Changes in posture through the use of simple inclines with notebook computers placed on a standard desk

Krishna Asundi, Dan Odell, Adam Luce, Jack T. Dennerlein*

*Department of Environmental Health, Harvard School of Public Health, Boston, USA
Microsoft Hardware Corporation, Redmond, USA
Department of Biomedical Engineering, Boston University, Boston, USA
Department of Orthopaedic Surgery, Brigham and Women’s Hospital, Harvard Medical School, Boston, USA

Abstract

This study evaluated the use of simple inclines as a portable peripheral for improving head and neck postures during notebook computer use on tables in portable environments such as hotel rooms, cafés, and airport lounges. A 3D motion analysis system measured head, neck and right upper extremity postures of 15 participants as they completed a 10 min computer task in six different configurations, all on a fixed height desk: no-incline, 12° incline, 25° incline, no-incline with external mouse, 25° incline with an external mouse, and a commercially available riser with external mouse and keyboard. After completion of the task, subjects rated the configuration for comfort and ease of use and indicated perceived discomfort in several body segments. Compared to the no-incline configuration, use of the 12° incline reduced forward head tilt and neck flexion while increasing wrist extension. The 25° incline further reduced head tilt and neck flexion while further increasing wrist extension. The 25° incline received the lowest comfort and ease of use ratings and the highest perceived discomfort score. For portable, temporary computing environments where internal input devices are used, users may find improved head and neck postures with acceptable wrist extension postures with the utilization of a 12° incline.

1. Introduction

In 2008, quarterly notebook sales exceeded desktop sales with over 9.5 million units sold (Mann, 2008). With their compact form factor and internal monitor and input devices, notebook computers are designed for portability; but the tradeoffs in design increase exposure to potential risk factors for musculoskeletal disorders (MSDs) relative to desktop computers. In particular, since the display and keyboard are connected, the height of the display is normally lower than recommended.

Compared to desktop computers, previous studies have shown that notebook computer use results in greater neck flexion and head tilt (Straker et al., 1997; Sommerich et al., 2002; Seghers et al., 2003), reduced range of neck movement (Szeto and Lee, 2002) and greater neck extensor activity (Saito et al., 1997; Villanueva et al., 1998; Seghers et al., 2003). Placing the notebook on a higher working surface, to optimize neck posture, is not a viable solution as it leads to increased discomfort in all body parts, including the neck (Price and Dowell, 1998). Elevating the whole notebook computer with a non-input device peripheral, such as a laptop station, does improve neck postures, reducing cervical spine torque and perceived strain (Berkhout et al., 2004).

As a result of these findings, practitioners and researchers typically recommend using an external monitor or elevating the notebook to raise the display screen and adding external input peripherals, especially for extended notebook use. This effectively makes the notebook equivalent to a conventional desktop computer setup. These recommendations, while useful in a semi-permanent workstation such as one’s office, have limited portability and are therefore not often used in portable computing environments.

An incline, which raises the back end of the notebook computer and thus elevates the screen, is a simple portable peripheral that may improve head and neck postures for computing environments that have a non-adjustable, standard height desk (Kroemer and Grandjean, 1997) such as hotel rooms, airplanes, and cafés. An incline could be as simple as extension legs built into the notebook.
or even the power supply box placed underneath the back side. With the use of an incline, the keyboard is still attached to the monitor and therefore the hands have to follow the keyboard, which is also altered by the incline. Specifically, the incline leads to a positive keyboard slope, which has been shown to increase wrist extension (Simoneau and Marklin, 2001).

Therefore, the aim of this study was to compare postures and comfort in users working on a notebook computer placed flat on a fixed height desk, with the introduction of small devices to incline the notebook to 12 and 25 degrees with the proximal edge of the notebook remaining at the same level. We hypothesized forward head tilt and neck flexion angles would decrease with the use of the inclines, while wrist extension angles would increase. We also evaluated the addition of an external mouse and the use of a commercially available riser, which fully elevates the notebook, with an external mouse and keyboard on these same outcomes. We hypothesized that the commercially available riser would lead to smaller non-neutral head and neck postures compared to use of the notebook flat on the desk with an external mouse and smaller non-neutral wrist postures compared use of the 25° incline with an external mouse.

2. Methods

2.1. Study participants

Eight men and seven women (ranging in age from 22 to 36 (mean = 28.4, sd = 3.5)) participated in this study. All participants reported no current or previous history of head, neck, back or upper extremity MSDs and either owned or had experience working with a notebook computer. The mean anthropometric measures for the subjects were typical of a North American population (Table 1). Each participant gave informed consent prior to beginning the study. The Harvard School of Public Health Internal Review Board approved all protocols and consent forms.

2.2. Experimental protocol

Each participant completed a standardized computing task six times, each with a different portable computing configuration: DESK, INC12, INC25, DESK + M, INC25 + M and RISER (Fig. 1). For the first configuration, a 15 inch notebook computer with two internal pointing devices (Int PD), a built-in touch pad and an isometric joystick (Thinkpad T61, Lenovo, Morrisville, NC, USA) was placed on top of a 72.4 cm high desk (DESK). For the next two configurations the notebook was placed on a 12 (INC12) and 25 degree incline (INC25), respectively, placed on top of the same 72.4 cm desk (Fig. 1). For the next two configurations, an external portable size mouse (Notebook Optical Mouse, Microsoft Corporation, Redmond, WA, USA) was added to the DESK (DESK + M) and INC25 (INC25 + M) configurations. For the last configuration (RISER), the notebook was placed on a laptop riser (Height Adjustable Laptop Stand, XBrand, Scottsdale, AZ, USA). This configuration also included the external portable size mouse as well as a full size QWERTY keyboard (KU-0225, Lenovo, Morrisville, NC, USA). The RISER configuration was the only one which included an external keyboard. For all configurations, the edge of the desk was padded with a thin strip of foam to reduce contact pressure (not shown in the images). The order of the configurations was randomized.

To reduce variability associated with seated posture, participants sat in an adjustable office chair with seat pan height selected to match popliteal height when the thighs were horizontal (mean (SD) chair height = 44.8(5.2) cm). To reduce variability associated with horizontal keyboard location (Kotani et al., 2007), subjects were instructed to place the notebook at a comfortable horizontal distance from the edge of the desk before testing began. The distance from the edge of the desk to the J key on the internal keyboard was then measured and kept constant for all configurations except for the RISER configuration in which the distance to the J key on the external keyboard was matched. The horizontal distance of the notebook and riser, placed behind the external keyboard, was selected by the subjects; vertical height of the top edge of the notebook screen on the RISER was adjusted to subject eye height. Subjects were allowed to adjust the screen angle relative to the keyboard for each configuration.

The standardized computer task involved a combination of pointing and clicking on icons, typing text, a comprehensive reading exercise and selecting-dragging-and-dropping of icons. The task was designed to require relatively equal amounts of keyboard and mouse use as well as periods in which input devices were not used (e.g. reading text from the screen). For configurations that did not include the external mouse, subjects were instructed to use the touch pad. Productivity for each configuration was calculated as the total amount of time required to complete the task. Participants were instructed to complete the task at a comfortable pace. The task was designed to take approximately 10 min.

2.3. Apparatus

An infrared three-dimensional motion analysis system (Optotak Certus, Northern Digital, Waterloo, Canada) tracked head, trunk and upper extremity kinematics. Five clusters of three infrared light emitting diodes (IREDs) fixed to a rigid surface were secured to the head, trunk, right arm, right forearm and right hand (Fig. 1). Three additional IREDs were placed on the base of the notebook and one on the top, right edge of the notebook screen. Using a single camera bank with 3 cameras, the 3-D locations of the 19 IREDs were tracked at 20 samples/s and data were recorded to a personal computer. The locations of specific bony landmarks relative to their associated IRED cluster (Table 2) were digitized using the systems digitizing probe. Then, modeling each body segment as a rigid body, the locations of these bony landmarks were calculated based on the translation and rotation of each IRED cluster (Winter, 2000). Data were digitally filtered through a low-pass, fourth-order Butterworth filter with a 5 Hz cutoff frequency and used to define local coordinate systems for each segment (Table 2). The shoulder IREDs for 2 participants came loose during the experiments. Shoulder, elbow and wrist posture data for these participants were discarded.

From local coordinate systems, rotation matrices were calculated (Winter, 2000) to obtain the orientation of the arm relative to the trunk, the forearm relative to the arm and the hand relative to the forearm. From these rotation matrices, Euler angles were calculated such that the first rotation was flexion/extension, the second was abduction/adduction and the third was internal/external rotation (pronation/supination for the forearm).

Shoulder elevation and retraction were defined as the vertical and horizontal translation, respectively, of the upper arm relative to

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Mean (SD) anthropometric measures by gender.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metric</td>
<td>Male (n = 8)</td>
</tr>
<tr>
<td>Age (years)</td>
<td>28.8 (3.8)</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>175.9 (5.5)</td>
</tr>
<tr>
<td>Shoulder width (cm)</td>
<td>34.6 (3.5)</td>
</tr>
<tr>
<td>Arm length (cm)</td>
<td>61.5 (3.3)</td>
</tr>
<tr>
<td>Hand length (cm)</td>
<td>19.0 (0.6)</td>
</tr>
<tr>
<td>Hand width (cm)</td>
<td>8.4 (0.3)</td>
</tr>
</tbody>
</table>
Download Full-Text Now

http://fulltext.study/article/549507

fullText.study

- Categorized Journals
  Thousands of scientific journals broken down into different categories to simplify your search

- Full-Text Access
  The full-text version of all the articles are available for you to purchase at the lowest price

- Free Downloadable Articles
  In each journal some of the articles are available to download for free

- Free PDF Preview
  A preview of the first 2 pages of each article is available for you to download for free

http://FullText.Study