The Effects of Visual Display Distance on Eye Accommodation, Head Posture, and Vision and Neck Symptoms

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Objective: Determine the effects of display viewing distance on both the visual and musculoskeletal systems while the text height is held constant across viewing distances. **Background:** The distance from the eyes to a computer display may affect visual and neck comfort. If the angular size of the characters remains the same, it is recommended that the display be placed at a farther viewing distance (e.g., 70–100 cm). However, in common usage, the character sizes are not adjusted based on viewing distance. **Method:** Participants under the age of 35 years ($N = 24$) performed visually demanding tasks using a computer display for 2 hr each at three viewing distances (mean: 52.4, 73.0, and 85.3 cm) while torso and head posture were tracked. At the end of each task, eye accommodation was measured and symptoms were recorded. **Results:** The near distance was associated with significantly less blurred vision, less dry or irritated eyes, less headache, and improved convergence recovery when compared with the middle and far distances. Participants moved their torsos and heads closer to the monitor at the far distance. **Conclusion:** If the computer screen character sizes are close to the limits of visual acuity, it is recommended that the computer monitor be positioned between the near (52 cm) and middle (73 cm) distance from the eyes. **Application:** The location of a computer display should take into account the size of the characters on the screen and the visual acuity of the user.

INTRODUCTION

The placement of a visual display may influence the neck symptoms, head posture, neck muscle activity, eye symptoms, and eye function of computer users (Daum et al., 2004; Hagberg & Rempel, 1997). For example, an increased height of the display is associated with a lower blink rate, greater eye symptoms, and lower amplitude of accommodation (Atchison, Claydon, & Irwin, 1994; Burgess-Limerick, Plooy, & Ankrum, 1998; Jaschinski-Kruza, 1988; Saito, Miyao, Kondo, Sakakibara, & Toyoshima, 1997; Villaneuva, Sotoyama, Jonai, Takeuchi, & Saito, 1996).

Since a low display height is associated with increased neck muscle activity and increased neck pain (Hagberg & Sundelin, 1986; Seghers, Jochem, & Spaepen, 2003; Sommerich, Joines, & Psihogios, 2001; Turville, Psihogios, Ulmer, & Mirka, 1998), it is generally recommended that the center of the screen be between 15° and 25° below the horizontal from the eye (Hagberg & Rempel, 1997; Sheedy & Shaw-McMinn, 2003; Sommerich et al., 2001).

The distance from the display to the eyes is also important and is the subject of this investigation. Factors such as visual display size, character and object size, screen resolution, and presbyopia (loss of near focusing ability) in an aging population are all factors that may influence optimal visual display distance. In addition, the workstation and chair design, use of keyboard trays, desk depth, and display

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depth and size will influence the available range of display distance. Recommended ranges for display distance are important for furniture and equipment manufacturers, ergonomics consultants, facilities designers, optometrists, and computer users. Recommendations for the distance from the display to the eyes vary from a minimum of 30 cm (Human Factors and Ergonomics Society, 1988) to a maximum of 1/3 of the farthest distance at which characters of a given size can just be identified (Sheedy & Shaw-McMinn, 2003).

The argument for a longer viewing distance is that the longer distance may put less demand than does near distance upon the ocular convergence and accommodative mechanisms. Jaschinski-Kruza (1988) showed that participants preferred working on a computer display at 100 cm, compared with 50 cm, when the character size was adjusted to provide equal visual angles for the two conditions. In a subsequent study, Jaschinski-Kruza (1990) showed that participants preferred the display at 70 cm, compared with 50 cm – even when a reference document from which they worked was fixed at 50 cm – indicating that they preferred the longer viewing distance even if it required them to change viewing distance to view the reference document.

It has also been shown that in the absence of any visual stimulation (i.e., in the dark), the accommodation and vergence positions of the eye generally assume resting positions of about 67 cm. This mean value has a considerable interindividual range, from about 40 cm to infinity in emmetropic participants (Owens, 1984; Owens & Wolf-Kelly, 1987). It has been proposed that visual work at this "dark" position should result in greatest visual comfort. Most participants with a distant dark vergence position experienced stronger visual strain at short viewing distances (Jaschinski & Heuer, 2004; Jaschinski-Kruza, 1991). Furthermore, most participants who prefer a longer viewing distance have a larger vergence error (fixation disparity) in near vision (Jaschinski, 2002). However, Jaschinski-Kruza (1988) has shown greater comfort at 100 cm than at 50 cm regardless of the dark accommodation position (which differs from dark vergence in most participants) of the eyes.

If the visual display is too close, the increased accommodation and convergence required of the visual system, may, over time, lead to decreased accommodative flexibility and capacity, possibly to convergence concerns, and ultimately to eye symptoms. The effect of distance from the monitor to the eyes on eye function and symptoms has been studied in the laboratory (Jaschinski, 2002). Participants self-selected optimal distances while performing a visually demanding task for 30 min. The preferred viewing distance was 63 cm (±13) with a range of 43 to 99 cm (Jaschinski, 2002). However, the effects of monitor distance have not been studied for longer durations. In addition, the effects of monitor distance on head posture have not been studied.

Thus, the physiological evidence appears to support longer viewing distances, provided the character size (in millimeters) is increased accordingly. However, in common usage, the character size remains fixed on a display regardless of the viewing distance; thus the visual angle decreases with increased viewing distance. The primary concern is that if the visual display is placed too far away, difficulty in resolving characters will over time lead to a forward head posture or forward leaning and ultimately neck symptoms.

The purpose of this study was to determine the effects of visual display distance on both the visual and musculoskeletal systems. In this study, the text height was kept constant across viewing distances, hence reflecting common usage in which the angular size decreases with increased viewing distance. Common usage was also simulated with long performance trials. The null hypothesis was that there would be no change in head posture, torso posture, accommodative capacity, accommodative flexibility, convergence ability, eye comfort, or neck comfort over a 2-hr period with a visual display set to three different distances from the eyes for computer users who are less than 35 years of age.

METHODS

This was a full-factorial, repeated measures study with 24 participants. All participants experienced all three conditions of computer monitor placement, in randomized sequence, while they performed visually demanding tasks. The participants were seated in front of the monitor and performed the tasks with a computer mouse. The study was approved by the University of California at San Francisco Committee on Human Research.

Participants

Participants were recruited from flyers placed on the campus and in the community. Interested recruits were screened and were excluded if they were left-handed; had less than 1 year of experience using a computer; reported current head, neck, back, or arm injuries; had difficulty sitting and using a computer for 6 hr; had difficulty with their vision; or used glasses when using a computer. Participants were between the ages of 18 and 35 years in order to limit the study to participants with appropriate accommodation to the viewing distances studied. Participants completed a demographic questionnaire.

Test Conditions

For the three test conditions, the center of the visual display was set to a near, middle, or far distance from the participants' eyes – target distances of 46, 66, and 86 cm (18, 26, and 34 inches), respectively – while the participants were seated in a reference posture. The order of testing was block randomized. Participants were not told of the specific distance tested. The monitor was centered along a line that was 15° below the horizon from the participant's eyes. The monitor was positioned directly in front of the participant. The viewing distances were selected to encompass a preferred viewing range (Jaschinski, 2002).

Tasks

Each of the three test conditions was performed for 2 hr, with a 30-min break between conditions. Prior to the study and during the breaks, participants were instructed to perform no near vision tasks (e.g., reading). The computer tasks involved document editing and Internet searching. The tasks were performed using the mouse so that head posture would not be influenced by visual gaze to the keyboard for those with poor touch typing skills.

The document editing task involved viewing a screen filled with an array of random text characters: 10 lines of text, 20 characters per line, and "words" between 3 and 10 random characters long, separated by blanks (Jaschinski, 2002). Characters were black on a white background, Arial, all capitals, with a height of 3.3 mm (10 points). The characters were selected so that to the left and right of a blank they were identical for about 50% of blanks. The participant clicked on each pair of words with the same character on either side of the blank. The Internet search task involved participants searching the Internet to find answers to a series of very specific geographic questions (e.g., "What is the tallest mountain in Columbia?"). For each test condition, participants performed 15 min of document editing, followed by 90 min of Internet searching, followed by 15 min of document editing.

Workstation Setup

The chair, monitor, and mouse surface were adjusted to the participant's anthropometry at the beginning of the study. At the beginning of each test condition, participants were required to sit with their backs against the chair backrest while looking at a mark on the wall at their eye level. Posture data were collected for this reference position, and then participants performed the computer tasks for 2 hr. During the 2-hr period, participants could assume any posture they preferred, but the chair and monitor could not be moved.

The chair (Leap model, Steelcase, Grand Rapids, MI) was secured to the floor, and the backrest was maintained at an inclination angle of 110°. The participant sat comfortably in the chair, and the seat pan depth and height were adjusted to his or her leg dimensions. The seat pan was locked so that it would not slide forward. The heights of the armrests on the chair were adjusted to comfortably support the forearm while the participant used a mouse. The participant practiced the computer tasks prior to the start of the experiment and made small adjustments to the chair height and depth for comfort. After the experiment started, participants could not make additional adjustments to the chair, but they were allowed to move their bodies to whatever position was comfortable and allowed them to complete the tasks. The mouse work surface height and location were positioned to allow the forearm to be level with the floor with minimal shoulder flexion or abduction.

A custom-made monitor stand was secured to the floor. The stand allowed for movement of the monitor toward or away from the participant along an adjustable axis, which was set to a line 15° below the horizontal (vertical gaze angle). The monitor and support arm were also adjustable in height. The monitor was an 18-inch (45.7-cm) LCD flat panel monitor (Model 9494-T860, IBM) with digital quality set at 75 Hz refresh rate and a resolution of 1280 × 1024. The video card was an NVIDIA Quadro2 Pro.

Head and Torso Posture

Participants wore a tank top shirt to expose their sternum. The head and torso postures were recorded continuously at 1 Hz with an Optotrack motion analysis system (Northern Digital, Ontario, Canada) (see Figure 1). To measure head posture, an active infrared marker was secured to the right side of the face adjacent to the canthus of the eye and a second marker was positioned just forward of the tragus (i.e., forward of the ear). In addition, two markers were placed vertically along the midline of the sternum to record the torso angle, the upper marker just below the sternal notch and the second marker approximately 5 cm below the upper marker. A marker was also secured to the center of the right side of the monitor. The 3-D location of each active marker was sampled using 2 Optotrak 3020 sensor banks (accuracy ±0.1 mm).

Reference postures for the head and torso were collected for 10 s prior to the testing of each condition. The reference posture measurements were made while the participants were seated with their back and bottom against the chair backrest and while they looked straight ahead (vertical gaze angle of 0°) at a mark on the wall positioned at their sitting eye height. The mean reference posture was the average of the three reference postures collected prior to each test condition.

Summary measures for each participant were calculated from the 2 hr of data for each test condition for the following outcome measures: head flexion angle relative to mean reference posture, head flexion angle relative to torso angle, head horizontal position relative to torso (i.e., head forward), torso angle relative to mean reference posture, and torso height relative to mean reference posture (i.e., measure of slouch). In addition, the mean viewing distance (from the eye plane to the monitor) was calculated.

Vision Function and Symptoms

At the end of each test condition, speed of accommodation and ocular convergence and divergence abilities were measured with computer administered tests (Vision Therapy Assessment, Home Therapy Systems, Noblesville, IN).

Speed of accommodation was measured by having participants view targets at a viewing distance of 41 cm with alternating +1.50- and –1.50-diopter lenses. Targets were squares with a small dot located in one of four locations within the square. The participant indicated the location of the dot with the arrow keys, at which time the lenses were switched and a new target appeared. The test lasted 60 s, and the measure of performance was the number of lens cycles.

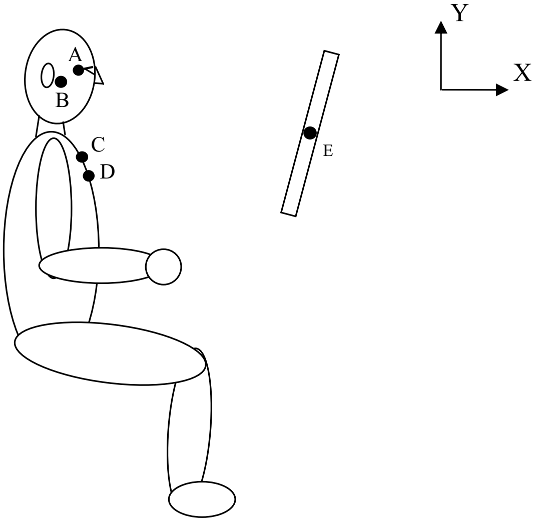

Figure 1. Diagram of participant and monitor with location of 3-D markers. Viewing distance = square root $[(E_x - A_x)^2 + (E_y - A_y)^2]$; head flexion angle = the angle between vector BA and the *X* axis; torso flexion angle = the angle between vector CD and the *x* axis; torso height = $(C_y + D_y)/2$; torso forward position: $(C_x + D_x)/2$; head forward distance: the difference between the mean *x* location of Markers A and B and the mean *x* location of Markers C and D.

The magnitude of ocular divergence and convergence (in that sequence) over which fusion with stereopsis could be maintained was measured using random dot stereo pairs in which one of four targets appeared in stereo depth. Paired images were shown, one to each eye, with red and blue channel separation at a viewing distance of 41 cm. The unit of angular measurement is the prism diopter, essentially equal to 1/100 radian or 0.57° for the range of angles tested. The vergence requirement was increased in a stepwise manner until two incorrect stereo responses were obtained; the vergence magnitude of the last correct response was taken as the "break" limit. The vergence magnitude was then reduced in a stepwise manner until a correct response was obtained, and this magnitude was recorded as the "recovery" finding.

Following each vision test, participants also completed a questionnaire that assessed their experience following the computer task for the following five symptom groups: eyestrain or eye fatigue, blurred vision, neck ache, dry or irritated eyes, and headache (Sheedy, Hayes, & Engle, 2003). Participants rated the severity of the symptoms on a 100-mm visual analog scale with 5 verbal anchors (*none, mild, modest, bad, severe*).

Given the randomized order of conditions and the breaks between the conditions, we assumed that the vision functions and the symptoms before each condition have the same group mean values. Therefore, we confined the visual function and symptom testing to the moment after each condition in order to represent the effect of a particular viewing distance.

Statistical Analysis

Differences among the three test conditions (monitor distances) for all outcome measures were initially evaluated using repeated measures ANOVA. Significant findings were followed up with the Tukey test for multiple comparisons. Because participants were permitted to adjust their body position after the start of a condition, the mean distance from the eyes to the monitor was not identical to the assigned condition. In order to evaluate the effect of actual distance on vision symptoms and vision test results, we applied a regression analysis to distance as a continuous predictor while adjusting for nonindependence of the three observations for the same participant (xtreg command, STATA, College Station, TX).

RESULTS

The mean age of the 24 participants was 25.4 (±4.1, range 19–35) years, and 16 (67%) were male. The ethnic distribution was 46% Caucasian, 29% Latino, and 25% Asian. Four participants used corrective lenses for distant vision but did not normally use lenses for computer use. All participants used the mouse with the right hand. The mean number of years of experience using a computer was 9.5 (±2.8). The mean height and weight of participants were 171.2 (±8.7) cm and 69.6 (±13.4) kg, respectively. The mean adjusted seat pan height, sitting elbow height, and sitting eye height were 47.1 (±3.0) cm, 65.8 (±5.2) cm, and 113.0 (±12.6) cm, respectively.

The mean postures during the 2-hr tasks demonstrate that overall, participants did not maintain the initial distance between their eyes and the monitor, nor did they maintain the initial reference posture (i.e., leaning back against chair back support and gazing straight ahead). The mean reference posture viewing distances were 52.4, 73.0, and 85.3 cm, respectively, for the near, middle, and far distance (Table 1). For each of these viewing distances, the participants moved, on average, closer to the display during the task. When the display was set to the far viewing distance, the participants moved their heads and torsos forward during the task so that the viewing distance decreased from a reference distance of 85.3 cm to 77.5 cm during the task (Δ viewing distance = 7.8 cm). Participants moved further forward during the task for the far viewing distance than for the near and middle viewing distances.

The torso and head posture data explain how the changes in viewing distance were achieved. The 3-D torso position changed from the initial reference posture to the posture during the task by rotating forward (Δ torso flexion angle) and moving down in height (Δ torso height) for all three viewing distances. The forward rotation was 10° more for the far monitor location (11.7°) than for the near monitor location (1.7°), and there was more of a decline in torso height at the far viewing distance (3.5 cm) than at the near viewing distance (2.5 cm). In addition, for the far viewing distance the torso moved 4.8 cm forward of the reference posture, toward the monitor, whereas for the near distance it moved slightly away from the monitor (0.4 cm).

The head flexion angle was close to the initial reference head flexion angle throughout the tasks (only 2.3°–3.8° more) and was not significantly different among the three viewing distances (p = .36). However, the head moved forward of the torso during the tasks and moved the most forward (3.4 cm) at the far viewing distance.

Mean visual, neck, and head symptom intensity scores after each test condition are summarized in Figure 2. There was a trend for lowest symptom intensity at the near location of the monitor. Based on the repeated measures ANOVA, differences among test conditions were significant for blurred vision (p = .01), dry or irritated eyes (p = .03), and headache (p = .01) but not for eyestrain or eye fatigue (p = .15) or neck ache (p = .62). The Tukey follow-up test found significant

TABLE 1: Initial Reference Body Posture, Mean Posture During 2-Hr Computer Task, and Differences (Δ) Between the Two

	Viewing Distance			
	Near	Middle	Far	*p*
Viewing distance				
Reference posture (cm)	52.4 (4.3)	73.0 (4.7)	85.3 (5.8)	<.0001
During task (cm)	50.2 (4.1)	67.7 (6.4)	77.5(9.8)	<.0001
Δ Viewing distance (cm)^{a}	–2.3 (4.2)	–5.3 (5.3)	–7.8 (8.2)	=.001
Δ Head flexion angle^{b}	2.3° (6.0°)	2.9° (5.0°)	3.8° (4.7°)	=.36
Δ Torso flexion angle^{c}	1.7° (7.2°)	7.5° (9.4°)	11.7° (8.3°)	<.0001
Δ Torso height (cm)^{d}	2.5 (1.5)	3.0 (1.6)	3.5 (1.6)	=.0003
Δ Torso horizontal position (cm)^{e}	–0.4 (2.9)	1.8 (5.0)	4.8 (5.0)	<.0001
Δ Head forward distance (cm)^{f}	1.2 (1.7)	2.2 (1.4)	3.4 (1.6)	<.0001

Note. Mean viewing distance during task differs from reference posture viewing distance because participants were allowed to change posture during the study. However, participants were not allowed to change the chair or monitor location during the study (*N* = 24). Standard deviations in parentheses.

[a] Distance from eyes to screen during task relative to initial reference posture. [b] Head forward flexion angle relative to reference posture. Reference posture is mean of relevant measure across the three reference postures collected at the beginning of each test condition. [c] Torso flexion angle relative to reference posture; with larger value, torso is more upright. [d] Torso height relative to reference posture; with larger values, torso is lower. [e] Torso horizontal shift relative to reference posture; with larger values. torso moves forward. [f] Distance head is forward of torso relative to reference posture; with larger values, head has moved farther forward of torso.

differences between the near and far condition for blurred vision and for dry or irritated eyes and between the near and middle condition for headache.

A linear, random-effects model was applied to the data in order to test the effect of the actual viewing distance on visual symptoms. The results of this analysis were similar to those of the repeated measures ANOVA: Distance had a significant effect on blurred vision (p = .003, coefficient = .0012), dry or irritated eyes (p = .006, coefficient = .0014), and headache (p = .003, coefficient = .0011) but not on eyestrain or eye fatigue (p = .10) or neck ache (p = .48).

The convergence and divergence test results after each test condition are summarized in Figure 3. There appeared to be a trend associated with distance for convergence recovery with improved measures at the near distance. Based on the repeated measures ANOVA, distance had a significant effect on convergence recovery (p = .05) but not on divergence break (p = .64), divergence recovery (p = .88), or convergence break (p = .29). The Tukey follow-up test for multiple comparisons

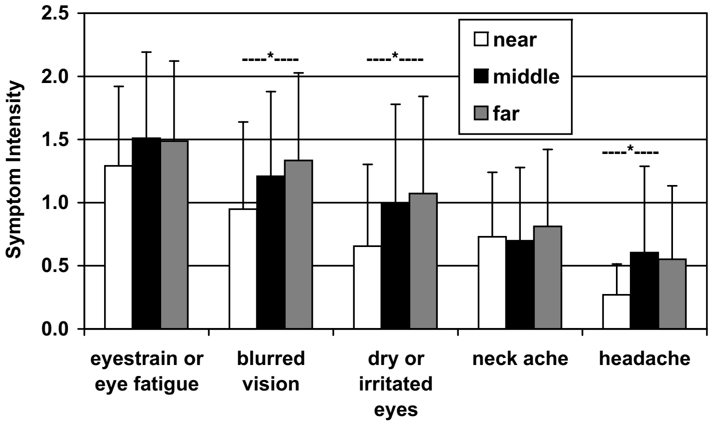

Figure 2. Vision, neck, and head symptom intensity following 2-hr task with computer display set to three different distances. Significant (Tukey follow-up test) differences between distances are marked (----*----). N = 24. Error bars indicate standard deviations.

for convergence recovery found a significant difference only between near and far distances.

A linear, random-effects model was applied to the data in order to test the effect of the actual viewing distance during the task on the vision test results. Based on this analysis, viewing distance (in centimeters) had a significant effect on convergence break (p = .03, coefficient = –.01) and convergence recovery (p = .01, coefficient = –.02) but not on divergence break (p = .84) or divergence recovery (p = .88). Viewing distance had no significant effect (p = .86) upon the speed of accommodation test, with values of 25.3 ± 5.2, 24.0 ± 6.1, and 26.1 ± 7 cycles/min at the near, middle, and far distances respectively.

DISCUSSION

This study found that the viewing tasks on a computer display led participants to make postural adjustments to their torsos and heads that moved them closer to the display; the amount of the postural adjustment and foreshortening of the viewing distance increased with farther viewing distances. In addition, the farther viewing distance caused an increase in visual symptoms and headache pain and a decrease in convergence recovery. The decrease in convergence recovery indicates greater visual fatigue with the longer viewing distance. These outcomes may be attributable to the smaller angular size of the text at the longer viewing distances. The longer viewing distance causes visual discomfort and fatigue as well as postural adjustment as the participants apparently try to mitigate the problem.

In common usage, the size of the characters is fixed on the computer display; therefore the angular visual size decreases with increased viewing distance. A properly corrected eye (20/20 visual acuity) can identify characters with a size threshold of 5 minutes of arc (arcmin). However, the angular size of characters must exceed 5 arcmin because not all people have optimal correction. Even if they did, several studies (Legge, Pelli, Rubin, & Schleske, 1985; Legge, Rubin, Pelli, & Schleske, 1985; Lovie-Kitchin & Woo, 1987) have shown that character size must exceed threshold size for optimal visual performance. The amount by which the character size must exceed threshold size has been termed the *acuity reserve* (Whittaker & Lovie-Kitchin, 1993) and is usually represented as a ratio.

Recommendations for the amount of the acuity reserve are wide ranging. Cheong, Lovie-Kitchin, and Bowers (2002) determined that reading rate leveled off with an acuity reserve of 2:1 for low vision patients, whereas Yager, Aquilante, and Plass (1998) determined an acuity reserve of 4:1 for normally sighted young adults. These acuity reserves would require character sizes of 10 and 20 arcmin, respectively, for a person with 20/20 vision, or 15 and 30 arcmin for a person with acuity reduced by one line to 20/25. The BSR/HFES 100 draft standard (Human Factors and Ergonomics Society, 2002) recommends character sizes of 16 to 18 arcmin for the design distance. Jaschinski-Kruza (1991) found that a group of participants adjusted a screen with 5-mm characters to a

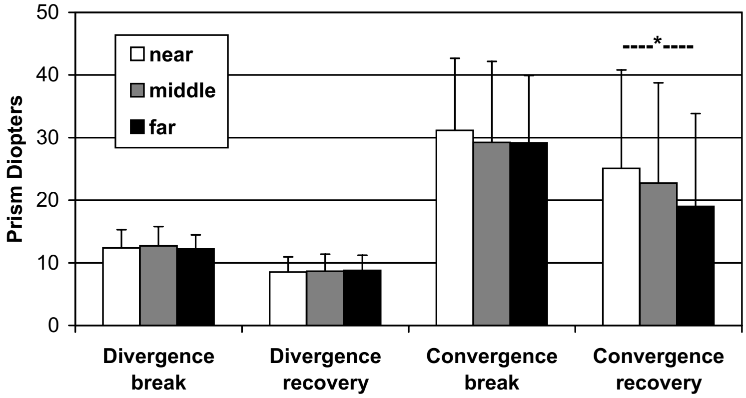

Figure 3. Vergence test results following 2-hr task with computer display set to three different viewing distances. Significant (Tukey test) differences between distances are marked (----*----). N = 24. Error bars indicate standard deviations.

preferred distance of 74 cm. This results in character sizes of 23 arcmin.

The Arial capital letters used in the editing task of our study subtended 21.6, 15.5, and 13.3 arcmin, respectively, at the reference posture viewing distances for the near, middle, and far viewing conditions. The angular size of the characters at the near viewing distance (21.6 arcmin) exceeds the acuity reserves reviewed previously, whereas the angular size at the far viewing distance (13.3 arcmin) results in a smaller acuity reserve than desired for optimal viewing. This is the likely explanation for the result that the participants moved toward the display more with the farther viewing distances, as compared with the shorter one; it is also the likely reason for the result that symptom measures were significantly higher at the two longer viewing distances.

Thus, with the present fixed character size, which was chosen to resemble many practical conditions, the text on the screen can be easily resolved only at a rather short viewing distance. As a consequence, this means a certain load on the oculomotor systems of accommodation and vergence. In order to reduce this oculomotor load and to adapt the preferred viewing distance to the individual oculomotor functions of vergence and accommodation (see the Introduction), longer viewing distances and, accordingly, larger characters would be required. Because such large characters are not commonly used in the workplace, they were not used in the present study.

It is likely that a balance occurs between visual efficiency and postural adjustments. At the farther viewing distances the gains in visual efficiency by moving closer are greater, and hence more postural adjustment occurs. At the near viewing distance the gains in visual efficiency by moving closer to the display are less, and hence less postural adjustment occurs. Greater postural adjustments may lead to greater joint moments and increased muscle loads and fatigue. At the far viewing distance, the participants' postural adjustments were done by moving both the head and torso toward the monitor. During the task, the increase in torso flexion angle and the lowering of the height of the torso (i.e., slumped posture) suggest that the torso motion was done by flexion at the thoracic and lumbar spine, not by flexion of the torso at the hips.

At the far viewing distance, the head forward movement was done by moving the head forward of the torso without changing the head flexion angle. This forward head gliding motion maintains the same up-down gaze angle of the eyes in the orbit across the three distances. This forward head motion also maintains the head in the same location relative to the C1 vertebra and, therefore, should not alter the moment and muscle load about that joint. However, the forward head motion is done by increasing the moment of the head about the C7 vertebra and, therefore, increases the muscle load about that joint. This increased moment would be balanced by an increased load of the upper trapezius and splenius capitis muscles.

Several limitations of the study should be considered. The assumption that the initial, upright reference posture represented an "optimal" torso and head posture may not be valid. However, the initial posture measured at the beginning of each of the three tasks was very similar within participants; therefore, it provides a common reference from which to evaluate the effects of the three screen positions on posture. Another limitation is that participants were allowed to freely move their upper bodies during the task. This movement led participants to alter their viewing distance to the monitor. Therefore, the study is not a test of a fixed viewing distance. A fixed posture and viewing distance may have been difficult for participants to maintain for 2 hr. A final limitation was that the protocol of testing all three viewing distances on the same day likely led to an order effect associated with fatigue; however, this should have been mitigated by the randomized block design.

In conclusion, the viewing distance to a computer monitor over the range of 50 to 85 cm, if the screen character sizes are held constant, can affect visual and head symptoms, convergence recovery, and head posture. The near distance was associated with less blurred vision, less dry or irritated eyes, less headache, and improved convergence recovery when compared with the middle and far distances. Participants moved their torsos and heads closer to the monitor when it was set to the far distance. These findings are likely to be mediated by the reduction in visual angle of the characters with the far viewing distance.

It is important to note that this study does not address the independent effects of character angle and viewing distance. In workplace conditions in which the character size is fixed to about

3.3 mm, as in the present study, it is recommended that the computer monitor be positioned between the near (52 cm) and middle (73 cm) distances from the eyes. However, the physiological evidence reviewed in this paper suggests that a viewing distance of about 50 cm may lead to visual strain, particularly in participants with problems in near convergence (independent of accommodative problems in presbyopia). These participants may benefit from using a longer viewing distance, provided the character size is increased accordingly with an appropriate software tool.

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