Analytical Design Methodology for Recommending VDT Workstation Settings and Computer Accessories Layout

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Abstract. Repetitive stress injury at the wrist has been reported as a common injury among visual display terminal (VDT) users (i.e., computer users). Adjusting a VDT workstation (computer table and chair) to maintain a correct seated posture while operating a keyboard is perhaps the most frequently recommended preventive solution. This paper proposes an analytical design methodology based on ergonomic design principles for recommending appropriate VDT workstation settings and layout of individual computer accessories on the computer table. The proposed design methodology consists of two interrelated phases: (1) determination of VDT workstation settings, and (2) design of computer accessories layout. Based on the information about the VDT user, dominant task to be performed, typing skill, and degrees of physical and visual interactions between the user and computer accessories, adjustment and layout solutions are recommended to allow having a correct seated posture while minimizing both physical and visual movements. The results from an experiment show that when adjusting the workstation and locating the computer accessories according to the recommendations given by the proposed design methodology, the user’s hand movements can be significantly reduced.

Keywords: VDT workstation, adjustment settings, computer accessories layout, human-computer interaction

1. INTRODUCTION

Nowadays most office workers routinely use a computer to assist them in performing assigned tasks. Some workers use it on an intermittent basis while some do on a prolonged basis. It has been reported that long-term usage of computer (or visual display terminal – VDT) is a possible cause of carpal tunnel syndrome (CTS), neck tension syndrome (NTS), and low back pain. One of the risk factors that lead to developing these injuries is seating with improper posture while interacting with VDT. It is suspected that this improper seated posture is due to the following causes: (1) using a non-adjustable poorly design VDT workstation (i.e., computer table and chair), and (2) using an adjustable VDT workstation but failing to adjust its settings appropriately.

Generally, two ergonomic approaches for preventing and controlling CTS (the most common injury reported among VDT users) are eliminating occupational factors that contribute to the development of the syndrome and redesigning workstation and/or workplace (Babski and Crumpton, 1997). Workstation redesign is helpful to eliminate or minimize awkward postures of VDT users. The positioning of the keyboard relative to the user is a crucial factor affecting wrist posture and the risk of cumulative trauma injury (Hedge et al., 1996).

Ergonomic improvements in the design of VDT workstations and tasks have been widely embraced as a primary measure for preventing musculoskeletal disorders (MSD) problems in VDT work (Sauter and
Schleifer, 1991). Key elements of an ergonomic VDT workstation include height-adjustable work surface, position-adjustable monitor, document holder, detachable keyboard, adjustable seating, wrist support, footrest (if necessary), and appropriate lighting and glare reduction (Gross and Hassel, 1991). Nanthavanij and Venezia (1999) suggested mathematical formulas that use body height to determine a set of workstation settings that are appropriate for an individual. The results (recommended workstation settings) were experimentally tested and found to be more effective in adjusting the VDT workstation than without it (Nanthavanij, 1996a; Nanthavanij, 1996b). Mekhora et al. (2000) also tested the effect of ergonomic intervention on discomfort in VDT users by adjusting their workstations according to the results from Nanthavanij and Venezia’s formulas. Significant improvements were also found in that study. However, only the vertical heights (from the floor) and horizontal distances (from the VDT user) of the computer keyboard and monitor are the main emphases of those formulas.

A recent study by Cook et al. (2000) supported the importance of proper VDT workstation design in terms of positions and level heights of computer accessories. Both spatial factors were found to affect work posture. Most users are used to placing a mouse at the right side of a keyboard. This practice, as a result, causes increased activity in the deltoid and trapezius. Poor arrangement of computer accessories also forces the user to sit in constrained, unnatural, and stressful postures. There are other studies that also mentioned about the computer accessory arrangement but did not propose the solution (Hastings et al., 2000; Berns and Klusell, 2000). Berns and Klusell (2000) mentioned only placing an input device in front of the user as a recommended approach.

Another computer accessory that has been widely studied is a monitor. Ankrum and Nemeth (2000) reported that the monitor viewing angle in the range of 35°-38.5° below eye level is associated with head tilt and head/neck angles consistent with the “comfortable” postures. Straker and Mekhora (2000) categorized monitor positions into two groups: high monitor position (inclined backward 5° with the top of the monitor level with the subject’s eyes), and low monitor position (inclined 25° backward and with the bottom of the monitor level with the desk). The study shows that subjects working with a high monitor position have less head, neck, and trunk flexion and less cervical and erector spinae muscle activity than when they work with a low monitor position.

Recently a field survey was conducted to investigate the effects of dominant input device and its location on the upper extremity discomforts of Thai VDT users (Rurkhamet and Nanthavanij, 2000). The results indicated that some computer accessories layout design strongly affects the physical discomforts at a wrist, lower arm, and upper arm, especially when a computer mouse is predominantly used. It was also recommended that the adjustment of VDT workstation settings and the layout of computer accessories be based on both user-related and task-related information.

2. PROPOSED DESIGN METHODOLOGY

2.1 Relevant Ergonomic Principles

The proposed design methodology utilizes several ergonomic principles that provide relevant guidelines/recommendations for workstation design and arrangement of components. These principles, to some extent, can be adapted for the design of computer accessories layout. They are summarized in this section. For more details, readers are suggested to consult Sanders and McCormick (1993).

2.1.1 Anthropometric design principles

Anthropometric design principles give guidelines on how to utilize relevant anthropometric data in the design of products, equipment, and workstations. Specifically, it is necessary to know the body dimensions that are fundamentals for the design and define the population (of VDT users) that a VDT workstation is to be designed for. Since the VDT workstation is intended to be adjustable, the adjustment ranges (for individual features) must cover from the 5th percentile of the male population to the 95th percentile of the male population of each key body dimension.

2.1.2 Design of horizontal work surface

The horizontal work surface is usually used by “sitting” or “sit-stand” workers to perform manual activities. It is essential to determine both the work area and the work surface height. Generally, all computer accessories should be located within the normal work area where they can be accessed conveniently. If the space is insufficient, those that are used more frequently or are more important should be located within the normal area while others will be located within the maximum area. For the height of the horizontal work surface for a seated worker, the following general guidelines may be followed.

1. Whenever possible, the work surface height (or at least the height of those portions where computer accessories are placed on) should be adjustable to fit individual physical dimensions and preferences.
2. The accessories to be operated by hand should be at the elbow height.
3. The work surface should provide adequate clearance for a person’s thighs under the work surface.

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