IT Kids: is a high computer display more physically demanding for children?

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Abstract

The majority of children in affluent countries now use computers. Whilst adult guidelines suggest a computer display height below eye height, we observed many children working with displays higher than their eyes. This study aimed to determine the 3D posture and neck/shoulder muscle activity impact of an ultra-high display in children. We measured posture and emg in 24 school children working with a display above eye height or below eye height. Working with an ultra-high display resulted in less head and neck flexion and less cervical erector spinae activity but more upper trapezius activity. A better understanding of cervical deep tissue loads is required.

Keywords: children, computers, display height, posture, emg, musculoskeletal disorder

1. Background

The majority of children in affluent countries use computers. For example, in 2000 95% of Australian children used a computer [1].

A meta analysis of international studies on TV and computer use by children [2] found average computer use by children to be around 30 minutes per day. However this is recognized as an out of date estimate as computer use has almost doubled (as the proportion of total media use) in the five years since 1999 (when the meta analysis data was collected) [3]. Recent data shows children in the USA spent on average over one hour each day using a computer [3].

Although the evidence base for postural guidelines for children is minimal [4], most current child guidelines, and also most adult guidelines, suggest a computer display should be positioned somewhat below eye height. However our observations of children working with computers in schools, homes and public facilities such as libraries suggests children commonly use computers with displays higher than their eye height. Whilst one group has suggested this may be suitable [5], most researchers recommend against this setup [eg 6,7,8].

Only one study has been reported which measured the posture and muscle activity impact of different display heights in children [9,10]. The results of that study showed an inconsistent relationship between head/neck posture and neck/shoulder muscle activity. Specifically, head and neck flexion increased with lower visual targets, yet cervical erector spinae and upper trapezius muscle activities were highest with the mid height display.

Fig. 1: Ultra-high display

Fig. 2: Mid display

Whilst their study included a comparison with reading from a book, it only included reading from a display with no input either via keyboard or mouse. This limits the applicability of their results as computer use will usually involve reading from the display and some form of input. Further, their study only assessed sagittal plane postures with no account of lateral flexion or rotation.

Therefore this study aimed to determine the 3D head/neck posture and neck/shoulder muscle activity impact of an ultra-high computer display in children reading and inputting data. It also aimed at clarifying the relationship between posture and neck/shoulder muscle activity.

2. Method

2.1. Design

This study was a repeated measures experimental design laboratory study involving 24 children.

2.2. Subjects

Twelve boys and 12 girls (mean age 11yr 7 m [±9.5 m], height 154 cm [±10 cm], weight 43 kg [±6.7kg]) were recruited as volunteers to the study. Children with extreme anthropometry, uncorrected vision problems or neuromuscular disorders were excluded.

2.3. Conditions

Each child worked for 10 minutes at a computer task with the display in either ultra-high (bottom of display at eye height – see Figure 1) or mid (bottom of display at 100mm from desk – see Figure 2) positions.

Following a 5 minute break away from the workstation, each child completed a similar task with the display in the other position. The task involved completion of an electronic worksheet on world history based on retrieving information from an electronic encyclopaedia. Position order and task were balanced across subjects.

2.4. Dependent Variables

Retro-reflective markers were placed on outer canthi, external auditory meati, C7 and T3 spinous processes. The 3D coordinates of these markers and relevant head and neck angles were determined using a 7 infra-red camera motion analysis system. Table 1 shows the definitions of angles reported. The mean posture over the final 2 minutes in each condition was used for data analysis.

Muscle activity in left and right cervical erector spinae and upper trapezius muscles were gathered using standard electrode sites and preparation. Mean RMS over the final 2 minutes of work in each condition was normalised to maximum voluntary exertion (MVE).

2.5. Controlled Variables

The study was conducted in a lighting and climate controlled motion analysis laboratory. A standard office chair was adjusted to the subject's popliteal height and a flat rectangular desk was adjusted to the subject's elbow height. A foot stool was used when the chair and desk height adjustments would not go low enough for the smaller children.

Children used a standard QWERTY keyboard, mouse and 15" thin film transistor liquid crystal display.

Table 1
Angle definitions

Angle	Description
Head flexion	Angle between Cyclops (virtual point midway between eye markers), OC1 (virtual point midway between ear markers) and vertical axis
Head lateral bending	Lateral angle between OC1, external auditory meatus and vertical axis (negative to the left)
Head rotation	Angle between OC1, Cyclops and anterior axis (negative to the left)
Neck flexion	Angle between OC1, C7 and vertical axis
Neck lateral bending	Angle between OC1, C7 and vertical axis in the frontal plane
Cranio-cervical angle	Angle between Cyclops, OC1 and C7
Cervico-thoracic angle	Angle between OC1, C7 and T3
Gaze	Angle between the centre of the display, Cyclops and vertical axis

2.6. Statistical Analysis

The mean postures and muscle activities in the two display height conditions were compared using paired T tests with SPSS software. A critical alpha level of 0.05 was used.

2.7. Ethics

The study was approved by the Human Research Ethics Committee of Curtin University of Technology.

3. Results

3.1. Posture

Gaze angle (from vertical) to the ultra-high display was 79.2° (0.6) compared with 105.7° (0.8) to the mid display.

Head and neck flexion were smaller with the ultra-high display as expected (head flexion ultra-high 69.4° (1.8), mid 80.3° (1.6), t=-6.1, p<.001; neck flexion ultra-high 47.9° (1.1), mid 52.2° (1.6), t=-3.9, p=.001; see Figure 3).

There were no differences between displays for head rotation or head and neck lateral bending (head rotation ultra-high -0.2° (0.9), mid 1.7° (0.9), t=-1.9, p=.077; head lateral bending ultra-high 0.1° (1.0), mid -0.1° (1.0), t=0.3, p=.796; neck lateral bending ultra-high 0.8° (0.9), mid 0.4° (0.8), t=0.6, p=.528).

Cranio-cervical and cervico-thoracic angles were greater (CC ultra-high 158.4° (2.2), mid 151.8° (2.1) t=3.3, p=.003; CT ultra-high 152.3° (1.3), mid 149.0° (1.6), t=2.5, p=.022) in the ultra-high condition.

3.2. Muscle Activity

Cervical erector spinae activity was reduced in the ultra-high condition (CES left/right ultra-high 10.6/10.3% (0.7/1.0), mid 13.0/12.7% (1.2/1.4), t=1.5-2.6, p=.018-.149) however upper trapezius activity was greater in the ultra-high condition (UT left-right ultra-high 12.2/14.8% (1.5/1.7), mid 10.6/12.0% (1.3/1.4), t=1.5-2.6, p=.018-.138). The different effects on the muscles is illustrated in Figure 4.

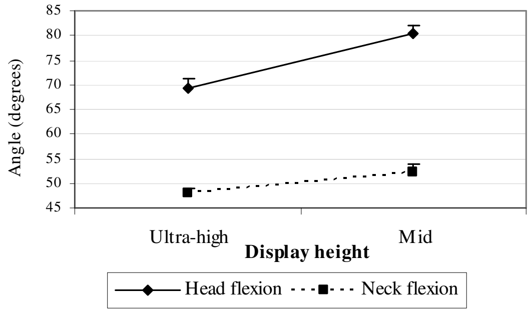

Fig. 3: Comparison of mean (SD) head and neck flexion angles across two display heights

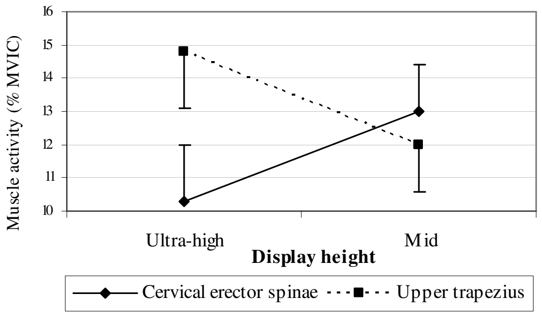

Fig. 4: Comparison of mean (SD) RMS right cervical erector spinae and upper trapezius muscle activity across two display heights

4. Discussion

4.1. Comparison with prior studies

Computer display height clearly effects the head and neck posture of children like it does adults [11,12,13,14,15,16,17,18]. The head and neck flexion postures recorded from children in this study are in the midrange of prior adult studies with similar display height conditions. Head flexion (this study 69°) ranging from 52-80° has been reported for similar ultra-high conditions and ranging from 66-92° for mid display heights (this study 80°). Similarly, neck flexion (this study 47°) ranging from 37-55° has been reported for ultra-high conditions and ranging from 37-60° for mid display heights (this study 52°).

No prior studies reporting 3D posture of the head and neck segments independently could be found, although Szeto and Lee [17] reported 3D posture of a combined head and neck relative to the thorax. Our results show very neutral mean head rotation and head and neck lateral bending during use of keyboard and mouse. This suggests the potential risk of musculoskeletal disorders related to excessive stress from asymmetrical head/neck postures [19,20] is unlikely in these conditions.

Computer display height also clearly affects muscle activity in the neck/shoulder region in children as it does in adults [11,12,15,16,21,22,23,24,25,26,27].

Babski-Reeves et al. [21] is the only prior study to report CES activity in response to ultra-high displays with adults. Their results showed lower levels (~3% MVE) for the ultra-high display and a similar mid height display (~5%). Turville et al. [23], Sommerich et al. [26] and Villaneuva et al. [24,25] also report CES activity in adults during work with displays similar to our mid display height. Again their CES activity levels are lower than ours, ranging from less than 2% to around 8% MVE. In contrast, Greig et al [10] report CES activity in children to be similar in ultra-high condition (~9%) and higher in a mid height condition (~23%).

The only prior studies to record upper trapezius activity during work with an ultra-high display [10] reported lower values (~5%MVE) than recorded in the present study (~13%MVE). The higher values in the current study may be due to arm movements required for keyboard and mouse use. However, in the mid height condition Grieg et al. [10] found activity levels similar to the current study (~10%). Several adult studies have also reported upper trapezius activity in response to a mid display position [22,23,24,25], with mean activity in the range 2-11%MVE.

CES EMG amplitude differences between this study and prior adult reports may be due to differences in the proportional weight of the head in children. The increased proportional weight would tend to increase the flexion moment around C7 and occiput/C1, demanding a greater muscular resistive force.

Differences could also be due to differences in amplitude normalisation. Babski-Reeves et al. [21] and Straker and Mekhora [16] normalised to a submaximal contraction. Saito [27] reported integrated emg with no normalisation and Bauer and Wittig [12] reported emg relative to emg when gaze was horizontal. Sommerich et al. [26], Turville et al. [23] and Villanueva et al. [24,25] used maximum exertions in a seated position, using dynamometer or manual resistance. Our current normalisation protocol aims for a high level of consistency by taking the mean of the best two of three trials. Each trial involved a 1 second ramp up, three seconds hold of maximum exertion and 1 second ramp down. The mean RMS over the highest one second period was taken as the MVE value for each trial. This protocol, whilst providing good reliability, would provide a lower MVE value than other protocols using a peak rectified EMG value. The effect of a lower magnitude MVE value is to increase the task amplitudes. Therefore our slightly higher task amplitudes may be due to the conservative MVE protocol.

4.2. Posture – Muscle Activity Relationship

The lack of a similar relationship between CES and Upper Trapezius muscle activity and head posture, as shown in Figures 3 and 4 is consistent with the prior reports by Briggs et al. [9]. Whilst superficial CES muscle activity appears to be positively related to head and neck flexion and thus increasing flexion moment around occiput-C1 and C7-T1, upper trapezius activity has a different relationship. The roles of upper trapezius include head/neck extension, lateral bending and rotation as well as scapular elevation and rotation. Upper trapezius is often considered a scapula stabilizer during upper limb movement [28] and these multiple roles may explain the different relationship with head/neck flexion.

The evidence from adult and child studies now shows a relatively clear trend for increasing CES activity with increasing head and neck flexion across the mid range of flexion. Extremes of flexion, such as during reading from a book flat on the desk, has shown a reduction in EMG activity [10], perhaps as a result of flexion relaxation. A higher display therefore appears to require less activity from superficial CES, however the load on deeper upper cervical muscles and other tissues is not known.

The evidence from adult and child studies suggests a less clear relationship between head and neck flexion and upper trapezius activity. The general trend across the collated studies is for upper trapezius activity to *not* vary consistently, with amplitudes from ~5%MVE to ~10%MVE reported for ultra-high, mid and low display positions. It therefore appears that the other roles of upper trapezius, related to scapular stabilisation for upper limb movement, may be more critical in determining activity levels. Whether an interaction exists between the demands of display height and arm support or movement demands is unknown.

5. Conclusion

Children using a computer with an ultra-high display had a more upright head and neck posture and more open head/neck and neck/thorax angles. However, whilst cervical erector spinae activity was reduced, upper trapezius activity increased. This suggests a change in cervical tissue loading. Prior to recommending a display height for children, further data on the deep sub-capital muscles is needed to clarify the tissue loading.

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