistically significant amount of time. The small number of subjects contributed to the low variability and low power of this data.

Both non-experienced users spent the majority of their time in neutral flexion, with a support PRESENT, in the extension-flexion continuum. It is interesting to note that the differences in non-neutral wrist extension postures (15+°) were more pronounced for the non-experienced Gel-eez™ users, although not statistically significant. The non-experienced Gel-eez™ users spent an average of 33% total time in non-neutral extension when the wrist support was PRESENT. Of this, 31% of the time was spent in 15° to 30°, and 2% in 30+°. They spent an average of 34% in non-neutral extension when the support was ABSENT. Of this, 11% of the time was spent in 15° to 30°, and 23% in 30+°. However, when the Gel-eez™ support was PRESENT, there was 23% to 2% shift out of the extreme extension range 30+°. Although not statistically significant, these data confirm the findings by both Damann and Kroemer (1995) that the use of mouse wrist supports decreases wrist extension, and Hagglund and Jacobs' (1996) theory, that a wrist support moves the wrist towards a more neutral posture.

Wrist Flexion

The hypothesis stating that there would be a significant difference in time spent in neutral wrist postures while using a mouse support was not supported for wrist flexion. Overall, the use of a mouse support did not result in statistically significant time in neutral wrist flexion.

However, when analyzing total mean values for all four groups for Support Use, the SoftSpot® users and the experienced Gel-eez™ users spent more time in neutral wrist flexion categories, and the non-experienced Gel-eez™ users spent roughly equal time in neutral wrist flexion with the support PRESENT, as compared to when the support was ABSENT. The non-experienced SoftSpot® and Gel-eez™ users spent 56% and 62% (respectively) of the time in a neutral wrist flexion posture (0° to 20°), when the support was PRESENT, and 48% and 63% (respectively) when the support was ABSENT. The experienced Softspot® users and Gel-eez™ users spent 12% and 10% (respectively) of the time in a neutral wrist flexion posture (0° to 20°), when the support was PRESENT, and 8% and 2% (respectively) when the support was ABSENT. The small number of participants in this study did not contribute enough variability to be significant for the Support Use factor.

The hypothesis that there would be no significant difference in wrist flexion for the factor Support Experience (experienced vs. non-experienced) was not supported. The interaction between subjects for the factor Support Experience was significant. The non-experienced users spent statistically more time in the neutral wrist flexion range (0° to 20°), whether a support was PRESENT or ABSENT, as compared to the experienced users. As described earlier, the experienced users spent more time in neutral wrist extension postures compared to the non-experienced users. Current literature does not distinguish if neutral wrist flexion is better than neutral wrist extension. Hedge et al. (1995) describe the "neutral zone" as any wrist posture within 0° to 15° of wrist extension, or 0° to 20° of wrist flexion. The data from this study are not consistent with Damann and Kroemer's (1995) study, where the researchers found a slight increase in wrist flexion with the use of a mouse support compared to not using one.

Figure 35. Neutral wrist flexion posture with the Gel-eez™ support.

None of the participants spent time in awkward wrist flexion postures (20+°) when the support was PRESENT or ABSENT. A practical outcome from this study for the ergonomic community to disseminate is the practical result that mouse supports do not appear to pose an Upper Extremity Cumulative Trauma Disorder (UECTD) risk for non-neutral flexion postures greater than 20° with mouse support use. More interestingly, mouse use in general, without a support, does not appear to pose a risk for non-neutral flexion postures. With more power to find statistical significance, these data might suggest wrist flexion with mouse use (with a support or not) is not a risk factor for developing UECTDs with confidence.

Wrist Ulnar Deviation

The hypothesis stating that there would be a significant difference in time spent in neutral wrist ulnar deviation postures (0° to 20°), while using a mouse support, was supported. All participants (Gel-eez™ or SoftSpot® users) spent a greater amount of time in neutral wrist ulnar deviation postures with the support PRESENT, compared to when the support was ABSENT, when analyzing the 0° to 20° range. These finding were expected, as a mouse support provides friction and contact at the wrist, and therefore limits large wrist deviation movements.

The interaction between Support Type and Experience was marginally significant for neutral extension 0° to 20°. For the Gel-eez™ support, the experienced group spent more time in neutral ulnar deviation postures than the non-experienced group, whether the support was PRESENT or not. In contrast, for the SoftSpot® support, the non-experienced group spent more time in neutral ulnar deviation postures than the experienced group, whether the support was PRESENT or not.

There was a significant effect for Support Use for the moderate wrist ulnar deviation range (20+°). Participants spent significantly more time in non-neutral ulnar deviation when the support was ABSENT, compared to when the support was PRESENT.

When comparing all groups for time spent in neutral versus non-neutral ulnar deviation, for the Support Use factor, some interesting patterns were observed. All participants spent the majority of the time in non-neutral ulnar deviation ranges (on the ulnar-radial deviation continuum) when the support was ABSENT. Experienced

SoftSpot® users spent 74%, non-experienced SoftSpot® users spent 68%, experienced Gel-eez™ users spent 59%, and non-experienced Gel-eez™ users spent 97% in non-neutral ulnar deviation postures when the support was ABSENT.

When either support was PRESENT, there was a substantial shift to neutral ulnar deviation for all the groups, except the non-experienced Gel-eez™ users. With the support PRESENT, the SoftSpot® users and the experienced Gel-eez™ users spent the majority of their time in neutral wrist ulnar deviation (0° to 20°). Ultimately the non-experienced Gel-eez™ users spent the majority of the time in non-neutral ulnar deviation with the support PRESENT or ABSENT. However, when the Gel-eez™ support was PRESENT, there was a 97% to 72% (a 25% increase) shift for time spent in the non-neutral range, and a 3% to 26% shift for the neutral range. From this data, there was some benefit when the support was introduced. The small number of participants of the non-experienced Gel-eez™ group (n = 3) contributes to the low variability of this data.

These data partially support the results of Hagglund and Jacobs (1996), that all wrist motions remained under 20° of motion when utilizing some form of wrist rest. However, it is in contrast to the research of Hedge and Powers (1995) who concluded that there was no difference in wrist ulnar deviation with or without the use of a wrist support. In this study, experienced SoftSpot® and non-experienced Gel-eez™ mouse support users demonstrated a transition in spending their time in awkward wrist ulnar deviation postures (> 20°) when the product was ABSENT, to spending the majority of their time in neutral wrist ulnar deviation postures when the support was PRESENT (0° to 20°). As the above researchers looked at wrist supports for keyboard use, more research is necessary to determine the effect of mouse supports on wrist ulnar deviation.

Only non-experienced Gel-eez™ users stayed the majority of time in non-neutral zones of ulnar deviation, albeit with a 25% change toward a more neutral posture when the support was added. Presenting a new product to the workstation may initially cause muscle tension, accounting for the awkward ulnar deviation postures. With time and experience, the user becomes more comfortable with the product, and muscle tension diminishes, resulting in less extreme wrist posture.

In summary, experienced Gel-eez™ and SoftSpot® users and non-experienced Softspot® users benefited from the use of a support, as it placed them in more "neutral zone" postures. Hedge and Powers (1995) reported an increase in pain symptoms in computer operators working in greater than 20° of ulnar deviation. With repetitive tasks, it is advisable to get out of extreme ranges into a more neutral wrist range of motion.

Figure 36. Awkward wrist ulnar deviation without a wrist support.

Figure 37. Neutral wrist ulnar deviation with SoftSpot® mouse support.

Figure 38. Neutral wrist ulnar deviation with Gel-eez™ mouse support.

Wrist Radial Deviation

The hypothesis stating that there would be a significant difference in time spent in neutral wrist postures while using a mouse support was not supported for wrist radial deviation. There was no significant difference in the amount of time spent in neutral wrist radial deviation postures. All four groups spent less than 4% of the time in the neutral wrist radial deviation range (0° to 20°), and no time in the moderate radial deviation range (40°+), whether they used a mouse support or not.

Points of Contact

The hypothesis that there would be no significant difference in points of contact of the upper extremity during mouse use for the factors Support Use (PRESENT or ABSENT), Support Type (Gel-eez™ vs. SoftSpot®), and Support Experience (experienced vs. non-experienced) was not supported. The absolute values demonstrate a greater number of total points of contact in the PRESENT condition for experienced SoftSpot® and Gel-eez™ for users. Non-experienced users had a greater number of total points of contact in the ABSENT condition.

The volar wrist was the most common area of contact stress with the use of the mouse support or not, for all groups. Distal forearm contact was the other most common area of contact stress with the use of the mouse support or not, for all the groups, with the exception of the non-experienced SoftSpot® users. They demonstrated minimal contact stress when the support was ABSENT (20%). This demonstrates a greater risk for distal forearm contact stress when using a mouse support, regardless of experience for all groups. It also demonstrates a greater risk of distal forearm contact stress when not using a mouse, except for non-experienced SoftSpot® users.

Figure 39. Volar wrist and distal forearm contact with use of a SoftSpot® mouse support.

The incidence of contact stress on the volar wrist with mouse use is well documented in the literature (Armstrong et al.,1995; Davie et al., 1991). It is a known risk factor for nerve compression. However, a concern derived from this study is the issue of more contact distributed over a large surface area better than contact at a relatively small surface area. This researcher suggests that we need to have a better understanding of the quality and nature of contact stress before we can evaluate whether a given amount is good or bad. This issue needs further research.

The high incidence of distal forearm contact stress with mouse use in this study (whether a mouse support is PRESENT or not), is a new finding. The high incidence of volar wrist and distal forearm contact from this study may be due to "planting of the wrist" during mouse-only tasks. It was noted that participants did not change their right arm position throughout testing. All participants maintained the same posture and did not move or shift their posture, or change their points of contact during the test conditions. This may be a feature of the short duration of the test (15 minutes per test condition) and the mouse-only tasks, even though the custom mouse tasks required moving the cursor to all quadrants of the screen. Unlike keyboard typing that covers a broader surface area and requires a larger radius of continuous arm, wrist, and hand movement, the mousing surface area is relatively small, with a small radius of intermittent movement. Another possible factor of wrist "planting" may be attributed to the type of surface the mouse rests upon. A desktop is smooth and slick, with no resistance, encouraging more freedom of arm movement, whereas the mouse pad and mouse wrist supports are rubberized or plastic with some texture that may create friction, thus reducing freedom of movement.

Another possible explanation for the high incidence of volar wrist and distal forearm points of contact may be due to the elevation and length of the mouse wrist supports and the mouse pad. When you combine the average length of the mouse, plus the mouse pad or mouse support surface, with the length of the hand and distal forearm, both the volar wrist and part of the distal forearm are likely to come in contact with the pad or support underneath.

The risk for contact stress at the elbow for experienced SoftSpot® and Gel-eez™ users and non-experienced Gel-eez™ users, whether using a mouse support or not, was low. In contrast, the non-experienced SoftSpot® users demonstrated a higher risk for contact stress at the elbow when not using a mouse support and a lower risk of elbow contact stress when using a SoftSpot® support. The explanation for this may be more a factor of chair armrest use and arm length than mouse support use. Whether or not participants used their chair armrests could account for contact stress at the elbow. Also, whether or not participants rested their entire forearm (including the elbow) on the table top, or the elbow hung off the edge of the table while performing mouse tasks, could account for the incidence or lack of elbow contact stress. Observation of the use of chair armrests was not a function of this study. More research is needed to address the effect of chair armrests on total arm points of contact.

Grip and Pinch

The hypothesis that there would be no significant difference in grip and pinch style for the factors Support Use (PRESENT or ABSENT), Support Type (Gel-eez™ vs. SoftSpot®), and Support Experience (experienced vs. non-experienced) was supported for experienced (SoftSpot® and Gel-eez™) users only. The absolute values demonstrate a dominance (across all groups) of the thumb fingertips enclosure type grip when the support was PRESENT. This may be due to the height of the mouse support in relation to the height of the mouse. When the wrist is elevated on a support, it is at or near the same level of the mouse, and the palm does not touch the mouse; only the fingers and thumb come in contact with the surface of the mouse.

When either mouse support was ABSENT, there was a general trend, with more variability for the non-experienced users, to transition to the finger-palm enclosure type grip. The experienced users demonstrated a clear transition to the finger-palm enclosure type grip. When the wrist is flat on the table top, the entire surface of the palm is more likely to drape over the mouse and have greater palm contact with the mouse, in a finger-palm enclosure type grip. This type of grip seems to be the prevailing preferred method that is evident in most recent mouse designs. Recent designs of the mouse have focused on the natural contour of the palm to encourage draping the palm over the mouse.

Figure 40. Thumb/fingertip enclosure type grip with mouse support PRESENT.

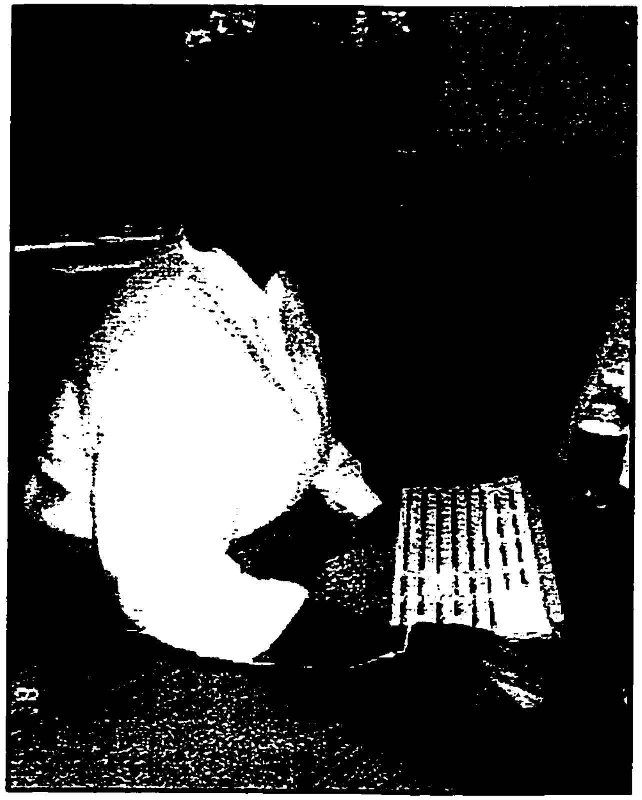

Figure 41. Finger palm enclosure type grip with mouse support ABSENT.

This research was an initial exploration to identify possible grip and pinch postures used during computer mouse function with the use of two common mouse supports. There has been no research to date addressing the advantages or disadvantages of either of these two grip and pinch postures. Researchers Johnson et al. (1994) determined that mouse dragging operations placed the operators' forearm tendons and muscles under great biomechanical stress, and there is a clear relationship between mouse usage and musculoskeletal fatigue and injury. However, these researchers did not identify the type of grip or pinch posture used when testing for pinch forces. Clearly, more research is needed to address this issue.

Another aspect of pinch and grip styles that warrants further research is the pinch forces applied to the mouse. Gripping and pinching a mouse requires prolonged, static forearm and hand muscle contractions, which leads to fatigue, and is a known risk factor for developing Upper Extremity Cumulative Trauma Disorders. The type of grip and pinch style may not be as important as the forces the individual applies to the mouse during computer mouse function.

Subjective Data Regarding Perceived Benefits From Using a Mouse Support Relative to Not Using a Mouse Support

The hypothesis that there would be no significant difference in subjective ratings for the factors Support Use (PRESENT or ABSENT), Support Type (Gel-eez™ vs. SoftSpot®), and Support Experience (experienced vs. non-experienced) was not supported. The Gel-eez™ mouse support had more categories with much better ratings than the SoftSpot® mouse support.

When analyzing data from individuals in each group, the experienced Softspot® users reported the greatest variability in their answers, ranging from a score of 1 (much worse) to 7 (much better) for the subjective physiological and performance categories. Comfort was the only area of reported improvement for the experienced Softspot® users. All other categories were rated no different than when not using a mouse support. They basically found no benefit for the support. The non-experienced SoftSpot® mean score rated all categories much worse with the use of the SoftSpot® as compared to no mouse support at all. It is interesting to note that one participant in the non-experienced SoftSpot® group (n = 3) consistently scored higher (a score of 4 or higher) in all categories compared to the other two participants in the group (who scored mostly 3 or lower).

In contrast, the Gel-eez™ users consistently scored a 4 or higher for all physiological and performance categories. Both the experienced Gel-eez™ users and the non-experienced Gel-eez™ users reported improvement in the areas of comfort, fatigue, and pressure on the wrist. This finding is not surprising, as the Gel-eez™ is made from a gel material that is soft and conforms to the wrist. Accuracy and speed were rated no different than when not using a mouse support.

The data from this research is consistent with the research in the literature (albeit research done on keyboards) claiming conflicting responses on the benefits of wrist supports. Only one study to date, by Damann and Kroemer (1995), researched the effects of a mouse wrist support on wrist posture during mouse function. Their research did not include any performance measures. Berqvist et al. (1995a), Grandjean et al. (1983), Hagglund and Jacobs (1996), and Nakaseko et al. (1985) reported reduced static muscle load, increased comfort, and decreased awkward wrist postures with the use of a support. These researchers used subjective and objective measures. Fernstrom et al. (1994), Hedge and Powers (1995), and Horie et al. (1993) disclaim any benefits from using a wrist support in terms of reduced muscle load, pressure, or awkward postures. These researchers used objective measures.

It is interesting to note that in the process of doing this study, this researcher spoke with various mouse support manufacturers to discuss design characteristics and their development. The manufacturers denied performing any controlled studies of ROM, accuracy, speed, fatigue, or pressure. They replied the basis of their designs was comfort. It has been this researcher's experience as a practicing ergonomist, that comfort was a deciding factor in the purchase of a particular mouse support.

Comparison of Objective Data and Subjective Reports of the SoftSpot® and Gel-eez™ Mouse Supports With the Manufacturer's Claim

The manufacturers' claims that a wrist support provides neutral alignment and reduces fatigue and discomfort has some support in this research. Specifically, the manufacturers of the SoftSpot® claim a natural, neutral position and a reduction in stress on the wrists and forearms. They claim their product distributes weight that improves circulation and decreases pressure points.

As the data in this study suggest, the use of the SoftSpot® mouse support did not place the wrist in a neutral position for flexion or extension. It did place the wrist in a neutral ulnar deviation posture. Subjectively, the experienced Softspot® users did report improvement in the area of comfort. However, the analysis of upper extremity points of contact revealed an increased risk of distal forearm contact stress with the use of the Softspot®.

The manufacturers of the Gel-eez™ claim a reduction in fatigue and discomfort, with diminished chances of developing Repetitive Strain Injuries. The data from this study revealed the use of the Gel-eez™ mouse support did not place the wrist in a neutral position for flexion or extension. For experienced users, the Gel-eez™ did place the wrist in a neutral ulnar deviation posture. However, non-experienced Gel-eez™ users stayed the majority of time in non-neutral zones of ulnar deviation, albeit with a 22%

change toward a more neutral posture when the support was added. The data from the subjective ratings support the claims of increased comfort and reduced fatigue. The experienced and non-experienced Gel-eez™ users consistently reported the same or much improvement in comfort and fatigue.

Design Guidelines

From this research, using a small sample size of 18 participants and two mouse wrist supports, some design components emerged for creating a functional mouse wrist support. Many of the participants reported a preference for a pad that is smooth, soft yet firm, and malleable, in order to improve comfort and reduce fatigue. Keeping the wrist in a resting position to reduce strain on the wrist was also a high priority. Some participants commented on the advantage of a slick surface to make mouse movements more fluid. Ideally, mouse wrist supports should come in variable sizes to accommodate the small-, medium-, and large-sized hand.

Limitations of the Study

1. The participant sample size was limited to 18 people.

2. The mouse wrist support type was limited to the Gel-eez™ and the SoftSpot® mouse wrist supports.

3. The test conditions in the study were mouse tasks only (Solitaire and mouse games). There was no keyboard use. Normal computer office work consists of a combination of keyboard and mouse use. It is unknown whether the results would be different if typical computer office work was performed.

4. The two test conditions were of relatively short duration, 15 to 20 minutes each. It is unknown whether the results would be different if longer test conditions were instituted.

5. Participants were required to wear the Greenleaf WristSystem™ sensor glove on the right hand throughout the test conditions to obtain data. The glove was made of lightweight fabric and did not restrict movement, however it did have a wire attached to it. Use of the glove could result in a change in sensation, which could have impacted subjective ratings of comfort, pressure, fatigue, accuracy, and speed.

Recommendations for Future Research

To further understand the effects of mouse wrist supports on computer mouse function, additional studies are recommended. These include:

1. A controlled study in a laboratory setting, with controls for workstation set up and mouse settings for all participants, looking at the effect of a mouse wrist support on shoulder and trunk posture, mouse height to elbow height ratios, and wrist posture.

2. A study to analyze the different pinch and grip styles, including pinch forces during computer mouse use.

3. Exploring the effect on wrist and forearm pressure of various product materials and dimensions (lengths and widths) used in the design of mouse wrist supports (i.e., gel, foam, rubber, and plastic).

4. A more comprehensive wrist posture study using a mouse wrist support with more participants, over a longer period of time, that incorporates typical computer office work of intermittent keyboard and mouse use.

Conclusion

There has been a dramatic increase in the incidence of Upper Extremity Cumulative Trauma Disorders (UE CTDs) related to the use of the mouse. Ergonomists play an active role in providing a safe work environment for the worker by eliminating known physiological and biomechanical risk factors associated with UE CTDs. Mouse wrist supports, designed to encourage proper wrist alignment, have come in vogue recently. There exists little guidance in the ergonomic literature regarding the potential beneficial aspects of mouse wrist supports. What does exist are numerous, yet contradicting studies on the benefits of wrist supports for keyboard users.

The primary objective of this study was to determine the effect of two common mouse supports (the SoftSpot® and Gel-eez™) on wrist posture, points of contact, grip and pinch styles, and subjective responses, with the hope of providing some guidelines for the design of mouse wrist supports.

The results showed that overall, using a mouse support during computer mouse function did not result in more time spent in neutral wrist extension or flexion postures. However, SoftSpot® users and experienced Gel-eez™ users spent more time in neutral ulnar deviation with a mouse support PRESENT. There was evidence of a long-term effect whereby the experienced support users developed better mousing postures in neutral extension, whether the support was PRESENT or TEMPORARILY REMOVED.

Contact stress appears significant at the volar wrist and distal forearm when the support was PRESENT or ABSENT. All mouse users tended to plant their wrist, regardless of the presence of a mouse support or not. Participants generally rated the mouse supports as more comfortable, less fatiguing, and producing less pressure.

From this study, it is recommended that mouse wrist support designers and manufacturers design a mouse support that keeps the wrist in neutral alignment, and to consider using materials that provide comfort and increase fluidity when designing a support. Most important is to design with the individual in mind, therefore producing mouse wrist supports in variable sizes that reflect the mouse operator population.

From this limited study, there is some evidence that using a mouse wrist support may be beneficial in reducing awkward wrist postures over the long term. However, regardless of our use and manipulation of ergonomic products, computer operators spend a significant amount of time in non-neutral postures. The effect of using a computer for extended periods of time may be a more critical factor than the products used during this time.

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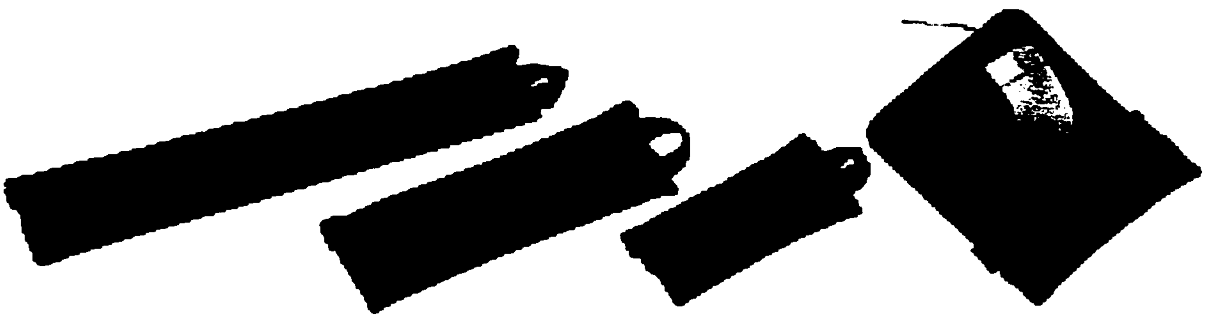
APPENDIX A

RESEARCH STUDY FLYER

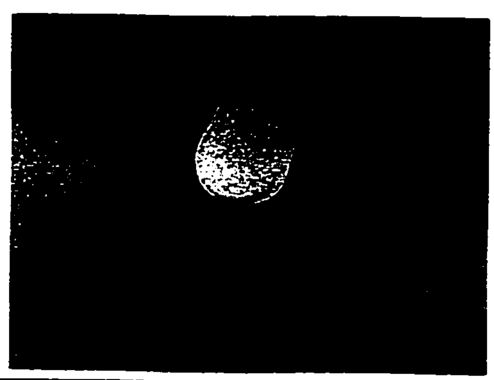
Wanted: PEOPLE TO PARTICIPATE IN A RESEARCH STUDY.

If you use one of following mouse wrist supports, a standard mouse, and are uninjured, you are eligible to participate in this research project.

The Gel-eez™ Wrist Rest



The SoftSpot® Mousepad Wrist Support



- **Participation takes approximately 1 hour.**
- **The study is conducted at your office, using your computer.**
- **Earn $20.**

IF INTERESTED, PLEASE CALL LISA VOGE-LEVIN AT 650-326-3965
OR E-MAIL TO: ERGOVOGE@AOL.COM

APPENDIX B

PARTICIPANT SCREENING TOOL

Introduction

This questionnaire is part of a study being performed for a Master's thesis in Human Factors and Ergonomics at San Jose State University. This survey is one of the first in the field of ergonomics to study the use of mouse wrist supports. Your participation will assist us in providing understanding to both the ergonomic and industrial design professions of the real needs of the mouse user. All survey responses are anonymous.

Instructions:

Fill out the following questionnaire.

Fax completed questionnaire to Lisa Voge-Levin at 650-326-3965.

You will be contacted, and an appointment time will be set up if you qualify to be a participant in the study.

Thank you for your time.

Lisa Voge-Levin
Human Factors Engineering Master's Candidate
Anthony Andre, Ph.D.
Professor of Human Factors Engineering at San Jose State University
Telephone: 650-326-3965

Please answer the following questions:
(Information is confidential)

Participant's Name: ______________________ Today's Date: ____________
Telephone Number: Work ________________ Home ___________________
E-mail Address: __________________________

1. Age: __________ years

2. Gender: _____Male _____ Female

3. Are you right handed? ____YES ____NO

4. Do you use a PC? ____YES ____NO

5. Have you used a computer mouse for more than one year? ____YES ____NO

6. What kind of mouse do you use? ______________________

7. Which of the following mouse wrist supports do you currently use?
   a. (Gel-eez™) _________
   b. (SoftSpot®) _________
   c. (North Coast Medical Work Mod) _________
   NONE_____ I do not use a mouse support.

8. If you checked a., b., or c.: How long have you used your wrist support?
   ______________ months/years

9. Is your mouse placed at the same height or near the same height as your elbow, when you are sitting down in your chair? ____YES ____NO

10. Have you been diagnosed by a physician with an arm, wrist, or hand repetitive strain injury in the last year? ____YES ____NO

11. Have you ever injured your wrists or hands? ____YES ____NO
    If yes, explain______________________________________

12. Have you had any pain or discomfort, numbness or tingling in your arms, wrists, or hands in the last year? ____YES____NO

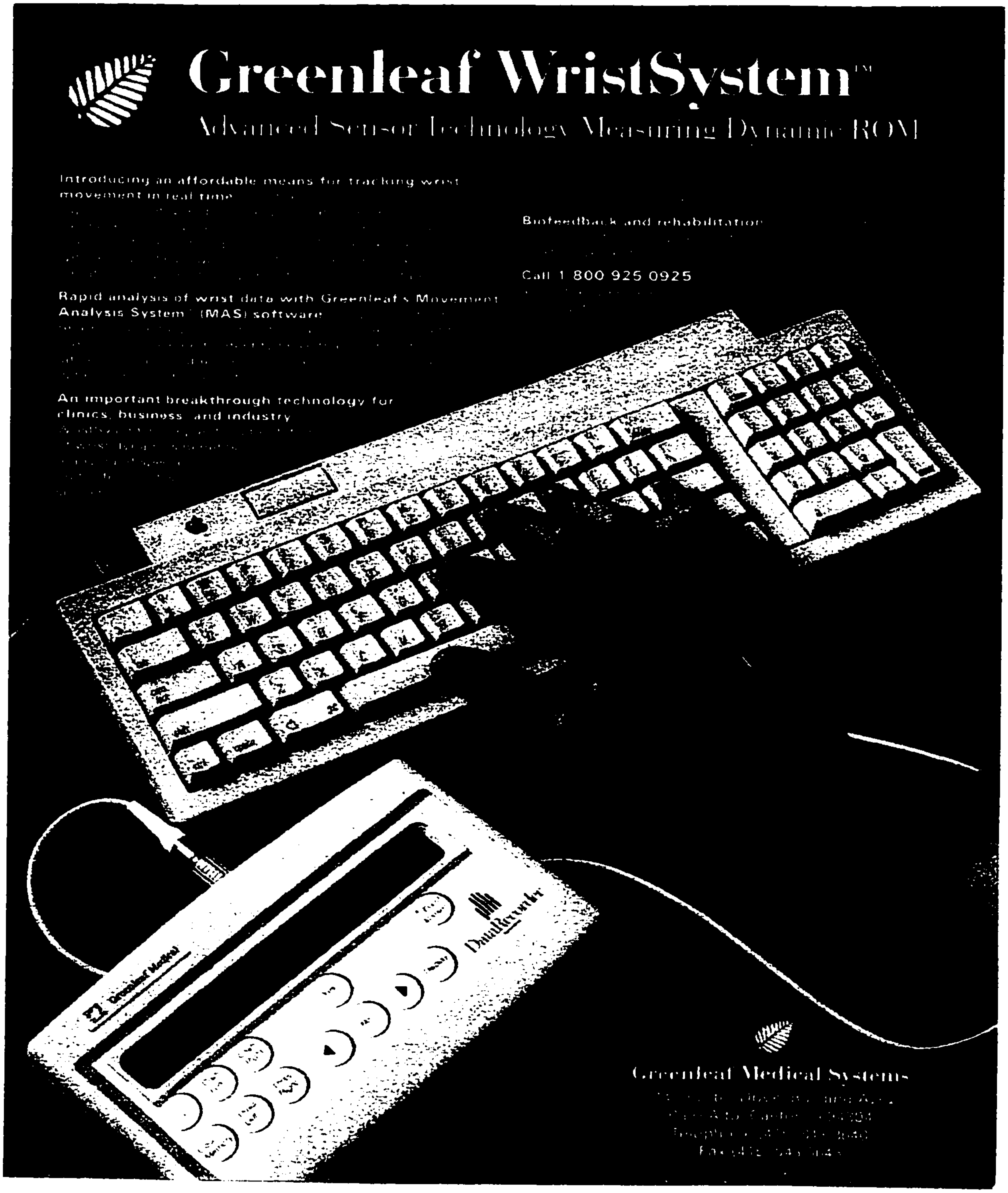
13. Do you know how to play Solitaire on your computer? ____YES ____NO

14. Do you have the program Excel on your computer? ____YES ____NO

15. What size screen/monitor do you have? _______ inches

APPENDIX C

GREENLEAF MEDICAL WRIST SYSTEM



APPENDIX D

MOUSE WRIST SUPPORT SURVEY (POST-TEST)

Date: __________
Participant Name: ________________________ ID Number:________________

Instructions

Please answer all questions as accurately as possible. Check or write in the response most appropriate for your experiences with the mouse support. If you do not want to answer a particular question, just leave it blank.

It should take approximately 10 minutes to complete this survey.
Thank you for your time.

Section 1: User Information

1. How much computer mouse use do you currently engage in daily? ____hours

Section 2: Mouse Wrist Support Information

1. Which computer mouse wrist support do you currently use?

    a. (Gel-eez™) __________
    b. (SoftSpot®) __________
    c. (WorkMod) __________
    d. None __________ I do not currently use a mouse support.
    If none, go to section 4, question number 1. After filling out the question , you are done with this test.

2. Why was this mouse support selected? (*check all that apply*)

    ____ It was recommended/provided
    ____ State-of-the-art design/it looked cool
    ____ No particular reason
    ____ Cost
    ____ Palm resting surface
    ____ Color
    ____ Size
    Other:____

3. Did you use a different mouse support prior to your current one?
_____Yes ____No
If yes. which type and brand did you use? ________________________________

Section 3: Setup of Mouse Wrist Support

1. How long did it take to set up your mouse support? _____ minutes

2. Who or what helped the most in setting up the mouse support?
_____ The mouse support instructions
_____ I figured it out myself
_____ Ergonomics specialist
_____ Friends
_____ Other:________________________________

3. Is the mouse at the same height as the keyboard? _____Yes ____ No

4. Did you make other changes to your workstation? _____ Yes ____ No

If yes, what were they? ________________________________
____

Section 4: Benefits Achieved from the Mouse Wrist Support
Tested with (a) Gel-eez™ or (b) SoftSpot®? *(circle one)*

1. Rate your mouse support or the one you were tested on, as compared to not using one, on the scale below: *(circle one)*

Comfort	much worse (**1 - 2 - 3 - 4 - 5 - 6 - 7**) much better
Fatigue from use	much worse (**1 - 2 - 3 - 4 - 5 - 6 - 7**) much better
Mouse accuracy/precision	much worse (**1 - 2 - 3 - 4 - 5 - 6 - 7**) much better
Mouse speed	much worse (**1 - 2 - 3 - 4 - 5 - 6 - 7**) much better
Pressure exerted on the wrist	much worse (**1 - 2 - 3 - 4 - 5 - 6 - 7**) much better

Section 5: Recommendations for Design Changes

1. What is/are the best feature(s) of your mouse support?

____

____

2. What is/are the worst feature(s) of your mouse support?

____

____

3. Does the mouse support do what you expect it to do? _____ Yes ____ No

Explain____

4. How would you improve your mouse support if you could?

____

____

APPENDIX E

WRITTEN CONSENT FORM

I, _________________________________ volunteer to participate in the research project entitled "A Comparison of Mouse Wrist Supports During Computer Mouse Function," to be conducted at the participant's office, under the direction of Lisa Voge-Levin and Anthony Andre, Ph.D.

The procedures have been explained to me, and I understand them fully. They are as follows: The purpose of the study is to compare the effects of different mouse wrist supports on wrist range of motion. The task involves performing a mouse task, using the right hand only. The experimental procedure will include two sessions lasting approximately 20 minutes each. The first test will be preceded by an orientation to the experiment, in which all procedures will be explained, and measurements and pictures will be taken. The pictures will be used for thesis educational purposes.

I understand there are no risks or benefits associated with my participation in this study. I understand that this consent and data may be withdrawn at any time without penalty. I have been given written notification of the principal investigators as well as the department chairperson's phone numbers.

Lisa Voge-Levin (principal investigator): 650-326-3965

Dr. Anthony Andre (advisor): 408-342-9050

Dr. Lou Freund (ISE Department Chair): 408-924-3890

Dr. Serena Stanford (contact for Department of Graduate Studies and Research at SJSU): 408-924-2480

I have been given the right to ask questions, and my questions, if any, have been answered to my satisfaction. I understand the data will be reported in group form, and individual data will be kept confidential.

____

Participant's Signature Date

____

Investigator's Signature Date

Contacts for study: A COMPARISON OF MOUSE WRIST SUPPORTS DURING COMPUTER MOUSE FUNCTION

Serena Stanford
Academic Vice President
San Jose State University
408 924-2480

Anthony Andre, Ph. D.
(Advisor to Lisa Voge-Levin)
Associate Professor Human Factors and Ergonomics
Department of Industrial Engineering
San Jose State University
408-342-9050 (Interface Analysis Office)

Lisa Voge-Levin, OTR
Master's Candidate in Human Factors and Ergonomics
Department of Industrial Engineering
San Jose State University
650-326-3965

If you would like a summary of the findings, please complete the following information:

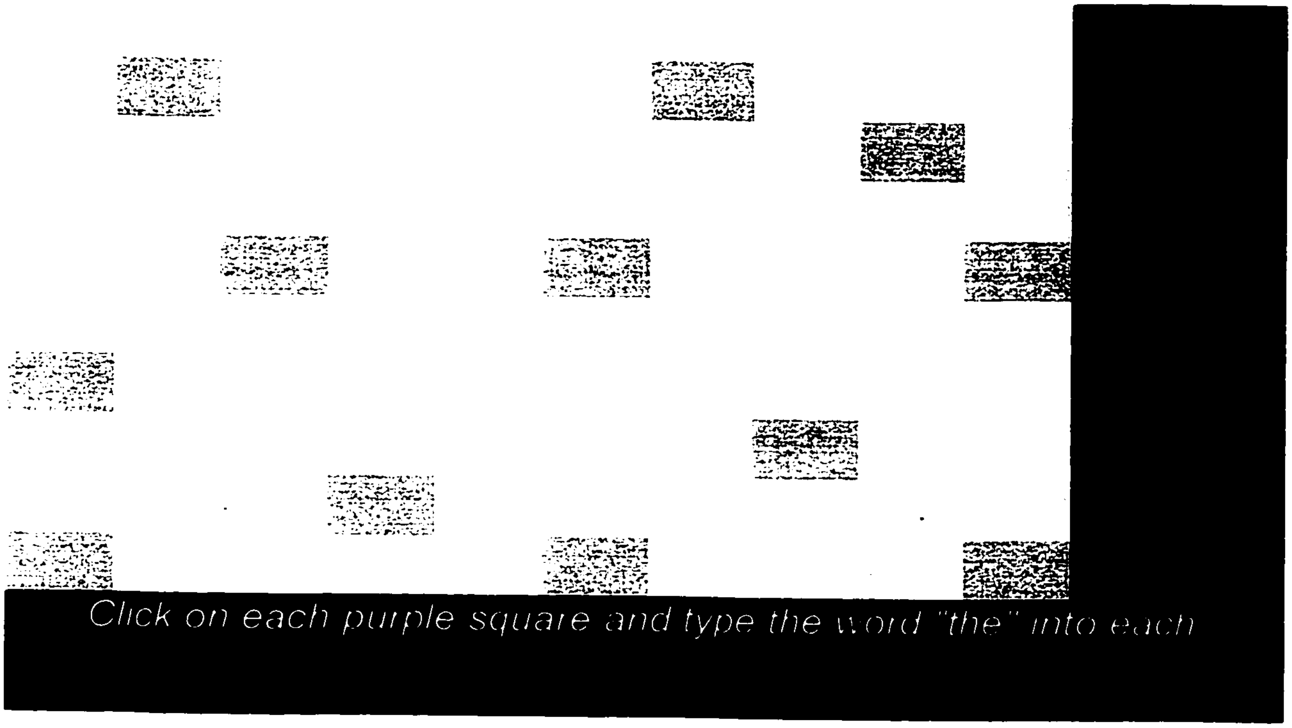
Name: ______________________________

Address: ______________________________

____

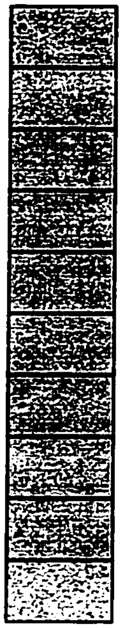
APPENDIX F

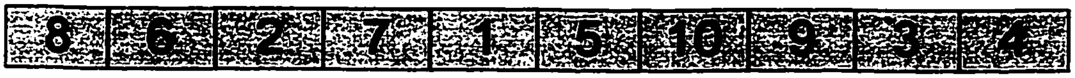
MOUSE TASK – CLICKER



APPENDIX G

MOUSE TASK – DRAGSTER





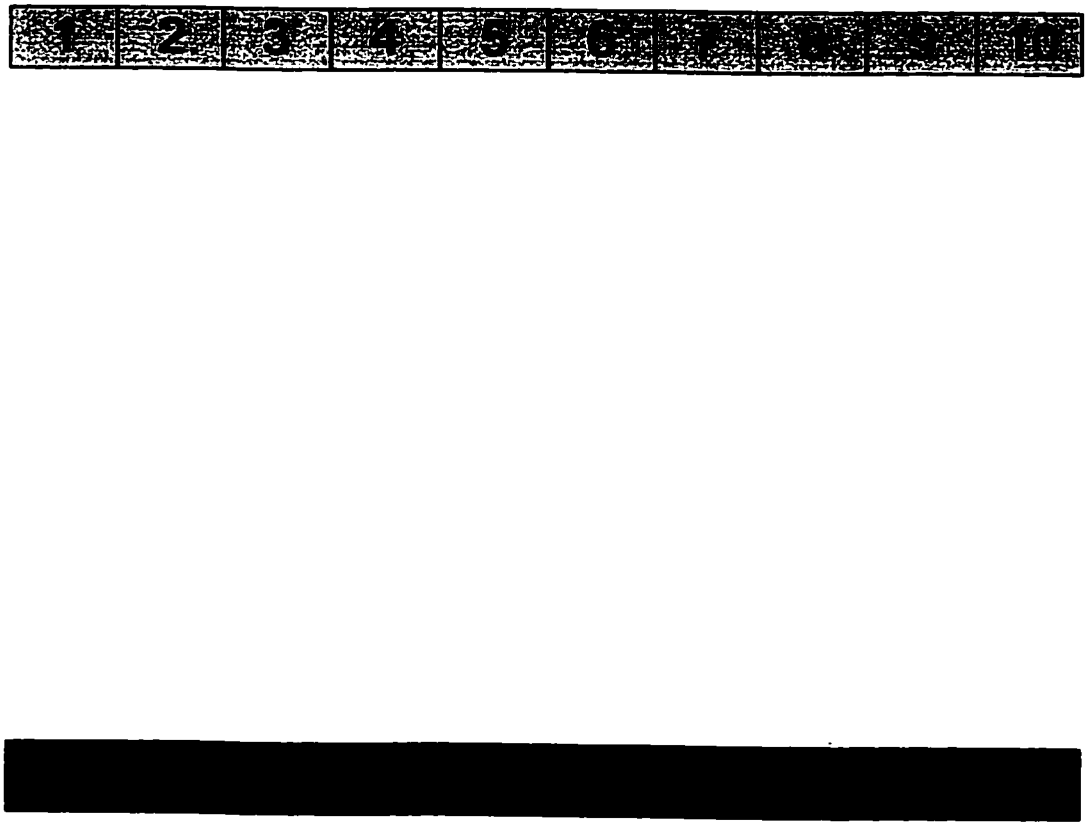
APPENDIX H

MOUSE TASK - SCROLLER

A	A	8	11	8	8	11	42	19	24
A	A	12	17	12	12	17	4	5	4
8	11	8	25	18	18	25	8	11	8
12	17	12	35	24	24	35	12	17	12
18	25	18	0	-13	-13	0	18	25	18
24	35	24	53	36	36	53	24	35	24
30	0	-13	11	8	12	61	30	0	-13
36	53	36	17	12	18	66	36	53	36
8	11	8	25	18	24	70	42	61	42
12	17	12	35	24	-13	102	A	A	54
18	25	18	0	-13	36	30	A	A	72

APPENDIX I

MOUSE TASK - VERTICAL DRAG



Drag each number to the red square below it.