ITKids: does computer use reduce postural variation in children?

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Abstract

Many schoolchildren frequently use computers. Lack of postural variation is proposed as a risk factor for musculoskeletal disorders (MSDs) in adult computer users, but the effect of computer use on children's postural variation is unknown. This study examined if there was a reduction in postural variability among schoolchildren when using computers compared to other tasks. Nine schoolchildren were observed in their natural environment while upper body postures were measured using inclinometers. Tasks performed and type of technology used was documented by an observer and matched to postural data with a minute-to-minute resolution. A comparison was made of postures during New Information and Communication Technology (ICT) tasks (electronic-based), Old ICT (paper-based), and Non ICT tasks. Mean postures were determined and postural variation was characterised using an index based on the Exposure Variation Analysis (EVA) matrix, and the range between the 10th and 90th percentiles of the Amplitude Probability Distribution Function (APDF). New ICT produced more neutral postures but significantly lower postural variation. Old ICT had less neutral postures but greater postural variation. The relationship between lack of variation and MSDs among children requires further investigation.

Keywords: Children, ICT, posture, variability

1. Introduction

Computer-based activities have become part of daily life for many school-aged children around the world [1-4]. The term *New* Information and Communication Technology (ICT) has been used to classify and differentiate these electronic-based media from paper and pen based *Old* ICT [5]. Children reportedly use New ICT for playing games, accessing the Internet, e-mailing friends and word processing tasks associated with school- work [6]. Daily use of computers had previously been limited to adult office workers, but has become an accepted tool for children to complete their daily activities. Computer use in schools is becoming commonplace with an increasing number of schools introducing mandatory 'laptop' programs into the curricula [7]. Video and computer gaming continues to be a popular choice of leisure activity among both boys and girls [6]. Consequently children's exposure to New ICT tasks may in fact exceed that of adults.

Prior studies of adult computer users have found an increased risk of developing musculoskeletal disorders (MSDs) based on various factors including hours of exposure [8,9], workstation design [10] and postures used [11]. There is growing support for promoting *variation* in posture during computer work as a means of reducing the health risks [12-14]. The focus of concern is thus not which average postures are more or less risky, but rather the posture time pattern, including the duration of periods for which certain postures are held and the overall posture range.

So, despite the fact that children are frequently engaging in New ICT activities very little is known about the effects of this exposure on the developing musculoskeletal systems of children. This study aimed to determine if postural variation in children is reduced when they are exposed to New ICT tasks compared to Old ICT or Non ICT tasks.

2. Method

2.1. Design

This study observed the daily activities of schoolchildren, performed in their natural school and after-school environments, with an emphasis on the use of different types of ICT. Direct measurements of head, trunk and dominant upper arm postures were collected.

2.2. Subjects

Nine right-hand dominant school children (5 boys and 4 girls) at public and private schools, with mean [sd] age 9.1 years [0.3], height 135.1 cm [4.3], weight 28.4 kg [1.9] were recruited into this study via an advertisement placed in the respective schools' newsletters.

Subjects were eligible for inclusion into the study if they reported using electronic-based media (i.e. computer, television, telephone) within school and/or non school tasks for at least 30 minutes per day, and were willing to be monitored and observed at their school, home and community. Subjects were excluded from the study if they had previously been diagnosed with a congenital or acquired musculoskeletal disorder.

Approval to conduct this study was obtained from the Human Research Ethics Committee at Curtin University of Technology. The children and their parents/guardians provided written informed consent prior to commencement of the study.

2.3. Data collection protocol

All subjects were observed and recorded for up to 12-h in one day, commencing at 9am. Data collection ceased after 12-h or when the subjects prepared for bath or bed. During the recording period daily activities were observed without interruption, and direct measurements were collected of postures (described below), and muscle activity (not reported in this paper). In the evening prior to the day of recording, the researcher met each child at their home after they had bathed and explained the procedures to the child and their parents/guardian. Inclinometers were positioned on the child to calibrate posture, as described below, and then removed. This familiarised the child with the equipment and protocols in order to shorten the set-up time on the day of recording.

On the day of recording the child was met either at home or the school at 7:45am. Inclinometers were placed on the child. Calibration of posture was made as before. A discomfort measure was obtained from the child. The time of day that postural recording began was documented and the task observations commenced simultaneously.

2.4. Task observations

Tasks performed by each child during the observation period were documented using time-stamped real-time observation by the researcher or a research assistant. The task observations included the geographical location (school or non-school) and the activity or task completed. Observations of the main posture used were documented, classified into seven categories including sitting, standing, walking and. squatting. The type of ICT used (Old, New or Non ICT) was also documented. Old ICT includes paper-based methods for completion of tasks and examples are reading a book, writing with a pen or drawing with a pencil. New ICT refers to electronic-based interfaces such as computers, television, telephones and interactive gaming devices. Non ICT describes tasks where no form of ICT media is used, such as playing a sport or board game, walking home from school or eating a meal. The ICT device (e.g. desktop computer or television) and the ICT interface control (e.g. paper/pen or keyboard/mouse) used to perform the tasks were also documented.

Observations (including time-stamped photographic recordings taken for illustrative purposes) were recorded in an HP Jornada 565™ personal data assistant (PDA) (Hewlett Packard, Palo Alto, USA) using data base software (PocketCreations™, OT International, Perth, Australia) programmed by the researcher. When the subject had a change in task performed, the type of ICT used or there was a change in the postural category, a new record was commenced. This produced a continuous time-line of tasks and observed postures at a minute-to-minute resolution.

The details of task time patterns are not reported here.

2.5. Measurement of posture

The position of each subject's head, upper torso and dominant upper arm, relative to gravity, was measured in the frontal and sagittal planes of movement using bi-planar electronic inclinometers (Physiometer PHY-400®, Premed A/S, Oslo, Norway),. The inclinometers were strapped to the back of the head, on the upper thoracic spine and on the lateral surface of the dominant upper arm using broad straps and held in place with additional sports tape.

Inclinometer output was sampled at 10 Hz, and stored temporarily in a portable computer (HP 200LX Palmtop®, Hewlett Packard, Palo Alto, USA) worn in a pouch strapped to the subject's waist. The position of the pouch did not interfere with upper torso posture of the subject.

The inclinometers had functional ranges of 120º. To maximize the usable range, the inclinometers were adjusted to cover from 90º flexion to 30º extension for arm, head and trunk, 0º to 90º arm abduction and 60º left to 60º right lateral bending of the head and trunk. Calibration of the inclinometers was performed for each subject in upright standing facing forwards, with both arms hanging down by the side of the body.

At the end of school the recording of posture stopped to allow the researcher to change the batteries in the computer collecting the postural data. The task observation log noted these procedural tasks. The synchronized recording and observation period re-commenced following these procedural tasks.

2.6. Data Processing

Task observation data was processed to identify the start of each type of ICT task. Arm elevation angles were calculated from the quality controlled recordings of arm abduction and arm flexion/extension values using spherical geometry algorithms.

The task observation and postural recordings were synchronized using the time of day displays on both the HP Jornada 565™ PDA and the HP200LX Palmtop®. A specially developed LabVIEW™ (National Instruments, Austin, Texas) program generated a series of outputs from the synchronized task observation and posture data including, for each ICT type, means and standard deviations for each posture variable; the amplitude probability distribution function (APDF) for each posture variable and from this, the range between the 10th and 90th percentiles ($APDF_{(90-10)}$). An exposure variation analysis (EVA) [15] was performed for each posture variable to characterise the duration of uninterrupted periods spent at different posture levels. The standard deviation of the EVA matrix ($EVA_{(sd)}$) was calculated to provide an index of the variation. The $APDF_{(90-10)}$, and the $EVA_{(sd)}$ represent different aspects of posture variation.

2.7. Statistical Analysis

To test the overall difference between ICT types, one-way RANOVAs were performed on the mean, $APDF_{(90-10)}$ range and $EVA_{(sd)}$ of each posture variable. Differences between types of ICT were identified using planned pairwise contrasts. All analyses were performed using the Statistical Package for the Social Sciences (SPSS v.11.5; LEAD Technologies, Inc.). A critical alpha probability level of .05 was used, with probabilities between .10 and .05 identified as trends.

3. Results

3.1. Mean postures

The mean postures (in degrees) adopted during different ICT types and the RANOVA summary statistics are presented in Table 1. As the table shows, there were main effects for arm elevation, head flexion, trunk flexion and trunk lateral bending, but not for head lateral bending. The results of means contrasts for each variable are described below.

3.1.1. Arm elevation

Mean arm elevation during Old ICT (35º) and New ICT (32º) tasks were significantly greater than during Non ICT tasks (25º; p=. 001; p=. 047).

3.1.2. Head flexion and lateral bending

Head flexion during Old ICT tasks (17º) was significantly greater than during New ICT (-2º; p< .001) and Non ICT tasks (0º; p<. 001). There was no difference in head lateral bending between the three ICT types.

3.1.3. Trunk flexion

Trunk flexion during Old ICT tasks (13º) was significantly greater compared to New ICT tasks (8º; p= .010).

Table 1
Mean [sd between subjects] postures by ICT types

	ICT Types [a]			RANOVA
	O	N	X	
AE	35 (5)	32 (11)	25 (3)	$F_{2,16}$ =5.4; p =.016
HF	17 (8)	-2 (10)	0 (9)	$F_{2,16}$ =54.8; p <.001
HLB	2 (12)	2 (14)	1 (13)	$F_{2,16}$ =2.1; p =.159
TF	13 (7)	8 (8)	11 (5)	$F_{2,16}$ =5.5; p =.015
TLB	3 (6)	4 (7)	1 (5)	$F_{2,16}$ =4.9; p =.021

[a] O = Old ICT; N = New ICT; X = Non ICT
(AE) arm elevation; (HF) head flexion; (HLB) head lateral bending; (TF) trunk flexion; (TLB) trunk lateral bending.

3.1.4. Trunk lateral bending

Trunk lateral bending in Non ICT tasks (1°) was significantly less than during New ICT (4°; p= .033) and Old ICT tasks (3°; p=.028), however the differences may be of little clinical relevance.

3.2. Postural Range

The mean posture range ($APDF_{(90-10)}$) for each ICT type is shown in Table 2, as are the RANOVA summary statistics.

3.2.1. Arm elevation

The range in arm elevation during New ICT tasks (35°) was less than during Old and Non ICT tasks (46°; p=. 069; p=. 060).

3.2.2. Head flexion

Head flexion had significantly larger range during Old ICT tasks (53°) compared to New (30°; p< .001) and Non ICT tasks (42°; p< .001). Non ICT tasks had a significantly greater range than New ICT tasks (p= .022).

3.2.3. Head lateral bending

There was no significant difference in the posture range of head lateral bending between the different ICT types, however there was a trend for postural range during Old ICT tasks to be greater than during New ICT tasks (p=.060).

Table 2
Mean [sd between subjects] of the $APDF_{(90-10)}$ range

	ICT Types [a]			RANOVA
	O	N	X	
AE	46 (8)	35 (13)	46 (5)	$F_{2,16}$ = 4.1; p =.037
HF	53 (7)	30 (12)	42 (7)	$F_{2,16}$ = 22.3;p<.001
HLB	37 (5)	29 (10)	34 (5)	$F_{2,16}$ = 3.2; p =.069
TF	40 (11)	29 (10)	40 (5)	$F_{2,16}$ = 6.4; p =.009
TLB	20 (3)	16 (5)	19 (2)	$F_{2,16}$ = 2.9; p =.082

[a] Abbreviations as in Table 1.

3.2.4. Trunk flexion

The range in trunk flexion during New ICT (29°) was significantly less than in Old ICT (40°; p=.037) and Non ICT tasks (40°; p=.014).

3.2.5. Trunk lateral bending

Whilst there was no significant main effect for trunk lateral bending, there was a trend for the range during New ICT (16°) to be less than during Old ICT (20°; p= .039).

3.3. Standard deviation of Exposure Variation Analysis

Postural variation, as characterised by $EVA_{(sd)}$, is shown for the different ICT tasks in Table 3, as are the RANOVA statistics. Small $EVA_{(sd)}$, values indicate a large diversity in posture patterns and high values are indicative of a narrow range of posture amplitudes and/or a narrow range of durations for postures. Means contrasts for significant main effects are described below.

3.3.1 Arm elevation

Although the main effect for arm elevation was not significant it was noted that diversity in posture patterns was significantly greater during Old ICT (1.7) compared to Non ICT tasks (2.2; p< .001).

3.3.2 Head flexion

Diversity in posture patterns was significantly greater during Old ICT tasks (2.0) compared to New ICT (3.0; p=.009) and Non ICT tasks (2.4; p<.001).

3.3.3 Head lateral bending

Diversity in posture patterns during Old ICT tasks (2.3) was significantly greater than during Non ICT tasks (2.8; p<.001).

Table 3
Mean [sd between subjects] of $EVA_{(sd)}$

	ICT Types [a]			RANOVA
	O	N	X	
AE	1.7 (.3)	2.2 (.9)	2.2 (.2)	$F_{1.1, 9.0}$ =2.3; p=.158
HF	2.0 (.2)	3.0 (.9)	2.4 (.3)	$F_{1.1, 8.9}$ =8.4; p=.016
HLB	2.3 (.5)	2.7 (.5)	2.8 (.4)	$F_{1.2, 9.9}$ =4.8; p=.048
TF	2.1 (.3)	2.6 (.4)	2.0 (.3)	$F_{1.4, 10.9}$ =8.9; p=.008
TLB	2.5 (.3)	3.0 (.3)	2.8 (.4)	$F_{1.1, 9.1}$ =6.2; p=.031

[a] Abbreviations as in Table 1.

3.3.4. Trunk Flexion

Diversity in posture patterns during Non ICT (2.0) and Old ICT tasks (2.1) were significantly greater than during New ICT tasks (2.6; p=.011 and p=.020 respectively).

3.3.5. Trunk Lateral Bending

Diversity in posture patterns during Old ICT tasks was significantly greater than during Non (2.8; p =.002) and New ICT tasks (3.0; p=.015).

4. Discussion

Mean posture values for arm elevation, and head and trunk flexion were higher during Old and New ICT tasks compared to Non ICT. Mean posture values for head and trunk flexion were higher for Old ICT than New ICT tasks. Head and trunk flexion in this study were less than results reported in other studies of children's postures during reading and writing tasks [5, 16]. Reasons for the differences between ICT types may include that children were observed in this study to abduct their arm to place their forearm on the desk surface, which was above the elbow height of all subjects. Increased head flexion may have been due to the placement of paper/pen media flat on the desk resulting in marked flexion of the head to view the documents. Also, very few of the children were observed to use the back support of the chair while reading and writing at the desk, which may have contributed to high trunk flexion values with Old ICT.

Mean postures of the head were close to neutral in New ICT and Non ICT tasks. The head and trunk postures in the current study were markedly more neutral than those reported by Harris and Straker [7] in their study of school aged laptop users. However, the children in this study used only desktop computers during New ICT computer tasks, with the display and keyboard placed central to the midline. Greater head flexion during laptop use compared to desktop use has also been reported in studies of adult users [17].

Although New ICT tasks produced the most neutral postures of the head and trunk, they also had the least postural variation, as measured through the posture range ($APDF_{(90-10)}$) and the diversity of posture patterns ($EVA_{(sd)}$). The Old ICT tasks that produced the higher postural values consistently had the greatest variability, similar to the postural variation within Non ICT tasks.

One explanation for the higher variation during Old ICT and Non ICT tasks is the portability of the media interface. For example during Old ICT tasks the children in this study wrote on the horizontal surface of their desks, but also on the vertical surface of the whiteboard when directed by the teacher. They read books placed on flat on their desk but also read from the whiteboard. Non ICT tasks are similar. Many self-care tasks such as eating and drinking can be done while moving around, and games in the playground are mostly physically active, involving a variety of postures.

Conversely, New ICT tasks including desktop computer use, watching television or video gaming are less portable and limit the location of the task and the postures the operator uses. New ICT in this study included TV viewing and using computers. Whether these tasks differ in postural variation should be determined given the large exposures most children have to both these technologies.

Prior ergonomics research of adult computer users has proposed that long duration exposure to computer-based tasks may increase the risk of MSDs, suspectedly because of sustained contractions of the muscles responsible for maintaining the postures used. However the risk associated with different levels of exposure variation has not been well quantified. Whether or not reduced postural variation within New ICT activities poses a risk for the development of musculoskeletal disorders or other ailments in children still needs to be determined. However, lack of postural variation should be considered as a generic risk factor when considering the effects of, for instance, workstation layout, technologic developments and increased psychosocial demands.

5. Conclusion

The children in the current study demonstrated close to neutral upper body postures but less postural variation when using New ICT including computers, compared to Old ICT and Non ICT tasks. Old ICT tasks were characterised by higher postural values, particularly for head and trunk flexion, but also had the highest postural variation. Further research is necessary to determine how children's postures compare with adult computer users, and if any associations exist between participation in tasks with low postural variation and the development of MSDs in children.

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