ITKIDS: READING FROM COMPUTERS CREATES DIFFERENT BIOMECHANICAL AND PHYSIOLOGICAL STRESSES FOR CHILDREN?

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There has been increasing concern in scientific and general public communities about the possible risk of musculoskeletal disorders in children associated with the increasing use of computers. The posture children assume when using a computer is thought to be a major risk factor, yet has only previously been measured by approximate observation techniques. The aim of this study was to describe in detail the head and neck posture and muscle activity of children using computers, compared to using older information technology. The sitting posture and muscle activity of 32 children aged 4-17 years was examined whilst they read from a desktop computer, a laptop computer and a book. There were significant differences in head and neck posture, with increasing flexion from desktop to laptop to book conditions. There were also significant differences in upper trapezius and cervical erector spine activity levels with greater activity in the laptop condition than in desktop or book conditions. Reading from a computer causes different postural and muscle activity responses compared to reading from a book. Whether these responses create a greater risk can only be determined with a more detailed understanding of the tissue stresses around the cervical spine.

INTRODUCTION

Computers have become an essential part of life in industrially advanced countries. Children now have greater accessibility to computers both at school and at home. This increased availability had been associated with an increase in computer use by young people. We are concerned that this increase could also be associated with the development of musculoskeletal disorders (MSDs) and visual impairments as occurred with adults in the 1980s (Straker 2001).

The risks to children could include health risks such as the development of MSDs and visual problems but could also include cognitive and social risks such as aversion towards computer use, decreased educational attainment, and decreased competency in future society which is likely to have an even greater reliance on computers. As well as these potentially significant costs to the individual, there could be significant costs to the community in the form of health treatment costs and lost work time and capacity costs. Yet despite the predicted risks, little research has been conducted directly on the health implications of this major change in the activities performed by children.

Computer use by children is growing at a marked rate. A recent report by the Australian Bureau of Statistics (2000a) found that 95% of Australian school-aged children use computers (94% in school and 76% at home) with 74% of children using computers two or more times a week. Associated with this increased use of computers at school and home is the replacement of physical activities during available leisure time. An alarming finding of the Australian Bureau of Statistics report (2000b) is that playing electronic or computer games was the second highest leisure activity (69%) after television viewing (97%). The musculoskeletal risk from exposure to these activities could be two fold. In the short term the sustained postures and muscle activities that may be associated with computer and television activities may cause discomfort and disorder in stresses tissues, especially in the neck and shoulder. However significant exposure to these sedentary activities may create an even more important long term effect of not providing the necessary stimuli to the developing musculoskeletal, neuromuscular and cardiovascular systems of children.

Reading from paper in the form of books, magazines and newspapers is an activity which children have been exposed to for hundreds of years. Whilst there have been some concerns about the potential for poor postures associated with paper based 'old' information and communication technologies (ICT), society appears to accept the traditional risk exposure as acceptable.

Although books are still used at home and school, there is evidence of increasing use of 'new' ICTs – desktop and laptop computers. At school these new ICT provide exciting new learning opportunities and many teachers and schools have adopted these technologies enthusiastically. Some schools in Australia now have mandatory laptop programs for students. However, this changing technology has brought with it new risks for the classroom and the home environments (Straker and Pollock, 2003).

Parents, teachers and education authorities appear to accept that the learning environment has important effects on students' productivity, health and satisfaction. However when the physical design of ICT workstations have been

investigated in school or home environments, significant ergonomic deficits have been identified.

New ICT classrooms have typically consisted of standardized school furniture with desktop computer workstations or the addition of laptop computers to traditional ICT workstations. As the classroom dimensions were traditionally designed for book learning, available classroom space and workstation dimensions may not accommodate the increased bulk and accessories associated with computers. Furthermore, lighting configurations may not support an ideal gaze angle.

Zandvliet and Straker (2001) gathered questionnaire information from 1404 high school students in Canada and Australia and found that workspace environment in classrooms was consistently rated poorly. Other studies have also found inappropriately designed ICT environments. For example Oates et al (1998) conducted a study on 95 primary school children. Postures assumed by children using desktop computer work stations were assessed with a visual approximation method (RULA). The researchers concluded that there was a marked lack of suitably designed facilities for the children to use at school. Another observational study by Laeser et al (1998) evaluated the effect of introducing an adjustable keyboard to a traditional desktop computer workstation for 58 secondary school students. The RULA results showed a significant improvement in sitting posture with a keyboard arrangement designed to fit the anthropometric needs of the student. It was concluded that computer workstation design can influence a child's posture..

Whilst the available literature has clearly identified a rapid increase in computer use by children it has not yet adequately described the postural and muscle activity response of children to using these new ICTs (indeed there is still a paucity of detailed information on the postures and muscle activities of children using paper based ICTs).

The aim of this study was therefore to provide a detailed two dimensional description of the head and neck posture and muscle activity in children using new and old ICT.

METHOD

Subjects

Participants were recruited for this laboratory study via notices in local newspapers and schools. Thirty two children completed the study and had viable data sets. The subjects ranged in age from 4 to 17 years (mean 10.7 years) and 20 were male. Participants were between the 5th and 95th percentile height for their age and had no significant visual, cognitive or musculoskeletal impairment. Ethics approval was given by the Curtin University Human Research Ethics Committee.

ICT Type

The main independent variable (ICT type) had 3 levels: desktop, laptop and book. The desktop computer was a Wintel PC with a "17 inch" cathode ray tube monitor positioned on top of the central processing unit. The top of the computer display was 575mm above the desk and the bottom of the display was 325mm above the desk. The display was positioned 250mm from the subject edge of the desk. A standard keyboard was placed between the central processing unit and the edge of the desk, with a Tiny Mouse (IttyBitty) placed on the right side of the keyboard.

The laptop computer was a Toshiba Satellite laptop with a 13.1 inch TFT display. The top of the display was 250mm above the desk. Subjects were allowed to move the angle of the display relative to the keyboard. The keyboard was 50mm high, 320mm wide, and 270 mm deep and sat 150mm back from the subject edge of the desk. The same mouse was used as in the desktop condition

The book condition used one of three age-appropriate educational books (picture dictionary, encyclopedia, and world history book). The books were placed flat on the desk and were positioned 150mm from the subject edge of the desk. The books for the older children were 280mm high and 440mm wide. The book for the younger children was 340mm high and 540mm wide.

Electronic and paper versions of the same books were used to maintain similarity of content between conditions.

The workstation consisted of a standard school desk (720mm high, 900mm wide and 600mm deep, Sebel) and standard school moulded plastic chair (seat pan 445mm high, 360mm wide and 370mm deep, Sebel).

Posture

Head and neck posture was measured using the Peak Motus Motion Analysis System™ (Peak Performance Technologies, Chattanooga, USA). A single camera and 800W lamp were positioned 8m lateral to the subject on their right side to capture a two dimensional image which was later digitized.. Hemispherical retro-reflective markers were used to define body segments. Two posture aspects are reported here:

Head Tilt (upper cervical flexion): angle between a vertical reference line through the right external auditory meatus marker and the line through the right external auditory meatus and right outer cantus of the eye (eye-ear line).

Neck Angle (lower cervical flexion): angle between a vertical reference line through the marker on the spinous process of C7 and the line through spinous process of C7 and right external auditory meatus.

Trunk, shoulder, elbow and wrist sagittal postures were also calculated but these data are not reported here as little change in the position of these joints was observed. Gaze angle was also captured for each trial.

Muscle Activity

EMG activities of cervical erector spinae (CES) and upper trapezius (UT) muscles recorded using a Physiometer

400‡. Four sets of 17mm surface electrodes (ungelled, Neuroline§) were applied over the left and right CES and UT Each set consisted of 2 active and 1 reference electrodes separated by 3mm. The placement of the CES electrodes was lateral to the spinous processes of the upper cervical vertebrae on the muscular prominence of semispinalis and splenius capitis. Electrodes were placed below the hairline and did not extend below the level of C7. The UT electrodes were placed lateral to the angle of the descending fibres. EMG was sampled at 1280 Hz and the Root Mean Square (RMS) values were calculated at 100ms intervals. Prior to task performance, subjects performed maximal and submaximal voluntary contractions to enable amplitude normalization. The procedure was followed according to methods outlined in previous studies.

After normalization, the subject performed a reading task in one of the three ICT conditions (book, laptop, desktop). The task duration was 5 minutes; the first 3 minutes was allowed for accommodation to the task. The average angle and RMS over the middle 60 seconds of the final 2 minutes were used for analyses. The subject had a 5 minute activity break between ICT conditions.

Results

Figure 1 shows the trend for increasing head tilt from reading from a desktop computer (mean 66.4, confidence interval 62-70) to laptop computer (83.3, 80-87) to book (95.2, 89-101). A one way repeated measures analysis of variance (RANOVA) found a significant difference ($F_{2,60} = 91.23$, $p < .001$, eta^2 .753) with contrasts showing desktop was different to laptop and laptop was different to book .
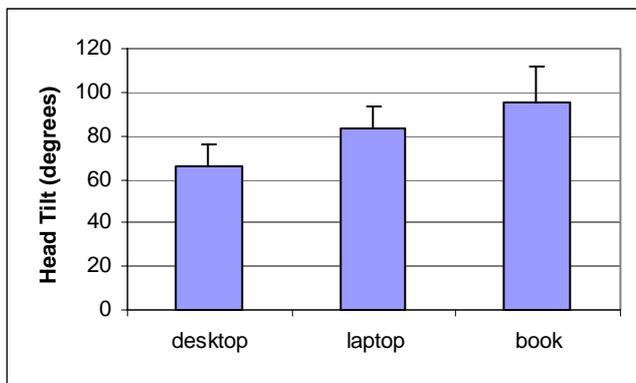
Figure 1 Mean (standard error) head tilt of children reading from desktop computer, laptop computer and book

Figure 2 shows the trend for increasing neck flexion from reading from a desktop computer (49.7, 48-52) to laptop computer (59.4, 56-63) to book (67.8, 64-72). A one way RANOVA found a significant difference ($F_{2,60} = 51.90$, $p < .001$, eta^2 .63) with contrasts showing desktop was different to laptop and laptop was different to book .
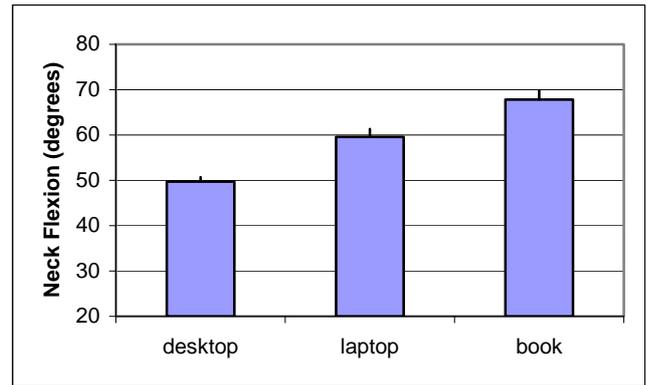
Figure 2 Mean (standard error) neck flexion of children reading from desktop computer, laptop computer and book

Figure 3 shows the trend for increasing CES muscle activity from reading from a desktop computer (Left 8.3, 6-11; Right 9.0, 6-12) to laptop computer (Left 23.8, 18-29; Right 21.0, 15-27) and book (Left 21.2, 17-25; Right 16.7, 13-21). A one way RANOVA found a significant difference (Left $F_{2,60} = 24.80$, $p < .001$, eta^2 .453; Right $F_{2,60} = 16.92$, $p < .001$, eta^2 .361) with contrasts showing desktop was different to both laptop and book.
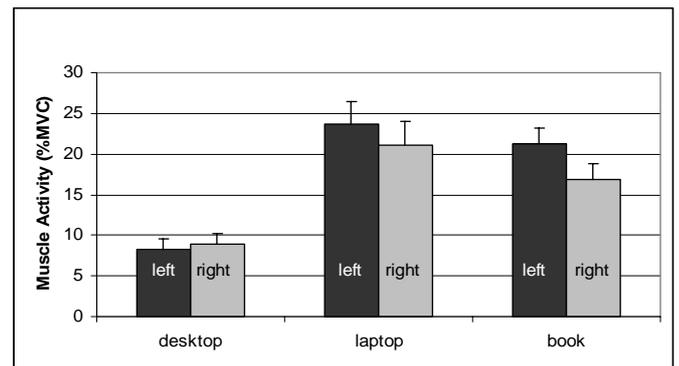
Figure 3 Mean (standard error) cervical erector EMG of children reading from desktop computer, laptop computer and book

Figure 4 shows the trend for increased upper trapezius EMG activity with a laptop computer (Left 9.3, 7-12; Right 11.6, 8-16)compared to from reading from a desktop computer (Left 4.0, 2.9-5.1; Right 6.3, 4.2-8.4) or book (Left 6.8. 5-9; Right 4.4, 3-6). A one way RANOVA found a significant difference (Left $F_{2,60} = 10.83$, $p < .001$, eta^2 .272; Right $F_{2,60} = 16.35$, $p < .001$, eta^2 .353).
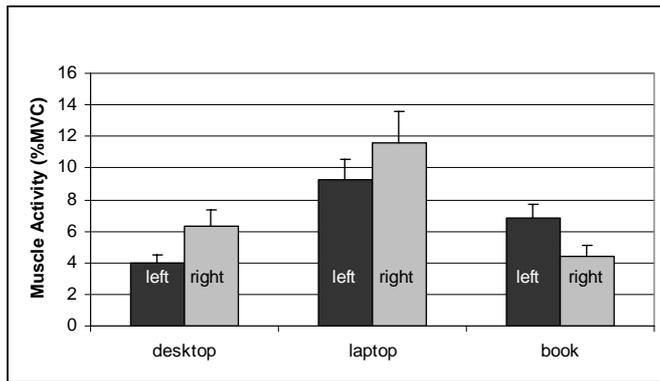
Figure 4 Mean (standard error) upper trapezius EMG of children reading from desktop computer, laptop computer and book

DISCUSSION

The subjects assumed positions of significantly greater head and neck flexion in the book condition compared with the laptop condition, and even less in the desktop condition. A simple biomechanical model suggests that increased head and neck flexion will result in increased load moment at the head and neck complex as the head center of mass moves horizontally further away from its axis of rotation. This would imply the desktop condition resulted in the least stressful posture.

However there is some debate about the adequacy of this simplistic model due to the instability of the osseous architecture of the cervical spine. Data in this study were also analysed as deviation from the resting head position, which may be considered the most physiologically optimal posture.

Interestingly the greatest deviation from a resting head position occurred during desktop use and the greatest deviation from the resting neck position occurred during book use. This implies that the desktop and book conditions may have been more posturally inefficient. The least deviation from resting head and neck position was found during laptop use, suggesting it may be the most suitable ICT.

We had anticipated that the muscle activity data would follow the postural data due to the assumption that increased forward bending of the head and neck would result in increased resistive muscle activity, as had been found in studies on adults. However our data clearly do not support this simple model.

The reduced muscle activity in the book condition compared with the laptop condition (despite an increase in head and neck flexion) suggests something other than superficial muscle activity is resisting the increased moment. Two mechanisms are obvious.

The first is that there may be an end of range 'silence' of CES similar to that found in the erector spinae in the lumbar region with full lumbar flexion. This would suggest that the extensor moment is either being opposed passively through the CES muscle or through deeper passive connective tissue structures.

The second mechanism is that deeper extensor muscles may take a proportionally larger role in resisting flexion moment as the head and neck approaches full flexion. Indeed a combination of these two mechanisms is also possible.

Based on the current EMG data a simple conclusion would suggest the desktop condition results in least stress. This is clearly an inappropriate conclusion given the postural findings. This conflict between criteria highlights the dangers of basing ergonomic recommendations on too simplistic a model of humans and too few criteria and the difficulty in accurately measuring musculoskeletal load.

CONCLUSION

Reading from a desktop or laptop computer clearly creates different biomechanical and physiological stresses on the head and neck of children compared with reading from a book. Whether these stresses represent a greater risk requires a more detailed investigation of the stresses on tissues in the neck.

ACKNOWLEDGEMENTS

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