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Integrating Neck Posture and Vision at VDT Workstations

Dennis R. Ankrum, Human Factors Research, Nova Solutions, 10007 San Luis Trail, Austin, TX 78733-1253 USA
e-mail: *Ankrum@aol.com*

1. Introduction

Studies and recommendations regarding monitor placement have usually concentrated on either gaze angle or neck posture. Both of these aspects have usually been viewed as static, i.e. *the* preferred gaze angle and *the* appropriate neck posture. The dynamic interaction between them has rarely been examined.

To complicate matters even further, questionable assumptions have been made about the characteristics of both the visual and postural systems, leading to recommendations that the monitor be placed at eye level. Only by combining the *range* of acceptable gaze angles with the *range* of acceptable neck postures can we arrive at appropriate monitor placement recommendations.

2. Vision

The scientific basis for the 15-degree-below-the-horizontal resting point of the eyes, part of the basis for eye-level monitor placement recommendations, has been shown to be questionable (Ankrum, 1997). Hill and Kroemer (1986) found it to be much lower and to change with viewing distance. As the object of view becomes closer, the preferred gaze angle lowers: at 1 m it averaged -24° and at 0.5 m -33° below the Frankfurt Line in a seated position. The Frankfurt Line (a line from the center of the ear through the lowest point of the eye socket) was held parallel to the horizontal in the condition. Because the Frankfurt Line moves as the head tilts, the preferred line of sight lowers with flexion.

The preference for downward gaze angles for near work is consistent with the capabilities of the visual system. As gaze angle lowers, the resting point of vergence moves inward which reduces the stress on the extraocular muscles. The ability to accommodate improves, and reports of headaches, eye strain, and fatigue decrease (see Ankrum and Nemeth, 1995 for a discussion).

Grandjean (1988) suggests that the monitor be placed within a cone 15° above and below the preferred the line of sight. This makes the assumption that variations in both directions are equally acceptable. Menozzi *et al*. (1992), however, demonstrated that users experience greater discomfort when looking upward at close objects than when looking at them at an equal, but downward angle. The range of comfortable gaze angles for near work extends farther downward from the preferred line of sight than it does upward.

3. Neck Posture

The head-erect posture has been recommended because it is believed to place the least biomechanical load on the neck. However, to balance the head on top of the spine and provide the least mechanical load, requires 30° of neck extension (Ear-Eye line 45° above horizontal) (deWall, e*t al*., 1992). As neck extension is extremely uncomfortable, it is clear that something other than biomechanical load is at work.

When degrees of flexion or extension have been reported, the starting or zero point has often been unclear. It appears that the zero point may be the head-erect posture of "greatest height." In that posture the Ear-Eye Line (a line from the center of the ear through the outer slit in the eyelid, about 10° higher than the Frankfurt Line) is about 15° above horizontal (Jampel and Shi, 1992).

Grey (1966) found that, in the seated posture of most comfort, the Ear-Eye Line averaged about 1° below the horizontal. Hsio and Keyserling (1991) found an average of 13° forward tilt of the neck/head in normal erect sitting. While the head-erect posture may be easy to determine, it should not be confused with neutral or ideal.

As with vision, movements in equal, but opposite directions do not yield similar results. While Chaffin (1973) found that 15° of static flexion resulted in no discomfort or elevated EMG readings after 6 hours, Kumar (1994) found that a mere 3° of extension resulted in increased discomfort.

Villanueva *et al*. (1996) examined neck posture at 5 different monitor heights. They reported that "...the neck became more erect as the screen position became higher." The three highest positions actually resulted in an Ear-Eye Line greater than 15° degrees above the horizontal, i.e. neck extension. Only the lowest of the screen positions resulted in a neck posture even close to that which has been found to be preferred.

In a study of document holder placement, Hamilton (1996) found 5° of extension in the reading task when the document was substituted for the eye-level monitor.

In reporting muscle activity, Grey (1966) found that the head-erect posture results in less activity of the trapezius muscles and greater activity of the sternomastoids. Flexion results in the opposite: more activity in the trapezius and less in the sternomastoids. The sternomastoids flex the neck, while the trapezius muscles maintain the flexion. The higher activity of the sternomastoids in the head-erect posture suggests that they are maintaining extension. As the trapezius muscles are larger and stronger than the sternomastoids, flexion would seem to pose less risk of fatigue. Perhaps even more critical is the ability to voluntarily alter posture. Lower monitor placement allows for a wider variety of comfortable neck postures while allowing visual comfort (Ankrum and Nemeth, 1995).

Two aspects influencing monitor placement are screen tilt and glare. If the monitor is lowered and not tilted back so that its top is farther from the eyes than the bottom (or is tipped downward to avoid glare) greater neck and postural discomfort may result (Ankrum, Hansen and Nemeth, 1995). That could be an explanation for occasional anecdotal reports of lower monitor replacement resulting in increased neck discomfort. If glare and reflections are not satisfactorily addressed, the benefits of lower monitor placement will be lost.

4. Conclusion

Gaze angle and neck posture are interrelated. They should not be viewed as independent aspects of the workstation. Eye-level monitor recommendations have assumed that the head-erect posture is desirable, and that the visual system is equally comfortable gazing both upward and downward from a preferred angle.

The visual system prefers downward gaze angles at near work. The neck is more comfortable in flexion than in extension. This is logical from an ecological point of view: the most varied information for the visual system is generally below the horizon. Objects above the horizon, such as the sky, are usually of less immediate importance.

To achieve a monitor location that corresponds to the capabilities of both the visual and postural systems requires that the monitor be placed at a minimum of 15° below eye level with the top farther from the eyes than the bottom.

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