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Computing postures observed in the living room: effects of a keyboard platform

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**COMPUTING POSTURES OBSERVED IN THE LIVING ROOM: EFFECTS OF A
KEYBOARD PLATFORM**

A Thesis

Presented to

The Faculty of the Graduate Program in Human Factors / Ergonomics

San Jose State University

In Partial Fulfillment

Of the Requirements for the Degree

Master of Science

by

Krupa Joshi Karvat

August 2002

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ABSTRACT

COMPUTING POSTURES OBSERVED IN THE LIVING ROOM: EFFECTS OF A KEYBOARD PLATFORM

By Krupa Joshi Karvat

This study was conducted to identify computing postures (trunk, shoulder, elbow, wrist, and head/neck) observed in a living room setting while using a Powerboard keyboard platform support. The postures observed were classified as either ergonomically beneficial or awkward/unsafe and contributing to the development of a cumulative trauma disorder and repetitive stress injuries. Sixteen participants were observed while they performed two types of computer tasks (web browsing and word processing) in a living room setting (sitting on a couch viewing the computer through a television), with and without the keyboard platform, and using one of two different wireless keyboard lengths (long and short). There were positive differences seen in posture while using the platform but mixed results were found with the different keyboard lengths. Significantly safer elbow postures (negative-slope) were found when the long keyboard was used with the platform during web tasks. Other behaviors observed show that the concept of living room computing has potential to cause musculoskeletal injuries.

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INTRODUCTION

The internet is used by millions of people all over the world. It has become so affordable that it has drastically changed the way information is retrieved and used. New products such as Web TV, interactive set top boxes, and "living room PCs" are moving the internet and computing experience from a desk, in the traditional office or den, to the living room couch. These devices now make it possible for people to perform traditional desk bound tasks while being seated comfortably, in any desired posture in the living room. Thus, the problem to be evaluated in this study, through observation, is the effect on posture during computer use in a living room environment.

Musculoskeletal problems occur primarily because of overuse, and awkward postures (Carter & Banister, 1994). "Overuse injuries occur when the force placed on a tissue is not large enough to cause sudden failure of the tissue but when repeated many times a day, produces some functional impairment or trauma in the long term (Carter & Banister, 1994, p. 1626)." The repeated action of typing on a keyboard with awkward positions of the wrist, elbow, shoulder, neck, back and legs can increase the risk of musculoskeletal problems with increased use (Psihogios, Sommerich, Mirka & Moon, 1998; Carter & Banister, 1994; Carson, 1994; Grieco, 1986). Awkward postures can occur during a number of recreational and occupational activities such as playing a musical instrument, knitting, golfing, and typing (Carter & Banister, 1994).

There is a high risk of developing musculoskeletal problems to the neck, shoulders, elbow, wrists, back, or legs during the use of a keyboard while seated on a

couch (Carter & Banister, 1994; Grieco, 1986:). This risk is greater when seated on a couch rather than seated at a computer work station due to the lack of support that is normally provided by an ergonomic chair (Grandjean, Hunting, & Pidermann, 1983). The biomechanical impact of sitting for long periods of time, in awkward positions, has been frequently studied (Carson, 1994; Carter & Banister; Anderson, 1987; Grieco, 1986). Studies range from traditional computer work station risk factors experiments (Psihogios, Sommerich, Mirka & Moon, 1998; Carter & Banister, 1994; Andersson, 1987) to observational studies comparing posture during internet navigation and data entry (English & Andre, 1999).

Research indicates there are many different postures and positions taken by users during web browsing and data entry tasks that may cause musculoskeletal problems (English & Andre, 1999; Carter & Banister, 1994). As a result of these types of studies, the traditional work station has been improved, decreasing user pain and discomfort. The awkward postures of the back, neck, shoulders, elbows, and wrists found in traditional settings will be used as a guide to evaluate the postures that will be observed for this study. At this time, no studies have been conducted concerning the risk factors and posture evaluation of computer keyboard users in a living room setting.

The use of computer keyboards has been linked to musculoskeletal injuries. A growing industry specializes in the development of equipment that would address these issues. One piece of equipment that may address the use of a keyboard in the living room is the Powerboard ("platform"). This has been developed by a physical therapist who proposes that it provides better support and better postural position while sitting at a

computer station. Thus it may also benefit users in many different environments such as the living room.

Figure 1 - Keyboard on top of Powerboard

The equipment benefits can only be ascertained through research that evaluates what users do while “surfing” the web, or typing a letter. In this manner one can study peoples’ postures and how they use the platform. These two tasks are chose because through past research (English & Andre, 1999) it as been shown that web browsing may cause more awkward postures when on a traditional desk and chair. Only one study has explored the postures observed during web surfing and data entry while seated at a traditional computer work station (English & Andre, 1999). This study addresses the growing trend towards the use of PC applications in the living room. It also evaluates the postures that users engage in during web browsing and data entry while sitting or lying down on a couch.

Nelson (1998) evaluated the EMG readings of musculature while using different computer keyboard positions. The Powerboard was used in two different positions, along with the elbows at 90 degrees and 110 degrees on a traditional desktop setting. He has found that the platform position 1 in which the Powerboard was placed on the lap with

the keyboard on top provided the best position for keyboarding. The Powerboard appears to be beneficial in a traditional computer station but for this study, it will be used with users seated on a couch while using a “living room” PC application.

The purpose of this study is to observe the effects on posture during the use of the Powerboard platform, while using a computer in a living room setting. The null hypothesis is that there will be no difference with or without Platform use, between the long or short keyboard, and between word or web tasks.

The research hypothesis is that when the platform is used, the users’ postures are more ergonomically appropriate and less awkward than when the platform is not used. Also, two different keyboard lengths (long and short) will be used to perform two tasks (web browsing and word processing). The research hypothesis is that the long keyboard will provide better support than the short keyboard and therefore, the users’ postures are more ergonomically appropriate. Lastly, the research hypothesis is also that while performing the word tasks compared to the web tasks, users’ postures are more ergonomically appropriate and less awkward.

LITERATURE REVIEW

Awkward postures during sitting have been studied by many researchers (Psihogious et al. 1998; Hamilton, 1996; Hedge & Powers, 1995; Carson, 1994; Carter & Banister, 1995; Andersson, 1987; Grieco, 1986; Bhatnager, Drury, & Schiro, 1985; Grandjean et al., 1983; Hunting et al., 1981) and they support the hypothesis that stress to the joints and muscle tissues caused by awkward postures may lead to musculoskeletal problems. The literature review for the purpose of this study will be divided into areas of concern such as the lumbar region of the back, neck muscles, shoulders, elbow, and wrist positions while seated.

Lumbar Curve

The lumbar curve is especially at risk of back injury with awkward postures (Carson, 1994; Andersson, 1987; Grieco, 1986; Bhatnager, et al., 1985). Carson (1994) states that the back is at high risk of injury when it is in a position that is away from the desired neutral position. When the spine is in neutral, the lumbar curve while standing has a 60 degree curve whereas while sitting it has 22 degree curve (Andersson, 1987) (Fig 2.). Just the sitting posture puts the lumbar curve in an abnormal position. When increasing the “slouched” posture, or movement away from the middle it makes it awkward and thus pain and discomfort can occur more easily. “The muscular strength is very limited in certain positions and in awkward positions (during slouching) require muscles to work at or near their maximum capacity.” (Carson, 1994, p.271)

More specifically, Carter and Banister (1994), Andersson (1987), Grieco (1986), Bhatnagar et al. (1985) and Nachemson (1965), all agree and that leaning the trunk far forward increases the compression load on the lumbar spine by reducing the normal curve of the lumbar region. Bhatnagar et al. (1985) also found with forward leaning, there were increased complaints of pain, and increased postural shifting which indicates postural fatigue. Lastly, they also found an increase in typing errors from 2% to 8% as time increased which may be due to the forward leaning causing discomfort and postural shifting.

Nachemson (1965) demonstrated that a 70 Kg individual who is seated in a neutral position will have approximately 140 Kg load on L3 lumbar region. While forward leaning 20 degrees, that same person seated will have a 190 Kg load on the L3 lumbar region. To decrease that load, Andersson (1987) states that support from backrests or armrests for the upper extremity can decrease the load on the lumbar spine and decrease discomfort from awkward postures. For the purpose of the study, it has therefore been assumed that while seated on a couch, support for the lumbar curve is minimal; the backrest is not as sturdy and armrests are not always available for support.

Another factor that appears to increase pain and discomfort is the amount of time that is spent sitting in a static posture (Carson, 1994; Grieco, 1986 ; Bhatnager, 1985). The term “postural fixity” used by Grieco (1986) and Andersson (1987) is used to describe static postures seen during sitting tasks. Pain occurs due to the lack of circulation and minimal amounts of nutrients being supplied to the whole spine (Grieco, 1986). Grieco (1986) also states that the problem of “postural fixity” cannot be solved by

ergonomically designed furniture but through proper use of pacing techniques, proper sitting postures, exercises and intermittent movement throughout the sitting task. While seated on a couch, “postural fixity” may occur and, therefore, this behavior is observed during the study.

Shoulder Region

Musculoskeletal problems can also occur with awkward postures involving the shoulders, elbows, and wrists (Carson, 1994; Andersson, 1987; Hedge & Powers, 1995; and Hunting, 1981). For the shoulder, both Andersson (1987) and Carson (1994) agree that if a keyboard is placed higher than the elbow and if arms are extended away from the body, the awkward postures will cause stress in the shoulder and cause muscles to fatigue faster. The shoulder and neck muscles are forced to raise the shoulders and arms up to fit the high keyboard height. The constant contraction of the muscles increases tension and stress that causes pain and discomfort. Similarly, if the shoulders are extended away from the body (shoulder flexion) than that also fatigues the muscles and thus accelerates the discomforting feeling (Carson, 1994). Many researchers conclude that postural load is decreased if the upper body is supported with armrests when the shoulders are in a neutral and relaxed position (Andersson, 1987; Hedges & Powers, 1995; Hunting et al., 1981).

Elbow Region

The traditional position of 90 degrees for the elbow position has been challenged by Grandjean et al. (1983) and Hedge & Powers (1995). Hedge and Powers (1995) stated that the slight downward negative-slope angle of about 0 to 25 degrees demonstrated less

muscle tension throughout the upper body. In this study, this “negative” position in which the keyboard is angled downward 0 – 25 degrees forces the muscles to relax. Thus, in the end giving the user a less awkward and more comfortable keyboarding experience.

Wrist Region

The position on the shoulders and elbow will effect the position of the wrists and awkward positions of the wrist could also lead to musculoskeletal problems (Hedge & Powers, 1995; Hunting et al., 1981; Carter & Banister, 1994). Hedge & Powers (1995) state that the wrist posture is more comfortable when the keyboard slope is on an adjustable downward (negative) elbow slope angle of approximately 0 – 25 degrees. This position forces the wrists to type in neutral and a slight flexion in the fingers that occurs naturally due to the position of the keyboard that is angled downward from the user (Hedge & Powers, 1995).

Hunting et al. (1981) observed that the lateral deviation of the hands increased with time when operating a straight and level keyboard. They also reported more pain and discomfort. The wrist joint is very flexible, and can work while flexed, extended, or deviated to the side, but if it is in any position other than neutral, there is a risk of increased muscle tension and tissue inflammation around the carpal tunnel area. This results in injuries such as tendonitis, tennis elbow, and carpal tunnel disease (Carson, 1994).

Head and Neck Region

The orientation of the head is determined by the location of the primary visual task (Hamilton, 1996; Psihogios et al., 1998). Therefore, how the TV screen is placed with respect to the user's body position will determine how the head will be positioned. A study by Hamilton (1996) found that with EMG studies, the greatest level of muscle tension was noted when the head was increased in either horizontal or vertical displacement from the center. Both flexion and rotation of the head produced significant results on muscle tension with EMG readings.

Psihogios et al. (1998) found that when the viewing angle is beyond 0 – 17 degree horizontal from the middle, the comfort of the users declined. This also would mean that muscle tension and stress that leads to cumulative trauma in the head and neck area may occur when they are deviant from the range beyond the neutral position.

Review of Methods from the Literature

Of the literature reviewed, some papers were field studies (Hunting et al., 1981; Grandjean et al., 1983) and others were experiments that showed results of awkward posture when participants interacted with a computer work station (Psihogios et al., 1998; Hamilton, 1996; Hedge & Powers, 1995; Bhatnager, 1985). They varied on what factors were studied, how the experiment was designed, and what instruments were used.

Video taping was used in many studies (Psihogios et al., 1998; Hamilton, 1996; Hedge & Powers, 1995; Bhatnager, 1985) to observe posture of the head, shoulder, trunk, or wrist. Along with other instruments, the review of video tapes assisted the researchers

in evaluating what postures resulted in pain or the most tension was seen in EMG reading.

Many studies (Psihogios et al., 1998; Hedge & Powers, 1995; Bhatnager, 1985; Hunting et al., 1981) had a survey or questionnaire that the participants filled out after the experiment on their level of pain or discomfort in various parts of their body after the experiment.

The number of participants varied according to the type of study. The field studies (Grandjean et al., 1983; Hunting et al., 1981) had a larger number of participants varying from 68 (Grandjean et al., 1983) to 295 (Hunting et al., 1981). The quasi-experimental studies varied from 12 (Bhatnager et al., 1985; Hamilton, 1996) to 20 (Psihogios et al., 1998; Hedge & Powers, 1995) participants in total. For the purpose of this study, 16 participants are chosen.

The study by Psihogios et al. (1998) used posture as the dependent variable with a quasi-experiment, within subjects design that was counter balanced. They measured posture in two ways: self reported discomfort and preference and a postural assessment that is quantified in the area of head tilt, neck angle, trunk angle, thoracic bending, and viewing angle. Through video tapes, researcher observation and participant survey, the results are determined. Similarly, for this study, observation of relevant postures by videotaping will be completed along with a self report preference after the observation.

METHOD

Participants

Sixteen participants were observed in a usability lab. The study was affiliated with Interface-Analysis lab and therefore, participants were selected from a participant list from the lab and/or appropriately selected from an Introductory Psychology class between the ages of 17 to 45. Participants were given \$30 for up to two hours and students were given credits towards their Psychology course.

Additional qualifications to participate in the study required that participants did not have any current or previous neuromuscular medical conditions (e.g., Carpal Tunnel or back injuries) that would effect their natural postures during the sessions. All participants were minimally familiar with basic web browsing and data entry techniques. Lastly, to participate in the study, the participants did not have previous experience or exposure with WebTV or other wireless computers used in the living room. All participants were asked to identify how many hours they typically interacted with the computer during web browsing and data entry. Each participant was identified with a number and only that number was used for the results. The participants were videotaped but their face was protected if their pictures were used for this thesis. The videotape was used only for research and further detail evaluation for the study. The key that matches the name and number of participant information (data and video) was locked in a safe with Dr. Andre with Interface-Analysis. This key will be destroyed after completion of the thesis and the videotape stored in a safe with Interface Analysis.

Equipment

Participants were seated on a couch while using a “living room” PC, and two wireless keyboards with a 27” TV during two tasks. For the purpose of the study, the keyboard length was an independent variable. The “long” keyboard was a Logitec keyboard with a 7 ½” X 18” length and width. The short keyboard was a Sejin Electron with a 6 ¼” X 11 ½” length and width. There was a coffee table in front of the couch for the users to interact with if they desired.

The Powerboard was used as an independent variable while performing the tasks. The Powerboard is a rectangular piece of plywood with a bean bag type of sac under the board. It also has an edge toward the back of the board so that when the keyboard is placed on it, it will not slide away. The Powerboard was originally designed to be used with a keyboard only. For the purpose of this study, the mouse attachment was not attached since a mouse was not needed.

Video cameras may be used for further detailed evaluations with a camera from an above angle, an angle from the side, and from the front. A TV screen will be in front of the participants while they are using a computer. The simulated living room will have an adjacent one-way mirror that leads to an observation room.

Design / Procedures

The design was a 2 X 2 X 2 mixed observation study. The dependent variable observed/measured was the posture during internet navigation tasks (web surfing) and data entry tasks (word processing). Posture was observed for five body (trunk, shoulder,

elbow, wrist, head/neck) areas. The first independent variable was the length of the keyboard (long and short), the next was the use of the platform (with platform and without platform, and lastly the type of task performed (web browsing and word processing). Each of the two tasks will be completed with a platform and without a platform.

Figure 2 - Pictorial Representation of Design of Experiment

Each subject received an observation point for the four tasks (web with platform, word with platform, web without platform and word without platform) for five body areas (see Appendix F). The primary observations being looked for were ideal and awkward postures for each body area. Ideal and Awkward postures for each body area were defined as:

Dependent Variable	Ideal Posture	Awkward Postures
1. Trunk Posture	Neutral	Forward, Slouched, Twisted
2. Shoulder Posture	Neutral	Abduction, Raised Shoulders
3. Elbow Posture	Negative-slope, Neutral	Positive-slope
4. Wrist Posture	Neutral	Flexion, Extension
5. Head/Neck	Centered	Forward

Table 1 – Ideal and Awkward postures

Identified participants that were recruited from the Interface-Analysis Lab list or an Introductory Psychology class. The students received credits and the other recruited participants received \$ 30 for up to two hours. A step by step process of choosing participants began with a screening process over the phone. From the screening, the participants were able to participate in the study if they were able to sit and type for about an hour without any discomforts or pain. Also, the participants did not have any experience with wireless products such as Web TV, and had minimal to moderate experience with the internet and word processing tasks. These provisions were used so the data achieved would reflect an unbiased, healthy population. The results could then be generalized to an inexperienced, healthy population using wireless technology in the living room. Without these provisions the awkward postures observed could have been the result of physical pain experienced from past injuries or postural habits formed from past exposure to wireless keyboard use in the living room.

The participants all signed an informed consent form before testing (see Appendix C) and filled out a demographics form (see Appendix B). Each participant was given a number for the paperwork and a standardized script was used for instructions (see

Appendix D). Four tasks were to be complete within approximate one hour. Each task was not evaluated on the quality or how much was completed but a fixed time of ten minutes was allotted to each task for organization.

The sixteen participants must interact with the wireless keyboard assigned to perform four tasks. Half the participants used a long Logitech wireless keyboard and the other half used a short sized Sejin Electron wireless keyboard. For the purpose of the study, with results and graphs, the number of long keyboard and short keyboard users each was counted as sixteen due to the use of data from both with and without platform use. The tasks were also counterbalanced for tasks and platform use or no platform use (see Appendix G).

The first condition was with use of the platform with a web browsing task for ten minutes and then the second task with a word processing task (see Appendix E). After the first task the experimenter comes in the main door to let the participants know ten minutes are up and that they should go on to the next task. The first two surveys (about each task) were administered and completed after the second task was performed (see Appendix H). For the second condition, the participants for ten minutes completed a web task without the support of the platform and then a word task without the platform. The next two surveys were about the two tasks from the second condition (see Appendix H). Finally, the participants were asked to complete a survey that compares the two Conditions: with a platform and without the platform (see Appendix H). After the survey forms are completed, the Debriefing Instructions are reviewed with the participants (see Appendix I).

Each task had a different focus while the participants interacted with the PC application: 1) focused Web searching and learning and 2) typing or editing email.

Examples of Task #1 (free web browsing or search/learn)

Find everything you can about vitamins and which ones boost your immune system.

How many web sites sell products such as ergonomic equipment to avoid carpal tunnel.

Find the stock price of 3Comm, Yahoo, and National Semiconductor.

Go to as many web sites as possible to find your favorite CD's for the best prices.

Examples of Task #2 (typing and edit or compose email)

Write a short paragraph about your career and future hope.

Write a letter to a friend you haven't seen lately about your life.

Write a short paragraph about a person you most admire and why.

Write a short paragraph about your childhood.

For statistical analysis, tables were used for each independent variable. A data table was developed to identify the observed awkward postures and a Chi-square statistical analysis was performed for the two main independent variables (keyboard length, and platform use) with the dependent variable (posture) for each task (web and word) separately. "The Chi-square is a technique that provides a statistical test as to the significance of the discrepancy between the observed and the expected results (Thomas & Nelson, 1996)." For the purpose of the study, the assumptions for a chi-square statistics

used for the three main effects are that “each observation is independent of all other observations in the study (Kepple, Saufley, & Tokunaga, 1992).

Then finally, a Log-Linear chi-square analysis was performed to identify the relationship or interactions between observed quantitative results. This analysis is a version of chi-square analysis in which the relevant values are calculated by way of weighted natural logarithms. A relationship between keyboard length, platform use, and posture for each task (web and word) separately is derived through calculations and combinations of the weighted logarithms.

Methods For Trunk Posture Observation

Figure 3 - "Forward" trunk posture

Figure 4 - "Neutral" trunk posture

Figure 5 - "Slouched" trunk posture

Figure 6 - "Twisted" trunk posture

Measured: Through video tape analysis, trunk angle was determined by identifying the relative distance from neutral trunk. One data score from the above four was given to each participant for each task condition (word with platform, word without platform, web with platform, and web without platform) that was 10 minutes long.

Definitions: The “forward” position occurred if the participant leaned forward away from neutral while sitting on the couch or sitting on the floor with or without back support. The “neutral” position was recorded if the trunk was perpendicular to the floor or couch. The “slouched” position occurred if the participant leaned back away from neutral and upper back and shoulder posture appeared rounded. Lastly, the “twisted” trunk was recorded if the participant leans to the side or the trunk had an awkward posture. The position of the trunk will effect the position of the lumbar curve and the amount of pressure that may result on the spine. The “slouched” posture, or movement away from the middle, makes the posture awkward and thus pain and discomfort can occur more easily. “The muscular strength is very limited in certain positions and an awkward position require muscles to work at or near their maximum capacity.” (Carson, 1994, p.271)

Methods For Shoulder Posture Observation

Figure 7 - Shoulder Abduction while sitting on the floor.

Figure 8 - Neutral shoulder while sitting on the couch.

Figure 9 - Raised Shoulder while sitting on the floor.

Measured: Through videotape analysis, the shoulder angle was determined by identifying the relative distance from neutral trunk. One data score from the above three was given to each participant for each task condition.

Definition: The shoulder angle was determined by observing the angle from the top of the shoulder joint to the elbow. If the elbows are positioned wide apart, the shoulder angle is recorded as “abduction.” If the arms (shoulder joint to the elbow) are located close beside the trunk, they are recorded as “neutral.” The “raised shoulder” position is observed and recorded if the shoulder is observed to be raised up towards the ears and away from chest. The shoulder and neck muscles are forced to raise the shoulder and arms up to fit the high keyboard height. The different shoulder postures were observed to be displayed during different sitting locations (on the floor or on the couch).

Methods For Elbow Posture Observation

Figure 10 - "Positive" angle seen while seated on floor.

Figure 11 - "Neutral" angle seen while seated on couch

Figure 12 - "Negative" angle seen while seated on the couch.

Measured: Through video tape analysis, each subject was given one score out of the above three for each four conditions. The elbow angle was recorded according to observed angle from elbow joint to the wrist joint.

Definition: A “positive” angle refers to the measurement of the angle to be from 150 to 90 degrees at the elbow. This is seen when the elbow is bent upwards and the forearm range is held from the top to a half bent elbow. The “neutral” angle is when the elbow is approximately at 90 degrees or the half bend elbow. Lastly, the “negative” angle ranged from 90 to 65 degrees; the forearm position ranged from the neutral position (90 degrees) to a dropped forearm position up to 25 degrees (65 degrees) (Hedge & Powers, 1995). This would allow a participant to relax their forearm while typing in a lower dropped forearm posture.

Methods For Wrist Posture Observation

Figure 13 – Wrist “flexion” observed while seated on floor

Figure 14 – “Neutral” wrist observed seated on couch.

Figure 15 - Wrist “extension” observed while keyboard is on the table.

Measured: Through video tape analysis, the wrist posture was measured by evaluating the angle and position of the wrist from the base of the wrist to the MCP (metacarpophalangeal) joint or the knuckles.

Definition: The wrist is measured with observed angles that are either flexed, neutral, or extended. Clarkson & Gilewich (1989) give basic definitions for the wrist positions as: “neutral” wrist is when the wrist is even and is at 0 degrees with the forearm, “flexed”

wrist is faced palm down with the angle that drops from 0 approximately 80 degrees when angle is measured from the side of the wrist, and “extension” is recorded when the wrist is palm faced down and the wrist is raised from 0 to approximately 70 degrees.

Methods For Head And Neck Posture Observation

Figure 16 - “Centered” head posture during word processing

Figure 17 - “Forward” posture observed during web browsing

Measured: Through videotape observation and analysis, the head position was subjectively observed to be relaxed in centered position approximately over the shoulders or the participants were observed to lean forward with the head extended outwards and away from the shoulder position.

Definition: The head and neck area is divided into two categories. One is “centered” which identified if the head sits comfortably over the shoulders and the neck muscles do not appear to be stretched in any position (left, right, up, down or outward). The “forward” position was observed when the head was leaning forward away from the shoulders. Many times, this is observed during web browsing tasks when the front on the TV was small and participant was forced to lean forward to see the letters.

RESULTS

The results are divided up among the three main factors: use of the platform (present vs. absent), keyboard length (short vs long), and type of task (Word vs Web). We first review the main effects for Keyboard Platform for web and word tasks separately. Then a review of Keyboard Length will be discussed for web and word tasks. Next, a discussion of the relationship or interactions between the three variables will be completed. Added discussion about the observations for sitting behaviors and survey data results ends the discussion. The main effects statistical data for all three factors was determined by the chi-squared test and the interaction results were determined by the Log Linear chi-squared test. Below is statistical data of p-values for the three factors.

P-Values for Platform Use and Keyboard Length with Web and Word tasks.

	No Platform versus Platform		Long versus Short	
POSTURE	WEB	WORD	WEB	WORD
Trunk	0.5539	0.4691	0.2637	0.9798
Shoulder	<u>0.0718*</u>	0.2019	0.2841	<u>0.0498*</u>
Elbow	0.4786	0.4786	<u>0.0226*</u>	0.4528
Wrist	1.0000	0.8854	0.097	0.3343
Head/Neck	0.4795	0.1441	0.4795	0.4652

*Double underline denotes significant results ($p < 0.05$)

*Single underline denotes marginally significant results

Table 2 – P-Value Summary

Effects of Keyboard Platform

Trunk posture. The effect of the Keyboard Platform (with vs. without) for trunk posture did not reach statistical significance for the web ($p = 0.55$) or word tasks ($p = 0.46$). Overall, more than half the subjects were in neutral posture and than majority displayed forward leaning at the trunk.

Figure 18 - Trunk Posture – Web Tasks

Figure 19 – Trunk Posture – Word Tasks

Shoulder posture. The effect of the platform for shoulder posture reached marginally statistically significant for web tasks ($X^2 = 5.27$, $p = 0.07$) but for word ($p = 0.21$) tasks it did not reach statistical significance. For web tasks the shoulder posture was more neutral with the platform compared to more abduction observed (awkward posture) when the platform was not used.

Figure 20 – Shoulder Posture – Web Tasks

Figure 21 – Shoulder Posture – Word Tasks

Elbow posture. The effect of the platform for elbow posture did not reach statistical significance for web ($p = 0.48$) or word ($p=0.48$) tasks. Most participants demonstrated negative-slope elbow posture with the positive-slope seen second most common.

Figure 22 – Elbow Posture – Web Tasks

Figure 23 – Elbow Posture – Word Tasks

Wrist Posture. The effect of the platform for wrist posture did not reach statistical significance for web ($p = 1.0$) or word ($p = 0.89$) tasks. With both tasks and platform use, wrist extension was observed more often than flexion or neutral wrist posture.

Figure 24 – Wrist Posture – Web Tasks

Figure 25 – Wrist Posture – Word Tasks

Head/ Neck Posture. The effect of the platform for head/neck posture did not reach statistical significance for web ($p = 0.48$) or word ($p = 0.14$) tasks. Both head/neck postures were equally observed to be centered or forward.

Figure 26 – Head/Neck Posture – Web Tasks

Figure 27 – Head/Neck Posture – Word Tasks

Summary. No other measure except for one marginally statistically significant measure for web tasks (shoulder posture) was observed with platform use. However, for most measures, using the platform did consistently show many benefits to the posture of the trunk, shoulder, elbow, and head and neck. While there was only one marginally statistically significant measure (shoulder posture for web tasks) that showed differences between these two conditions. Looking across all measures, there is a consistent trend for the Keyboard + Platform condition to produce less awkward postures than the keyboard alone condition.

	Keyboard	Keyboard with Platform
Trunk		
Shoulder		
Elbow		
Wrist		
Head/Neck		

Table 1 - List of rank differences in awkward posture observations

Shaded and checked cells represent fewer awkward posture observations.

As seen in the above chart, a trend demonstrates that the keyboard with the platform condition produced fewer awkward postures for the trunk, shoulder, elbow and head/neck measures. With platform use for both tasks, benefits such as more neutral posture was seen for the trunk, for the shoulder, more negative-slope angle for the elbow, and more centered head posture. The wrist was the only measure in which the wrist extension (an awkward posture) was seen with or without the platform. Thus, the platform did not assist towards an ergonomic posture for the wrist. For all measured areas of the body except the wrist, the platform appears to assist with the “ideal posture” and therefore, less awkward postures that would lead to musculoskeletal injuries.

Effects of Keyboard Length

Trunk Posture. The effects of the keyboard length (short vs long) for trunk posture did not reach statistical significance for web ($p = 0.26$) or word ($p = 0.98$) tasks. Although, both keyboard types demonstrated neutral posture the most and forward posture second.

Figure 28 – Trunk Posture – Web Tasks

Figure 19 – Trunk Posture – Word Tasks

Shoulder Posture. The effects of the keyboard Length (short vs long) for shoulder posture did not reach statistical significance for web ($p=0.28$) but did reach statistical significance for word ($\chi^2=6.0$, $p<0.05$) tasks. Even if there was an effect for word tasks, each keyboard fosters up awkward postures and neither one can be said to be of benefit. Although, both keyboard types fostered an ideal neutral shoulder posture the most (63%), the long keyboard showed more abduction (38%) when compared to the short (13%) keyboard. With the short keyboard, more raised shoulder (25%) was observed when compared to the long (0%) keyboard. Both abduction and raised shoulder are undesirable postures to have over an extended period of time.

Figure 20 – Shoulder Posture – Web Tasks

Figure 31 – Shoulder Posture – Web Tasks

Elbow Posture. The effects of the keyboard Length (short vs long) for elbow posture reached statistical significance for web ($X^2=7.58$, $p=0.02$) but did not reach statistical significance for word ($p=0.45$) tasks. For web tasks, negative-slope (safe ergonomic posture) was observed more with the long keyboard (81%) compared to the short keyboard (38%). In this case, the long keyboard fosters a negative-slope posture but with the short keyboard, no difference was seen between the negative-slope and positive-slope with 38% for both postures.

Figure 32 – Elbow Posture – Web Tasks

Figure 33 – Elbow Posture – Word Tasks

Wrist Posture. The effects of the keyboard Length (short vs long) for wrist posture did not reach statistical significance for web ($p = 0.10$) or word ($p = 0.33$). Overall, most participants demonstrated wrist extension posture.

Figure 34 – Wrist Posture – Web Tasks

Figure 35 – Wrist Posture – Word Tasks

Head/Neck Posture. The effects of the keyboard Length (short vs long) for head and neck posture did not reach statistical significance for web ($p = 0.48$) or for word ($p = 0.47$) tasks. Overall, equal amount of centered and forward head/neck posture was observed.

Figure 36 – Head/Neck Posture – Web Tasks

Figure 37 – Head/Neck Posture – Word Tasks

Summary. Two measures were significant for Keyboard Length: 1) for word tasks shoulder posture and 2) for web tasks the elbow posture. Some measures were significant, but the direction of results varied as some favored the long and others favored the short keyboard. During the word task, the shoulder posture had less abduction (an awkward posture) with the short keyboard. During the web task, the elbow posture had more negative-slope angle with the long keyboard. While there was two significant statistical differences between these two conditions, looking across all measures, there is no consistent trend for the Long Keyboard or the Short Keyboard condition to produce less awkward postures.

	Long Keyboard	Short Keyboard
Trunk		✓
Shoulder		
Elbow	✓	
Wrist		
Head/Neck		✓

Table 4 - List of rank differences in awkward posture observations
Shaded and checked cells represent fewer awkward posture observations. Clear cells represents that neither one benefited.

As seen from the above chart, the participants were in awkward postures most of the time over many of the measured that were observed. More detrimental postures were observed and many times neither condition was considered to have benefited. It appears as though awkward postures were more apparent rather than safe, ergonomic postures with the short and long keyboards.

Interactions

Log-Linear chi-squared (G^2) analysis was performed to identify the relationship or interactions between observed quantitative results. This analysis is a version of chi-square analysis in which the relevant values are calculated by way of weighted natural logarithms. A contingency table is derived through calculations and combinations of the weighted logarithms.

It was used to see the possible interactions between the two factors (Keyboard Length and Platform Use) and the dependent variable (posture) for each task (web and word) separately. The only statistical significant result ($p=0.05$) found was for elbow posture during web tasks.

Elbow Posture: From the results of main effects, Keyboard Length and the elbow posture showed statistical significance ($X^2=7.58$, $p = 0.02$): the long keyboard to be used during web tasks to foster negative slope angle. The posture of the elbow ($G^2 = 14.06$, $p = 0.05$) for web tasks was the only one measures that was significant with the interaction results of platform use, keyboard length and web task. Therefore, the relationship of Keyboard Length and Elbow Posture holds but with the long keyboard there is a magnitude of the effect (negative slope angle) when the platform is introduced (see Fig 38). In contrast, the elbow posture was not affected by the platform when it was used with the short keyboard. Regardless of whether the platform was used, elbow posture did not differ during short keyboard use.

As seen in Fig. 39, the elbow posture was affected with the use of the platform during use of the short keyboard. With the short keyboard, a positive-slope (awkward posture) increased (see Fig. 39) when the platform was used. The results are consistent but show the other side of the coin compared to the negative elbow posture and platform use.

Figure 38 – Interaction – Web Tasks – Negative Slope Elbow Posture

Figure 39 – Interaction – Web Tasks – Positive Slope Elbow

Sitting Behaviors Observed

Sitting Behavior. Sitting behaviors affected posture dramatically by either sitting on the floor or sitting on the couch. Overall, most participants sat on the couch instead of sitting on the floor. More participants during web tasks with the platform sat with their back against the couch with the keyboard on their lap verses sitting on the floor. This posture is a more neutral and ergonomic sitting posture rather than sitting on the floor or sitting on the edge of the couch.

Figure 40 – Sitting Positions with Platform During Web Tasks

Figure 41 – Sitting Positions With Platform During Word Tasks

Posture Trends while Sitting on the Floor:

Figure 42 – Shoulder Posture – Sitting on Floor

Figure 43 – Elbow Posture – Sitting on Floor

Figure 44 – Wrist Posture – Sitting on Floor

Figure 45 – Keyboard Placement – Sitting on Floor

There are trends analyzed in body posture while sitting on the floor. Only three participants out of sixteen sat on the floor throughout the one hour session. Using the keyboard alone while seated on the floor showed one thing that was different than using the keyboard and platform together. Two out of three participants abducted their shoulders to place the elbows and forearms on the table while typing or web browsing. None of the participants abducted their shoulders when the platform was added. Instead, all three raised their shoulders with tasks while sitting on the floor and none of the

keyboard alone participants demonstrated that. Overall, sitting on the floor fostered two awkward postures such as shoulder abduction and raised shoulders

The similarities in their posture was that they all demonstrated positive elbow posture, two out of three demonstrated wrist extension, and all three placed the keyboard on the table. This posture is not comfortable or healthy for long term use of a wireless keyboard being used in the living room. Sitting on the floor certainly has hazards associated with posture that should be avoided to prevent injuries to the body.

Posture Trends while Seated on the Couch:

Figure 46 – Shoulder Posture on Couch

Figure 47 – Elbow Posture on Couch

Figure 48 – Wrist Posture Seated on Couch

Figure 49 – Keyboard Placement Seated on Couch

There are nine participants that sat on the couch throughout the one hour session. The posture analyzed is different from the group of participants that sat on the floor. For the shoulder, six out of nine demonstrated neutral posture for both the keyboard alone and keyboard and platform conditions. With the elbow posture, differing from the participants sitting on the floor, five out of nine demonstrated negative elbow posture with the keyboard alone posture and for the keyboard and platform, seven out of nine. With the wrist posture, the posture was similar to sitting on the floor in that the participants for both conditions (keyboard alone and keyboard and platform) demonstrated wrist extension.

Other Observed Behaviors:

Figure 50 – Other Observed Behaviors

The participants in the short keyboard without a platform group appears to show the most incidents of other behaviors and the group with the short keyboard and platform demonstrated them the second most. The long keyboard on the other hand had very few behaviors with or without the platform. This may be due to the stability of the long keyboard.

One unsafe behavior is when the participants place the “forearms on the lap” which occur during web browsing when one hand is free to rest on the lap. Also, during typing when the keyboard is resting on the lap, closer to the knees, the forearms are resting on the thigh area. This forces the back to lean forward and the neck and shoulder muscles to stretch downwards so that the forearms can rest on the lap.

An unsafe behavior of placing the “forearm on the table” occurs when the participant is leaning forward to type while seated on the couch or seated on the floor. The forearms are resting on the edge of the coffee table during the tasks. This posture is

seen with traditional work desk environment in which the wrists and the forearms rests on the table. This causes wrist extension while the carpal tunnel is resting on the hard surface of the table. The forearms are also resting on the hard coffee table surface and at times resting on the edge of the table.

Survey Comparison: Preference for Keyboard vs Keyboard and Platform.

Keyboard alone with word tasks:

After completing the word tasks, all sixteen participants completed a survey (Appendix H) that rated different aspects using the keyboard alone. Each category was given a value from 1 to 5. One being very easy and five being very hard. The larger the weighted average the more difficult it was perceived.

	Very Easy (1)	Somewhat Easy (2)	Average (3)	Somewhat Hard (4)	Very Hard (5)	Weighted Average
Ability to type accurately	3	6	2	3	2	2.69
Ability to type quickly	3	4	4	2	3	2.88
Ability to type desired keys without mistakes	1	5	4	3	3	3.13
Ability to type desired keys with speed	3	4	3	5	1	2.81
Ability to type without fatigue to any muscle groups.	2	5	7	1	1	2.63
Ability to stabilize the keyboard while typing	6	4	2	3	1	2.31
Ability to easily position keyboard to type	5	5	2	4	0	2.31
Ability to type with comfort.	4	5	6	1	0	2.25
Overall Ability to type in an efficient manner	3	3	4	5	1	2.88

Table 5 – Survey Results – Preference for Keyboard Alone (Word Tasks)

Platform and keyboard with word tasks:

	Very Easy (1)	Somewhat Easy (2)	Average (3)	Somewhat Hard (4)	Very Hard (5)	Weighted Average
Ability to type accurately	2	7	2	1	4	2.88
Ability to type quickly	4	1	3	4	4	3.19
Ability to type desired keys without mistakes	3	3	3	3	4	3.13
Ability to type desired keys with speed	3	3	2	5	3	3.13
Ability to type without fatigue to any muscle groups.	2	6	4	3	1	2.69
Ability to stabilize the keyboard while typing	4	8	1	2	1	2.25
Ability to easily position keyboard to type	3	8	3	2	0	2.25
Ability to type with comfort.	3	7	3	3	0	2.38
Overall Ability to type in an efficient manner	2	4	2	7	1	3.06

Table 6 - Survey Results – Preference for Keyboard with Platform (Word Tasks)

Graphs for Comparison of Keyboard without Platform and With Platform.

Figure 51- Survey Question #1

With a small difference, greater number found it easier to type accurately without the platform.

Figure 52 – Survey Question #2

Greater number found it "somewhat easy" without the platform to type quickly.

Figure 53 – Survey Question #3

Not much difference was seen with or without platform to type desired keys without mistakes.

Figure 54 – Survey Question #4

With a small difference, a greater number found it easier to type desired keys with speed without the platform.

Figure 55 – Survey Question #5

With a small difference, greater number found it easier to type without fatigue to any muscle group without the platform.

Figure 56 – Survey Question #6

Greater number felt strongly that the use of the platform helps stabilize the keyboard while typing.

Figure 57 – Survey Question #7
Greater number felt strongly that the use of the platform helps easily position keyboard to type.

Figure 58 – Survey Question #8
With a small difference, greater number felt that it was easier to type with comfort without the use of the platform.

Figure 59 – Survey Question #9
Greater number found it easier to type in an efficient manner without the platform.

Summary.

For the word tasks with the platform, only two dimensions out of nine rated higher when the weighted average was calculated. One was "The ability to stabilize the keyboard while typing, and the other was "The ability to easily position keyboard to type." Six out of nine were rated lower with the platform such as accuracy, speed, comfort, and overall effectiveness. Only one measure, "type without mistakes" was considered the same between with or without platform use. With many of the measures being marginally different, overall the participants did not prefer to use the platform with keyboard for many of the aspects.

Keyboard alone with Web tasks:

After completing the web tasks, all sixteen participants completed a survey (Appendix H) that rated different aspects using the keyboard alone. Each category was given a value from 1 to 5. One being very easy and five being very hard. The larger the weighted average the more difficult it was perceived.

	Very Easy (1)	Somewhat Easy (2)	Average (3)	Somewhat Hard (4)	Very Hard (5)	Weighted Average
Ability to easily read text on the screen.	0	2	1	8	5	4.00
Ability to move the cursor	0	3	6	4	3	3.44
Ability to click on links and buttons	0	2	6	4	4	3.63
Ability to view graphics	1	2	6	5	2	3.31

Table 7 – Survey Results – Preference for Keyboard Alone (Web Tasks)

Keyboard and Platform with Web tasks:

	Very Easy (1)	Somewhat Easy (2)	Average (3)	Somewhat Hard (4)	Very Hard (5)	Weighted Average
Ability to easily read text on the screen.	0	1	1	8	6	4.19
Ability to move the cursor	1	3	5	5	2	3.25

Ability to click on links and buttons	0	2	4	5	5	3.81
Ability to view graphics	1	5	3	4	3	3.19

Table 8 - Survey Results – Preference for Keyboard with Platform (Web Tasks)

Figure 60 – Survey Question #1

Not much difference with or without Platform to read text on the screen.

Figure 61 – Survey Question #2

Ability to move the cursor was better with the platform.

Figure 62 – Survey Question #3
Both with and without platform found it difficult to click on links and buttons.

Figure 63 – Survey Question #4
Ability to view graphics was "somewhat easy" with the platform.

Summary.

From the results, the use of the platform was not obviously better for the web tasks. Out of four questions, the platform did not rate well with: the "Ability to read text on the screen", and the "Ability to click on links and buttons." The platform did better with: "Ability to move the cursor" and "Ability to view graphics." From the results, it

shows that the subjects were not consistent with their preferences. Therefore, with the web tasks, the platform did not seem to have consistent results and thus the platform use can not be stated to be a benefit.

Final Comparison with use of Platform with Long keyboard

These sets of questions specifically were targeted and surveyed at the end of the study to evaluate the subjective opinion of the subjects to compare the experience with the platform and without the platform. Since half of the subjects (eight) used the long and the other half used the short keyboard, the results are divided as such.

	Keyboard Alone	Keyboard Plus Platform	Same
Easiest to type with	3	4	1
Less mistakes made during tasks	2	3	3
Easiest to position keyboard while typing	3	4	1
Muscles of the upper body relaxed	1	3	4
Muscles of the lower body relaxed	1	3	4
More comfortable to use	3	5	0
Less fatigue during use	2	5	1
Position of wrists and elbows comfortable	3	2	3
Position of head comfortable	1	4	3
Position of shoulders comfortable	1	4	3
Position of back	1	3	4

comfortable			
Easiest to stabilize keyboard	2	6	0
Best for typing in Word	4	4	0
Best for interacting with the Web	2	5	1

Table 9 – Survey Results – Long Keyboard – Number of People Preferring Platform versus No Platform

Summary.

It is clear that the subjects preferred the use of the long keyboard with the platform rather than the keyboard alone. Subjects reported in favor of using the platform was 8 out of 14 questions, and subjects that reported the experience to be the “same” was 3 out of 14. The rest of 3 out of 14 was a tie between the three categories. A preference of using the keyboard alone without the platform did not get a majority from any of the questions.

Some questions had an overwhelmingly positive effect for the use of the platform. Some of these were comfort, less fatigue, easy to stabilize, to interact with the web and position the head and shoulders. The responses that were considered the same were related to relaxing the muscles of the upper and lower body, and the muscles of the back.

Final Comparison with use of Platform with Short keyboard:

	Keyboard Alone	Keyboard Plus Platform	Same
Easiest to type with	5	1	2
Less mistakes	5	0	3

made during tasks			
Easiest to position keyboard while typing	5	2	1
Muscles of the upper body relaxed	5	1	3
Muscles of the lower body relaxed	3	0	5
More comfortable to use	6	1	1
Less fatigue during use	5	1	2
Position of wrists and elbows comfortable	8	0	0
Position of head comfortable	3	3	2
Position of shoulders comfortable	2	2	4
Position of back comfortable	2	1	5
Easiest to stabilize keyboard	5	3	0
Best for typing in Word	5	1	2
Best for interacting with the Web	5	1	2

Table 10 – Survey Results – Short Keyboard – Number of People Preferring Platform versus No Platform

Summary.

When comparing the effects of the platform on the short keyboard, the results were completely the opposite to the long keyboard. With the short keyboard without the platform 10 out of 14 questions were reported it to be better, 1 out of 14 was a tie between with or without a platform, 3 out of 14 questions were the “same.” The platform to be used with the short keyboard did not have any measures that was better.

The questions they perceived was the “same” were related to the relaxation of the lower body muscles, and the position of the shoulders and back. For the position of the head there was a tie between with and without the platform use.

The other ten questions were reported for the use of the short keyboard without the platform or using the short keyboard alone. With the survey results, it shows that the participants felt that with the short keyboard alone, typing was easier with word, during web surfing their were fewer errors, and it was easier to position and stabilize the keyboard with less fatigue and more comfort was achieved. The short keyboard alone was also reported to enhance relaxation of the upper body, wrists, and elbows.

DISCUSSION

As shown by the data analysis, the null hypothesis, “there is no difference on posture in a living room setting with or without use of a Platform”, can’t be rejected. There is not enough statistical evidence to suggest that when the Platform is used in a living room setting, posture is impacted for either word or web tasks. However, there are consistent trends that indicate that the Platform does make a positive impact on posture. Additionally, the null hypothesis, “ there is no difference for Keyboard Length on posture in a living room setting,” can not fully be rejected. Statistical significance was seen for elbow posture with web tasks and shoulder posture with word tasks. Evidence from the data shows that Keyboard Length and Computer Task do affect certain aspects of user posture.

Since this is the first study to examine the effects of posture in a living room setting while seated on a couch or the floor, it is not possible to compare these results with those from previous studies. This study explored factors such as Platform use, Keyboard Width, and Computer Task on five different target areas of the body. The body postures that were observed during the study for each factor were: a) Trunk posture, b) Shoulder posture, c) Elbow posture, d) Wrist posture, e) Head/Neck posture. The subjective data was reviewed along with other behaviors that occur in a living room such as sitting behaviors. The findings of the study were reviewed, keeping in mind the possible reason for the results and their ergonomic implications.

Effects of Platform

Summary. Platform use does have advantages in a living room setting. While seated on a couch, some important postural measures benefited with the use of the platform. With web tasks, shoulder posture benefited the most. There was also some benefit to the trunk, elbow, head, and neck. With word tasks little difference was seen with platform use. Additionally, the platform encouraged sitting back into the couch with the back supported while the platform was placed on the lap. Research shows that when the back is supported, it may prevent future discomfort and injuries (Hedges & Powers, 1995).

Trunk. Platform use did not make a statistically significant difference with either web or word tasks. The neutral trunk posture was observed almost equally, although, while using the platform, there was a slightly greater number of neutral postures and no slouched postures recorded. This is consistent with the theory that the platform helps keep the trunk posture neutral, in this case, even while seated on a couch.

Figure 65 - The platform allowed for a neutral trunk posture seated on the couch.

Shoulder. With web tasks, statistical significance was almost reached ($p=0.07$).

The platform condition allowed for a more neutral posture for the shoulder with both web and word tasks. This may be due to the weight and the design of the platform as it can easily be conformed and used on the couch while being placed on the lap. Placing something on the lap forces the user into a neutral shoulder and trunk posture. In addition, shoulder abduction (which is an undesired posture) was observed less with the platform. Perhaps this was due to the lack of structure without the platform; the wrists and arms are stretched outward so the upper body is out of balance.

Elbow. Elbow posture was significantly effected by the use of the platform for both web and word tasks. The subjects demonstrated a negative-slope posture when the platform was used and a positive-slope posture when it was not used. A negative-slope elbow posture exhibits less stress on the upper body muscles and therefore is considered better for the health of the human body over time (Hedges & Powers, 1995). By placing the keyboard on the lap while it is safely supported by the platform, the arms and elbows are naturally positioned in a negative-slope posture. Perhaps without the platform, users raised their legs and thighs to create support, but in so doing, also raised their elbows.

Figure 66 - The keyboard and platform fostered more negative elbow posture.

Wrist. The platform did not significantly effect wrist posture for either web or word tasks. Regardless of whether the platform was used, significant wrist extension was observed. This may be because people are habituated to rest wrists down while typing. Wrist posture is believed to be optimum when it is at neutral during any typing (Carson, 1994) .

Figure 67 - Wrist extension observed while resting wrists on the edge.

Head/Neck. When the platform condition was compared to the keyboard alone condition, there were more observances of a centered head posture with the platform for both web and word tasks. A neck posture that is close to centered is believed to be ideal for the health of the neck muscles (Psihogios et al., 1998). The results show that with the use of the platform, the posture of the body was neutral, fostering a centered head posture rather than a posture with the head extended forward.

Effects of Keyboard Width

Summary. Results with the two keyboard widths, long or short, did not significantly favored either keyboard type for a safer posture with either web or word tasks. The short keyboard appears to be beneficial for the trunk, and head/neck, however, the long keyboard appears beneficial for the elbow. For the shoulders and wrist they both have their benefits and areas of concern.

Trunk. Although not statistically significant for web tasks, the long keyboard had more observances of awkward postures of leaning forward, slouching, and twisting. The short keyboard appears to be more beneficial for trunk posture as this showed the most neutral and forward postures for both web and word tasks. This may be due to the instability of the short keyboard which forced the subject to sit in stable neutral trunk posture.

Figure 68 - The short keyboard enhances a neutral trunk posture.

Shoulder. With statistical significance for word tasks, the results show that the long keyboard encouraged more abduction but the short keyboard encouraged raised shoulders. The abductions may be due to the subjects placing and using the long keyboard on the coffee table while sitting on the edge of the couch or placing and using the keyboard on the coffee table while sitting on the floor.

The raised shoulder may be due to the short keyboard keys being closer together, forcing the arms to be close to the trunk and thus contracting the shoulder and neck muscles which raises the shoulders. Shoulder abduction and raised shoulder posture are both undesirable postures that cause stress on the shoulder muscles. Even though this was a significant result, neither the long or short keyboard benefited since both fostered awkward postures.

Figure 69 - With the long keyboard abduction observed while sitting on the floor.

Elbow. It is beneficial for the health of the upper body muscles to maintain a downward slope angle called the negative-slope posture with the elbow. With statistical

significance for web tasks, the long keyboard fostered a negative-slope posture. With the short keyboard, not much difference was seen between the negative-slope and positive-slope elbow angle. The long keyboard in this case appears to be beneficial for the elbow angle because the design may act like the platform. The greater stability allows the arms to be placed in a relaxed and natural position of the negative-slope angle.

Figure 70 - The long keyboard is easily placed on the lap.

Wrist. Both flexion and extension are away from the ideal neutral wrist posture. The long keyboard had a slight incline on the keyboard forcing the wrists to extend to use the keys whereas the short keyboard was flat. The short keyboard, therefore, seems to assist more with a neutral wrist posture. This neutral posture is believed by researchers (Carson, 1994) to be the best posture.

Head/Neck. With both web and word tasks, the short keyboard fostered a more centered posture. Perhaps the short keyboard was not stable enough to risk moving the body forward. Most of the time when the neck is extended forward, the trunk also moves forward. Therefore, one must have stability of the keyboard and the trunk before the body or neck can extended forward.

Other Observed Behaviors and Postures:

Sitting Postures. Back support is believed to assist the body to be relaxed and the muscles to be supported during the tasks. Subjects' posture is believed to be ideal when sitting back in the couch (Andersson, 1987). This was observed most often during the use of the platform.

The sitting posture most often adopted by the subjects was to sit back in the couch when the platform was used during word tasks. This condition gave the subjects a stable working area where their body posture was comfortable without straining the trunk, shoulder, elbow, wrists, or head/neck.

Figure 71 – Common Sitting Posture on Couch

Other behaviors. Many other behaviors were observed throughout the study, including some unsafe posture behaviors. The subjects with the short keyboard without a platform group exhibited the most incidents of other unsafe behaviors. This may be due to the instability of the short keyboard causing increased movement and postural shifting.

One of the unsafe behaviors seen was the “forearm on the table.” This occurred when the subject was leaning forward while seated on the couch or seated on the floor. The forearms were resting on the edge of the coffee table during the tasks. This is an unsafe behavior that has potential to cause discomfort to the muscles and nerves by contact stress. This posture has been seen with the traditional work desk environment in which the wrists and, at times, the forearms rest on the table. This causes wrist extension while the carpal tunnel and/or forearm muscles are resting on the hard surface of the coffee table.

Figure 72 - Contact stress observed on wrist.

Some other unique behaviors that were observed were the use of the platform upside down with the short keyboard placed on top of the bean bag and also lying down on the couch. Turning the platform upside down solved two problems; the edge of the

platform no longer rubbed along the wrist and the sensor of the keyboard was no longer blocked. However, the edge of the platform did put pressure on the thighs causing some discomfort.

Figure 73 - Platform turned upside down for the short keyboard.

Lying down on the couch was seen rarely in the experimental environment but may be occurring more often in the real living room environment. Twisting and lying down causes stress on the back, upper body, and lower body muscles.

Figure 74 - Lying down on the couch causing twisting and damage to muscles.

Subjective Survey Data for Long and Short Keyboards with Platform.

The subjective results are consistent with the postural observation results of the long keyboard and platform. Specifically, the long keyboard was overwhelmingly chosen to fit with the platform better than the short keyboard from many aspects.

Long Keyboard. Perhaps the long platform is shaped easily to fit with the design of the platform. Therefore, as reported by the subjects the platform is able to easily support the keyboard and thus perform its functions to position and support the shoulders. As a result, the subjects felt less fatigue and were more comfortable.

Short Keyboard. The difficulty reported in stabilizing or positioning the keyboard and platform may be due to the small size of the keyboard. It did not fit well on the platform, and slid from side to side, making it difficult to support and place it on the platform.

Another reason subjects preferred the short keyboard without the platform was because the platform could not be used as it was designed with the edge away from the body as on the longer keyboard. The wireless sensor was blocked with the platform edge when it was on the outside. Because of this, the platform was turned around with the edge right under the wrists causing some people to rest their wrists on the edge, around the carpal tunnel, resulting in some discomfort in the upper body, wrists, and elbow.

Subjective Survey Data for Web and Word Tasks with Platform.

Unlike the subjective data for Keyboard Width in which the long keyboard was preferred with the platform, the task results were mixed. No preference for the platform was seen for Web tasks, and for most of the measures during Word tasks the participants preferred to type without the platform. Although, the weighted averages for the various measures showed that the platform was easier to use with the word tasks (range of 2.88 to 3.19 out of 5) than with the web tasks (range of 3.19 to 4.19 out of 5).

Word Tasks. “Stabilization” and “positioning,” two aspects of platform use, were rated “easy” when the platform was used. Perhaps some of the participants had previous experience with structured and traditional work station environments with a solid table on which to place their keyboards, making it easier to become habituated to the platform. Other aspects such as accuracy, speed, and comfort were rated to be more difficult with platform use. Perhaps this was the result of getting familiar with a new piece of equipment. Overall, the platform was not preferred during word task performance.

Web Tasks. The use of the platform was not consistently preferred for the web tasks. Out of four questions, the platform was rated lower with: the “Ability to read text on the screen,” and the “Ability to click on links and buttons.” The platform did a bit better with the: “Ability to move the cursor” and “Ability to view graphics.” With the

web tasks, the platform did not seem to have consistent results and thus platform use can not be stated to be a benefit for the web tasks.

Final Summary.

In this study, three factors were researched in a living room computing setting: platform use, keyboard width, and computer task. The effects of these factors were observed with respect to various areas of the body that may be at risk of injury and other ergonomic related behaviors. In addition, to determine if the participants' preferences and opinions differed from the observations, subjective surveys were also administered.

The postures observed in the living room setting are somewhat different from postures seen during the use of a computer on a traditional computer workstation. In the traditional workstation, trunk/back is mostly supported with ergonomic chair with armrests whereas while sitting on a couch the back is not always supported and the armrests are not easily accessible and adaptable for good posture. The shoulder, elbows, and wrist are mostly in a structured environment with limited amount of mobility options when sitting in a computer station. Due to the keyboard being fixed on a desktop, the shoulders are in neutral, and the elbows do not sway too far away from neutral (90 degree angle). Although, the wrists being more flexible, wrists can be seen in extreme extension and flexion due to habits and/or the fixed keyboard height (too high or too low). Lastly, the head is fixed on the monitor in neutral with very little movement.

Platform Use:

Even with only one marginally significant finding (shoulder posture), use of the keyboard platform made a positive ergonomic postural difference across all of the measures except for the wrist. The key attribute of the platform is to provide “stability” especially with the long keyboard. Thus, when using the platform with the long keyboard, participants were more likely to place the keyboard on their laps while sitting on the couch. This behavior allowed the trunk and shoulders to be neutral and the elbow to be at a negative slope. These postures have been identified as “safe” postures in recent research (Hedge & Powers, 1995). Although the platform appeared to benefit posture, especially for Web tasks, the participants were not aware of how much the platform was affecting their behaviors and postures.

The results from this study are similar to the study by Nelson (1999) in that when the Powerboard was placed on the lap seated normally on a computer chair, muscles around the neck, shoulder, and wrist appears to be safer. Eventhough the study conducted by Nelson (1999) was in a traditional workstation setting, the effects of the Powerboard seem to be beneficial. Similar to this study, when the Powerboard was tested in the living room setting many postural measures were more ergonomically safe.

Advantages of using a Platform:

1. Provides stability for a long keyboard so that it is comfortably placed on the lap
2. Provides comfort and safety while seated on the couch
3. Conforms upper body (head/neck, shoulders, and elbows) into a safe posture

4. Restricts unsafe behaviors such as sitting on the floor and lying down on the couch during computer use

Disadvantages of using a Platform:

1. Platform edge restricts wrist movements and puts pressure on carpal tunnel if used improperly with the edge on the inside.
2. The platform does not allow for keyboard types such as the short keyboard to be used with the platform edge away from you. The wireless sensor is blocked by the platform edge if used as it is designed with the edge on the outside.
3. The platform edge is not flexible in that it does not have an option to remove it.

Keyboard Width:

With regards to the keyboard width, some measures favored the long keyboard (the elbow with statistical significance) while others favored the short keyboard (trunk and head/neck without statistical significance). Measures such as shoulder and wrist posture were negatively affected by both. The behaviors and postures observed with the short and long keyboard were somewhat consistent with the survey results: The long keyboard was preferred when used with the platform, while the short keyboard was preferred when used alone.

Computer Task:

The type of task that is performed (web browsing or word processing) appeared to also influence the behaviors and postures. During web tasks, behaviors such as

leaning forward and extending the head and neck outward were apparent. This finding is consistent with those of English and Andre (1999). The observation findings from the web browsing tasks were not consistent with the findings from the participant survey and preference data. The observations show that the platform when used with the long keyboard significantly improved posture compared to the survey results show that the subjects did not like the platform and felt it did not improve their performance during web browsing tasks. Perhaps the platform limited their freedom to take on a variety of postures that may have been unsafe.

As seen with the consistency of data from the participants' surveys and observations made by the researcher, with word tasks participants were able to demonstrate good ergonomic behaviors and postures even without the platform. Perhaps this is due to past experiences and habits developed over years of sitting up straight on a traditional chair with the back supported during word processing tasks.

Table 11 below presents an overall summary of the three factors in the study (Platform Use, Keyboard Width, and Computer task). For web and word tasks, most ergonomic posture was chosen between Platform or No Platform and also between Long or Short Keyboard

Posture	<u>Platform vs No Platform:</u>		<u>Long vs Short Keyboard:</u>	
	Web Tasks	Word Tasks	Web Tasks	Word Tasks
Trunk	Platform	Platform	Short	Short
Shoulder	Platform	Platform	Same (negative)	Same (negative)
Elbow	Platform	Platform	Same (negative)	Long

Wrist	Same (negative)	Same (negative)	Same (negative)	Same (negative)
Head/ Neck	Platform	Platform	Short	Short

* Indicates that the results were statistically significant.

Table 11– Summary of three main effects and Statistically Significant Findings

As seen from the above summary table, the platform has some benefits and some concerns. For both the web and web tasks, the condition of when the platform was used compared to when it was not shows that for the trunk, shoulder, elbow, and head/neck safe, ergonomic posture is observed. Also, for both web and word tasks, the long keyboard appears to significantly benefit only the elbow whereas the short keyboard seems to benefit the trunk and the head/neck measures.

Other Observed Behaviors:

Aside from the five body areas that were observed, many other unexpected behaviors and postures were observed. These are behaviors that are seen everyday in the living room, but with the addition of a computer task to this equation, postures such as sitting on the floor with the keyboard on the coffee table have the potential to cause extensive muscle damage. While sitting on the floor, the shoulders are abducted and the wrists are resting the carpal tunnel on the hard edges of the table. Other behaviors such as sitting on the couch and leaning forward to type on the keyboard that is placed on coffee table also can cause damage to the lower back, trunk, and neck areas. Lastly, lying down on the couch for long periods while typing with the keyboard alongside can

have detrimental effects on various parts of the body, including the trunk, neck, and shoulders.

Generally, even independent of the factors manipulated in the living room setting computing environment, a greater number of unsafe versus safe postures were observed. The participants generally did not change their posture often and thus did not take advantage of the potential flexibility of a living setting. The measure that had the safest postures observed was for the elbow with negative-slope angle, with safer postures being observed three quarters of the time. In contrast, the wrist was observed to have the most number of unsafe postures, with wrist extension being observed three quarters of the time. For the shoulder, shoulder abduction and raised shoulder were observed more than half the time. The trunk and head/neck areas also demonstrated awkward leaning forward postures approximately half the time. These findings are similar with other studies (Appenrodt & Andre, 1999) that show the dangers of computer use on various parts of the body, especially the wrist. This study focuses on the potential injuries that can occur in the living room environment due to unsafe behaviors or postures.

Implications

This research presents a number of avenues that can be explored to provide improvement in product development, training strategies, and education to increase awareness of risk factors in various environments that result in injuries. The results provide information about the possible use and effects of equipment like the Powerboard platform. The research also increases awareness of risky postures that are present with the use of PC applications while seated on a living room couch. This study attempts to address the growing health concerns for users of all ages faced with technology that is migrating to the living room. The guidelines below, derived from the study, may be beneficial to those users:

Guidelines for improved posture:

1. Use the platform.
2. Use the longer keyboard.
3. Be aware that web tasks result in more awkward postures than word tasks
4. Place the keyboard on the lap, not on the coffee table.
5. Sit on the couch, not on the floor.
6. Do not twist the trunk (do not lay down or lean to one side).
7. Support the back (sit far back into the couch or use pillows).
8. Avoid contact pressure on the wrist (place the platform edge away from you, and maintain neutral wrist).

Limitations

This study has a number of restrictions and limitations. The generalizability of this study may be restricted due to the sample of subjects. Many of the subjects were

from San Jose State University, and were taking psychology courses or were enrolled in the Department of Psychology. As a result, the demographics of the participants may affect the experience and habits they bring into the study.

The study assumes subjects filled in the questionnaire truthfully. Responses to questions such as the subjects' history of cumulative trauma disorders, or back pain, if not answered truthfully, may interfere with accurate data collection in this study.

The researcher was not able to control the subjects' level of ergonomic posture knowledge or awareness of awkward posture hazards. Prior knowledge may impact behaviors.

The age group of the student sample may not be fully representative of the range of the market that would purchase "living room PC" products. The full age range may be from someone in their mid-teens to septuagenarians.

The definition of what is considered "awkward" is based on literature review and professional experience. There is a degree of subjectivity in this that may limit the ability to generalize the findings of this study.

The short keyboard had one confounding variable which may have affected the postures and behaviors of the participants. The edge blocked the short keyboard sensor to connect to the box beside the TV. Therefore, the keyboard was only used with the platform edge in the inside, close to the participant. This posture restricted the movement of the wrists and there was pressure on the carpal tunnel as it was resting on the hard edge of the platform.

Lastly, the results may have been conservative in that subjects had knowledge that they were being videotaped. The behaviors observed were affected by the laboratory setting and that in the real “living room” environment the behaviors are expected to be even more unsafe and awkward.

Future Research

This research study has exposed other avenues of research that need to be explored. For example, many subjects sat on the floor possibly because a coffee table was present in front of them. This position changes multiple aspects of the body’s posture. This has not been researched. Further research may seek to study subjects “sitting on the floor” versus “sitting on the couch.”

Also, the design of the platform swayed the results of the comfort of the long keyboard versus the short keyboard because of the edge of the platform restricted wrist comfort with the short keyboard. If the design was changed to fit all keyboard types without effecting the sensor, it may enhance the posture of the subjects in which it would not require the use to rest the wrist on the platform edge. In the end, the platform design can be improved to protect muscles in the upper body for all keyboard types.

Additionally, longer test periods for the tasks utilizing EMG readings of the upper body muscles would give more detail and specific information about which muscles are under stress in certain postures.

CONCLUSION

Carter & Banister (1994) give one of many examples of previous research that link repetitive actions and awkward postures to musculoskeletal discomfort in the context of the common computer workstation. With the advent of “living room” computing (e.g., WebTV) it is important to examine if similar actions and postures are observed in this context relative to the traditional desk-bound setting, and if so, to evaluate any remedies that are offered in the marketplace. This study represents an initial attempt to document posture of living room PC users and to evaluate the utility of the Powerboard, a keyboard support platform designed to be used on one’s lap.

Sixteen computer users were asked to perform common word processing and web browsing tasks, while seated at a couch and using a wireless keyboard and a TV monitor. Various postures were observed and tallied in an effort to determine the impact of the Platform and of the keyboard width. For platform use, statistical significance was not seen for most postural measures but the Powerboard did make a consistent positive difference in the way people behaved (sitting location, and placing keyboards) and across the majority of posture measures (trunk, shoulder, elbow, and head and neck posture). The effects of the keyboard length and task type were less consistent, with levels of each supporting different ergonomic measures.

The results from the study, both the beneficial and detrimental postures in the living room, should be conveyed to future users of this type of technology. They should be made aware of how to incorporate beneficial postures and behaviors while using

platform type equipment in the living room. The present study is unique in that it observed an everyday event of using the computer but observed it in an unfamiliar environment, the living room. More research needs to address the potentially unique ergonomic needs of the living room computing setting. Increased awareness may promote the use of beneficial postures and mitigate the development of serious injuries.

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**APPENDIX A – SAN JOSE STATE UNIVERSITY INSTITUTIONAL REVIEW
BOARD APPROVAL**

San José State
UNIVERSITY

**Office of the Academic
Vice President**

**Associate Vice President
Graduate Studies and Research**

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TO: Krupa Joshi Karvat
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Santa Clara, CA 95050

FROM: Nabil Ibrahim,
AVP, Graduate Studies & Research

DATE: June 12, 2000

The Human Subjects-Institutional Review Board has approved
your request to use human subjects in the study entitled:

"Computing in a Living Room Setting"

This approval is contingent upon the subjects participating in your research project being appropriately protected from risk. This includes the protection of the anonymity of the subjects' identity when they participate in your research project, and with regard to any and all data that may be collected from the subjects. The Board's approval includes continued monitoring of your research by the Board to assure that the subjects are being adequately and properly protected from such risks. If at any time a subject becomes injured or complains of injury, you must notify Nabil Ibrahim, Ph.D., immediately. Injury includes but is not limited to bodily harm, psychological trauma and release of potentially damaging personal information.

Please also be advised that all subjects need to be fully informed and aware that their participation in your research project is voluntary, and that he or she may withdraw from the project at any time. Further, a subject's participation, refusal to participate, or withdrawal will not affect any services the subject is receiving or will receive at the institution in which the research is being conducted.

If you have any questions, please contact me at
(408) 924-2480.

APPENDIX B - DEMOGRAPHIC SURVEY

Date:

Subject#:

Name:

Age:

Sex:

Dominant Hand : left / right

Number of Years using a computer? _____

Number of minutes per day or week using the internet? _____

Amount of time per week spent on physical exercises?

Familiarity Level of word processing applications: (circle one)

None Below Average Average Above Average Excellent

Familiarity of Internet Web Browsing applications: (circle one)

None Below Average Average Above Average Excellent

Current computing input device used for navigation (mouse, trackball, other?):

APPENDIX C – CONSENT FORM

AGREEMENT TO PARTICIPATE IN RESEARCH FOR SAN JOSE STATE UNIVERSITY

RESPONSIBLE INVESTIGATOR: Krupa Karvat, Dr. Anthony D. Andre
TITLE OF PROTOCOL: Computing in a Living Room Setting

I have been asked to participate in a research study that is examining the use of a computer in a living room context. The results of this study should further our understanding of consumer preferences for functionality and comfort. I understand that:

I will be asked to interact with a computer while using a wireless keyboard.

The possible risks of this study are no greater or different than those which I might encounter in routine everyday life.

I might be videotaped during this session so that the experimenter can later review this session in detail. Some video snapshot images from this session might be used in the write-up of this study, but I will not be identified in any way and my face, if shown, will be occluded.

No discernible benefits are expected from my participation in this study.

No alternative procedures are included in this study. Each subject will receive the same treatment.

The results from this study may be published, but any information from this study that can be identified by me will remain confidential and will be disclosed only with my permission or as required by law.

Any questions about my participation in this study will be answered by Dr. Anthony Andre who can be reached at 408.342.9050. For questions or complaints about research subject's rights, or in the event of a research related injury, contact Nabil Ibrahim, Acting AVP, Graduate Studies and Research office at 408/924-2480.

My consent is given voluntarily without being coerced; I may refuse to participate in this study or in any part of this study, and I may withdraw at any time, without prejudice to my relations with San Jose State University.

Participant Name

Date

Researcher Name

Date

APPENDIX D – TASK INSTRUCTIONS

“COMPUTING IN A LIVING ROOM SETTING”

EXPERIMENTER INSTRUCTIONS

SET UP:

Get camera and videotape equipment ready

Hide powerboard under table if not needed

Place the keyboard to be used (long or short) on the table with or without powerboard.

INSTRUCTIONS:

Give subjects consent form on the side table and chair

Review and give subjects written instructions

Instruct them to thoroughly read the instructions, ask any questions they might have

Answer any questions the subject has

EXPERIMENT SETUP:

Bring subject to the couch

“Go ahead, take a seat and make yourself comfortable.”

“I’m going to have you interact with a few products. After each product I’ll have you fill out a survey and we’ll continue with the next one.”

“Again, the best case scenario would be if you were home alone and I wasn’t in the room observing, so feel free to do whatever it is you would do in your own living room. For example, lay down,. Put your feet up, take your shoes off etc.”

“So there first thing I’m going to have you do is.....(dependent on participant’s condition).”

Go over keyboard commands with participant. The commands are left with the subject.
(see bottom of page)

“I’ll come back in a little while to check on you. Go ahead and start with the first task. I’ll be back in 10 min.”

Exit out of the door that subject entered.

SURVEY FILL OUT OF CONDITION #1

After 10 min, enter through same door and say “the first task is over now go on to the next.”

After the next 10 min, enter through the same door and instruct subject to fill out the surveys corresponding to each task (web browsing and word processing)

Instruct subject to leave the surveys on the table when finished and begin task #3 and #4.
Give subject powerboard if they did not have it in the first condition.
Instruct subject that experimenter will come back into the room after 10 min and then they are to finish the last task.
Answer any questions before leaving from the same door.

CONDITION #2 AND FINAL COMPARISON SURVEY

Give surveys for task #3 and #4 and final comparison survey
Instruct subject to leave the papers on the table when they are done.
Debriefing handout is reviewed and given to the subject.
Payment is given and subject is thanked to coming in.

Tab - Tab function

Shift + Tab - Tabs backwards

Alt + Arrow - Back/forward

Alt + Tab - to switch between
applications of word and web

Arrows up and down - scrolls
web page

Esc - cancels last command

APPENDIX E – COMPUTING TASKS: Web Browsing and Word Processing

TASK LIST
CONDITION #1

Task #1: Word Processing

Write a short paragraph about your career and future hope.

Write a letter to a friend you haven't seen recently, discussing your life over the last year.

Task #2: Web Browsing

Find everything you can about vitamins and which ones boost your immune system.

Visit web sites that sell ergonomic products such as ergonomic equipment, chairs, etc. to avoid carpal tunnel syndrome.

Browse the Web, going to any web sites you want for 5 minutes.

TASK LIST
CONDITION #2

Task #3: Word Processing

Write a paragraph or two about a person you most admire and why.

Write a paragraph or two about your childhood and the place where you grew up.

Task #4: Web Browsing

Find the stock price of 3Comm, Yahoo, and National Semiconductor and find a site that provides a buy or sell recommendation for one of these stocks.

Find two CDs you like and then comparison shop for the best prices, comparing prices between at least 3 different web sites.

Browse the Web, going to any web sites you want for 5 minutes.

APPENDIX F – DATA COLLECTION POSTURE CHECKLIST

Posture Check List

	Condition
Measurements	
Body to keyboard distance	
Forward leaning	
Neutral	
Slouched	
Shoulder position	
Abduction (elbows splayed)	
Neutral	
Raised shoulders	
Elbow position	
Negative tilt (less than 90 deg.)	
Neutral (90 degrees)	
Positive tilt (greater than 90 deg)	
Wrist position	
Flexion	
Neutral	
Extension	
Head and neck position	
Centered	
Forward	

APPENDIX G – COUNTERBALANCE SHEET

Subject / keyboard	Condition	Condition	Condition	Condition
1 – Long keyboard	KB with 1	KB with 2	P with 3	P with 4
2	P with 2	P with 1	KB with 4	KB with 3
3	KB with 2	KB with 1	P with 4	P with 3
4	P with 1	P with 2	KB with 3	KB with 4
5	KB with 1	KB with 2	P with 3	P with 4
6	P with 2	P with 1	KB with 4	KB with 3
7	KB with 2	KB with 1	P with 4	P with 3
8	P with 1	P with 2	KB with 3	KB with 4
9 –Short keyboard	KB with 1	KB with 2	P with 3	P with 4
10	P with 2	P with 1	KB with 4	KB with 3
11	KB with 2	KB with 1	P with 4	P with 3
12	P with 1	P with 2	KB with 3	KB with 4
13	KB with 1	KB with 2	P with 3	P with 4
14	P with 2	P with 1	KB with 4	KB with 3
15	KB with 2	KB with 1	P with 4	P with 3
16	P with 1	P with 2	KB with 3	KB with 4

#1 – Word Processing

#2 – Web Browsing

#3 – Word Processing

#4 – Web Browsing

KB – Keyboard alone

P – Keyboard with Platform

APPENDIX H – POST TASK SURVEYS AND FINAL COMPARISON

Participant # _____

Cond# _____

Post Task Survey for Word Processing

Please rate your overall satisfaction using this wireless living room PC setup: (circle one).

1	2	3	4	5
Very Unsatisfied	Somewhat Unsatisfied	Neutral	Somewhat Satisfied	Very Satisfied

Please provide ratings, on a scale of 1 (very easy) to five (very hard), for each of the tasks/dimensions listed below (circle one number in each row).

	Very Easy	Somewhat Easy	Avg	Somewhat Hard	Very Hard
Ability to type accurately.	1	2	3	4	5
Ability to type quickly.	1	2	3	4	5
Ability to type desired keys without mistakes.	1	2	3	4	5
Ability to type desired keys with speed.	1	2	3	4	5
Ability to type without fatigue to any muscles groups.	1	2	3	4	5
Ability to stabilize the keyboard while typing	1	2	3	4	5
Ability to easily position keyboard to type.	1	2	3	4	5
Ability to type with comfort.	1	2	3	4	5
Overall ability to type in an efficient manner.	1	2	3	4	5

What is your preferred body posture for this type of computing setting?

Participant # _____

Cond# _____

Post Task Survey for Web Browsing

Please rate your overall satisfaction using this wireless living room PC setup: (circle one).

1	2	3	4	5
Very Unsatisfied	Somewhat Unsatisfied	Neutral	Somewhat Satisfied	Very Satisfied

Please provide ratings, on a scale of 1 (very easy) to five (very hard), for each of the tasks/dimensions listed below (circle one number in each row).

	Very Easy	Somewhat Easy	Avg	Somewhat Hard	Very Hard
Ability to easily read text on the screen.	1	2	3	4	5
Ability to move the cursor	1	2	3	4	5
Ability to click on links and buttons	1	2	3	4	5
Ability to view graphics	1	2	3	4	5

What is your preferred body posture for this type of computing setting?

Participant # _____
 Cond# _____
 Final Comparison Survey

(Keyboard Alone vs Keyboard+Platform)

Overall, which condition do you prefer? (circle one)

Keyboard Alone

Keyboard+Platform

Why?

2. What one thing do you like most and least about each condition.

Keyboard Alone
 Like Most

Like Least

Keyboard+Platform
 Like Most

Like Least

Please circle the condition that best supports each performance dimension listed below.

Easiest to type with	KB	KB+Platform	Same
Less mistakes made during tasks	KB	KB+Platform	Same
Easiest to position keyboard while typing	KB	KB+Platform	Same
Muscles of the upper body relaxed	KB	KB+Platform	Same
Muscles of the lower body relaxed	KB	KB+Platform	Same
More comfortable to use	KB	KB+Platform	Same
Less fatigue during use	KB	KB+Platform	Same
Position of wrists and elbows comfortable	KB	KB+Platform	Same
Position of head comfortable	KB	KB+Platform	Same
Position of shoulders comfortable	KB	KB+Platform	Same
Position of back comfortable	KB	KB+Platform	Same
Easiest to stabilize keyboard	KB	KB+Platform	Same
Best for typing in Word	KB	KB+Platform	Same
Best for interacting with the Web	KB	KB+Platform	Same

What would you change about the design or use of the platform?

APPENDIX I – DEBRIEFING INSTRUCTIONS

Participant Debrief

Thank you for your participation in this study!

As previously described to you, this study is being conducted to evaluate the usability of a wireless PC with the Internet and word processing in a living room setting. We define usability in a rather broad way—from the user's ability to easily obtain desired information, to the required postures and resultant comfort of the user. Thus, in addition to our interests in how the wireless PC supports the various tasks we asked you to perform, we are also interested in the postures and comfort level achieved when performing these tasks. We did not tell you specifically about the postural aspect of the research because we did not want you to feel self-conscious about it, or to influence the postures that are comfortable for you. Also studied were effect of using the long or short keyboards and the ease of use of a platform to support the keyboard. These aspects will also effect the posture and comfort. By characterizing the usability of the wireless PC both in terms of finding and writing information, and the resultant postures required of wireless PC interaction, we hope to develop a more comprehensive set of usability guidelines that speak to the efficiency and comfort of using the computer in the living room.

We very much appreciate your participation in this study, thank you again. If you have any questions, please feel free to ask the experimenter at (408) 406-1114.

APPENDIX J - GLOSSARY

Carpal Tunnel Disease: The Carpal Tunnel under the carpal ligaments is a tightly closed space and inflammation can lead to high pressure on the median nerve which runs in the carpal tunnel. This may be caused by retention of fluids, repetitive wrist motions or static loading of the wrist. This produces pain and sensory disturbances over the median nerve distribution in the hand and median nerve motor weakness and atrophy of thumb muscles.

Elbow “positive”-slope angle: This refers to the measurement of the angle to be from 150 to 90 degrees at the elbow. This is seen when the elbow is bent upwards and the forearm range is held from the top to a half bent elbow.

Elbow “neutral” angle: This is when the elbow is approximately at 90 degrees or the half bend elbow.

Elbow “negative”-slope angle: Lastly, the “negative” angle ranged from 90 to 65 degrees; the forearm position ranged from the neutral position (90 degrees) to a dropped forearm position up to 25 degrees (65 degrees) (Hedge & Powers, 1995).

Head “centered” position: This is identified if the head sits comfortably over the shoulders and the neck muscles do not appear to be stretched in any position (left, right, up, down or outward).

Head “forward” position: This was observed when the head was leaning forward and away from the shoulders.

Shoulder abduction: The shoulder angle was determined by observing the angle from the top of the shoulder joint to the elbow. If the elbows are positioned wide apart, the shoulder angle is recorded as “abduction.”

Shoulder neutral position: If the arms (shoulder joint to the elbow) are located close beside the trunk, they are recorded as “neutral.”

Shoulder “raised” position -The “raised shoulder” position is observed and recorded if the shoulder is observed to be raised up towards the ears and away from chest.

Tendonitis: May be the result of overuse of a muscle group, incorrect positioning for use, or trauma. Often related to repetitive motions.

Trunk “forward” position: This occurred if the participant leaned forward away from neutral while sitting on the couch or sitting on the floor with or without back support.

Trunk “neutral” position: This was recorded if the trunk was perpendicular to the floor or couch.

Trunk “slouched” position: This occurred if the participant leaned back away from neutral and upper back and shoulder posture appeared rounded.

Trunk “twisted” position: This was recorded if the participant leans to the side or the trunk had an awkward posture.

Wrist “neutral” position: This is when the wrist is even and is at 0 degrees with the forearm

Wrist “flexed” position: This is when the wrist is flexed palm down with the angle that drops from 0 approximately 80 degrees when angle is measured from the side of the wrist.

Wrist “extension” position: This is recorded when the wrist is palm faced down and the wrist is raised from 0 to approximately 70 degrees.