Are children at more risk of developing musculoskeletal disorders from working with computers or with paper?

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Abstract. Adult computer users are recognized as being at risk of musculoskeletal disorders. Despite children in modern societies being increasingly exposed to computer use, little has been published on the possible musculoskeletal risks for children. This paper reviews recently available evidence from epidemiological and laboratory studies. The early indications are that computer use creates different physical stresses on children than paper use. Whether these stresses are worse is still unclear.

1 Introduction

1.1 Information technology work associated with significant musculoskeletal problems in adults

Musculoskeletal disorders associated with information technology (IT) work are a significant problem in adults. Studies on neck and upper limb pain in adult computer users have reported high prevalence rates. For example, Cook et al. (2000) studied 270 clerical staff, technical staff, call centre operators and managers at 15 workplaces. Their findings included that 76% of adult computer users had experienced neck and upper limb pain related to computer use in the previous 12 months. In a similar study of 170 workers in 7 workplaces Evans and Patterson (2000) found that 67% of adult computer users had experienced neck and upper limb pain in the previous month.

For many adults the pain associated with computer use is sufficient to interfere with their work performance and with their non work activities. For a small minority, symptoms progress to a severely disabling level [3].

For the past 2 decades research on the negative health outcomes associated with computer use has focused almost exclusively on adults.

1.2 Increasing IT 'work' being performed by children

Computer use by children in modern societies has increased rapidly over the last decade. The Australian Bureau of Statistics released data in January 2001 [4] that shows 95% (nearly 2.5 million) of children aged 5 to 14 years used a computer during or outside school hours. School was the most common site of use (94% computer users) followed by

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home (76%). Computer use was frequent, with 74% children using computers 2 or more times a week.

Educational purposes were the most common reasons for use outside of school for older children, and whilst this was also a very common reason for younger children, playing games was the most common for the younger children. In a sub study (data taken over 2 weeks during school term) playing electronic or computer games was the leisure activity participated in by the highest percentage of children (69%) after watching television (97%).

It is therefore clear that the vast majority of Australian children are now regularly exposed to computers.

1.3 Concerns raised that increasing IT use may be creating musculoskeletal disorders for children

Recently concerns have been raised in both scientific and mass media forums that this increasing use of computers by children could result in an increase in musculoskeletal disorders in children.

For example the International Ergonomics Association (IEA) ran a special session on children and computers at its recent triennial congress [5,6,7] and has since established an international technical group aimed at investigating and ameliorating any problems arising from children's use of computers.

Parents, teachers and education authorities are also very concerned and the issue has been widely reported in the international media. For example the New York Times ran a large article on the potential risks in January 2001, and TV news stories ran in the UK, USA, Hong Kong and Australia in December 2000. Professional education magazines are also discussing the issue (eg Independence - the journal of the Association of Heads of Independent Schools of Australia.

The risk of musculoskeletal disorders in children from increased use of computers is clearly of considerable concern to researchers in this area and, more importantly, the community at large.

1.4 Estimates of the risk of developing musculoskeletal disorders related to computer use

In adults, the most common musculoskeletal disorders associated with computer use are in the neck and upper limb region. Scandinavian and European research has tended to focus on proximal disorders and North American research has tended to focus on distal disorders. Epidemiological studies suggest proximal disorders are the most common in adults.

Developing a causal relationship between risk factors and disorder development has been difficult. The two main streams of research being used to understand risk are epidemiology and laboratory studies.

Epidemiological studies have tried to estimate exposure to various hypothesised risk factors and associate these with health outcomes. A common difficulty with these studies is estimating exposure . Laboratory studies have tried to determine how various contributory factors change hypothesised risk factors. For example, how does visual display height affect trapezius muscle activity. The two most common risk factors assessed in laboratory studies, and some field studies, are posture and muscle activity.

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Posture may be related to disorder by mechanisms like: increased mechanical load, poorer mechanical advantage, poor length-tension relationship, pressure on neural or vascular tissue, less movement margin of safety and postural monotony. Muscle activity may be related to disorder by: higher muscle loading, continuous loading of some muscle fibres, chemical changes or suboptimal movement patterns due to local muscle fatigue.

Caveates in establishing evidence include: poor understanding of etiology, gross measures may not be sensitive enough to predict disorder, pattern of stresses likely to be important rather than just average or accumulation.

However, given these caveats on our knowledge about risk factors, what is known about the risk for children?

2 Evidence of risk to children from using computers

2.1 Epidemiological evidence

We have completed 3 epidemiological studies investigating the risk of musculoskeletal disorders in children using computers.

2.1.1 Laptop schools study

The first study [8] was a cross sectional study on 314 students in 3 schools in Australia. Students ranged in age from 10 to 17 years and all 3 schools had a manditory laptop policy. This meant that each student was required to use a personal laptop for most of their studies, both at school and at home. Students typically carried their laptop in a backpack, along with their study books, from class room to class room, and home at the end of a school day. The study provided a good description of the exposure of these children to IT use. Students reported using their laptop for a mean of 3.2 hours per day and 16.9 hours per week (with use ranging up to 15 hours per day for some students on some days). Duration of use in one sitting ranged from 11 minutes to 10 hours, with a mean of 102 minutes. The study also provided a description of the gross postures used by children when working with laptops, with an interesting finding that only 34% of laptops use was when sitting at a desk.

The mean daily use figures do not necessarily suggest high risk of musculoskeletal disorders (when compared with adult worker exposures). However the sustained periods of use and range of postures used suggest musculoskeletal problems may be a risk. The risk was supported by a finding that 60% of students reported discomfort associated with computer use. The validity of the nexus was confirmed by a significant association between longer duration of use and increased discomfort and the most common location of reported discomfort being the neck and shoulders. These results compared well with adult desktop literature, suggesting a similar level of risk.

This study was important in providing a description of the ways students are currently using laptop computers in technologically advanced schools and baseline information on discomfort prevalence rates. However it provided no information on the relative risk using computers compared with books, and laptop computers compared with desktop computers.

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2.1.2 Case-comparison classes study

The relative risk of using computers, and laptop computers in particular, was investigated in a second smaller cross sectional study [9]. 74 students attending a mixed gender school were surveyed. Forty of these students were 12 year old students (Grade 6) who had been participating for 6 months in a pilot program where laptop computers were integrated into the whole curriculum. The remaining 34 students were 11 years old (Grade 5) and only used desktop computers in a computer laboratory for a couple of hours each week during class time (although they used them outside of class time also). The Grade 5 group was the closest comparison group available.

Children completed a questionnaire delivered via the world wide web. Exposure data collected from students included the frequency (almost never, occasionally, weekly, daily) and daily duration (0 hours, about 1/2 hour, about 1 hour, 2-3 hours, 3-5 hours, 5+ hours) for a range of IT tasks (reading from paper, writing on paper, using a desktop computer with keyboard/mouse, using a laptop computer, using a desktop with joystick/game controller, using a TV with game controller, using a hand held computer game, watching TV/video) on school and non school days. We also collected some perceptions from students on their attitudes towards computers.

To assist in verification of the children's reporting of exposure, data was collected from the 4 class teachers. Teachers were also asked to record the nature of computer use in class, number and type of computers used in class, workspace where computers were used in class, timetable of computer use in class and estimates of home computer use for school work and leisure.

Outcome data collected from students included the location, frequency and intensity of discomfort associated with each IT task.

As expected, reading and writing with paper was a daily occurrence. Computer use was also a daily activity, with Grade 6 students using laptops each day and Grade 5 students using desktops each day. Game controllers connected to desktops and TVs and hand held electronic games were used occasionally or rarely by both groups. TV/video watching was a daily activity for both classes, as was vigorous physical activity.

Reading and writing on paper and exercising were all performed for 1-3 hours each school day. Grade 6 children also used a laptop computer for 2-3 hours each school day. Electronic game playing was almost never or occasional on school days (although some time was spent on these tasks on non school days). Reading and writing on paper were performed less on non school days. Similarly, most computer use was less on non school days, whilst TV/video viewing was performed more by both groups on non school days.

Table 1 shows a comparison of the proportion of students in both classes who experienced discomfort related to different IT tasks. It can be seen that a similar proportion of Grade 5 and Grade 6 children reported discomfort associated with reading and writing with paper, using a desktop computer and watching TV/video. A much higher proportion of Grade 6 students reported weekly or daily discomfort with laptop computer use ($Chi^2_{(3)}$ 18.4, p=.0004).

Table 1 Frequency of experiencing discomfort

IT Task	Grade	Frequency (%)			
		almost never	occasionally	weekly	daily
Reading from paper	5	62	24	9	6
	6	56	26	13	5
Writing on paper	5	36	54	4	7
	6	49	30	14	8
Using a laptop computer	5	75	15	5	5
	6	18	46	18	18
Using a desktop computer	5	52	41	4	4
	6	64	33	3	0
Watching TV/video	5	66	28	7	0
	6	67	28	3	3

Common locations for discomfort whilst reading from paper included eyes, neck, midback, and head. The most common location for discomfort associated with writing was the right hand. The intensity of this discomfort was typically 1/10, though was reported as high as 8/10. Other common locations for discomfort associated with writing on paper included neck, eyes, midback, low back and right shoulder. Whilst the intensity of discomfort in these areas was typically low, 15 students reported significant discomfort in at least one area (>= 5/10).

Discomfort associated with desktop computer use was most commonly felt in the eyes, followed by the neck, right hand, mid back and head. Some individuals reported discomfort up to 8/10.

Common locations for discomfort associated with laptop use in Grade 6 children included the eyes, neck, right hand, low back mid back, head and shoulders. Whilst discomfort was typically of low intensity, several students reported discomforts as high as 9/10.

The results showed a reasonable consistency in the frequency of discomfort reported by students from both grades for most tasks. Reading, using a desktop computer and watching TV all resulted in about 1/3 of the students noting discomfort. Watching TV is a more passive activity with a greater range of postural options so it should be possible to avoid discomfort. Reading also enables a wide range of postures. Thus the postural variety possible with these tasks may be the factor which minimises the experience of discomfort. The desktop computer use results are less easily explained. It was expected that the constrained posture necessitated by the input and output devices would have resulted in higher discomfort that reading from paper or watching TV.

Discomfort was associated with laptop use by 82% of the Grade 6 students. This prevalence for laptop discomfort was nearly twice that for reading from paper and, more significantly, working with desktop computers.

This research design made it impossible to determine the cause of the differences in discomfort reported by the Grade 6 students using laptops. Possible reasons include: different students, ages, amount of exposure to computer use, amount and intensity of school work and the type of computer used (laptop or desktop). However the differences do suggest a potentially important risk.

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Whilst the focus of this study was on the physical aspects of computer use, the evidence from adults suggests a strong relationship between psychosocial aspects of computer use and physical risk measures. Therefore some simple data on attitudes towards computer use were collected (Table 2).

Table 2 Attitudes to computers

Question	Grade	% Yes	% No	% Not Sure
Do you think using a computer helps you learn better?	5	53	9	35
	6	80	5	12
Do you think you learn more when using a computer?	5	53	18	26
	6	67	7	22
Do you find you 'waste' time trying to work a computer rather than learning about the topic?	5	18	59	21
	6	12	60	25
Do you get distracted from learning about the topic when using a computer?	5	24	59	15
	6	15	73	10
Do you get so nervous or anxious using a computer you find you can't learn well?	5	12	68	18
	6	0	95	2
Do you enjoy using a computer?	5	91	6	0
	6	93	2	0
Do you get frustrated using a computer?	5	15	59	24
	6	30	50	17
Do you get nervous or anxious when you have to use a computer?	5	6	76	9
	6	2	88	5
Would you like to work with computers when you finish school?	5	65	15	15
	6	67	7	22

Note: sum of % may not = 100 as not all students answered each question

The majority students felt that using a computer helped them learn better and that they learnt better using computers. Around 2/3 of students felt they didn't waste time learning with computers, with the remainder split between being unsure and feeling they did waste time. Attitudes concerning distraction were very similar to wasting time, with around 2/3 students feeling they didn't get distracted. Nearly all Grade 6 students did not get so anxious about using a computer that it interfered with their learning. However only 2/3 of Grade students felt this way. Nearly all students reported enjoying using a computer. One third of Grade 6 students reported frustration, about twice the proportion of Grade 5 children. Nearly all students reported they did not get nervous using computers. Around 2/3 students in both grades reported desire to work with computers when finished school.

The results of this small study suggest that intensive use of laptop computers may have more physical impact on students than using books alone or books with occasional desktop computer use. However the inherent weaknesses in a cross sectional study make it impossible to ascertain what caused the higher discomfort ratings in the Grade 6 children using laptop computers.

The small minority of students reporting significant intensities of discomfort fits with experiences in adult work forces where a large majority suffer mild to moderate discomfort which is not disabling, a small minority experience severe, accummulating discomfort which becomes disabling without intervention.

Interestingly there was no clear relationship between discomfort and negative attitudes to computers. With further studies it may be possible to determine whether discomfort and attitudes to computers are related in a 'J' shape – with discomfort adversely impacting on

attitude but very positive attitudes having a negative impact on discomfort when associated with excessive use of computers.

2.1.3 RASCALS study

We are part of the large-scale program coordinated by the Institute of Child Health Research which is tracking the health of a randomly ascertained cohort of 10% Western Australian children from birth to adulthood (around 1,500 children). Currently this program is surveying these children at age 5. We have included in this survey a measure of the exposure of children to IT and the prevalence of musculoskeletal discomfort associated with IT use.

2.1.4 Summary of epidemiological evidence

The evidence from epidemiological studies has convinced us that this is a real and significant problem which needs greater understanding. The studies suggest that the majority of students report discomfort associated with computer use and that there may be higher prevalence and intensity of discomfort associated with computer use versus book use.

2.2 Laboratory evidence

We are currently completing a series of linked studies on 33 children reading from a book, laptop computer and desktop computer. Subjects ranged in age from 4 to 17 years and represented a wide distribution of height and weight .

2.2.1 Upper quadrant posture in children using IT

One study [10] focussed on the upper quadrant posture using the Peak Motus (Chattanooga, USA) motion analysis system. Subjects wore retroreflective markers on key anatomical landmarks. Sagital video recordings were digitised, and head, neck, trunk, arm, forearm and wrist postural angles calculated in addition to gaze angle (eyes to center of visual target).

The type of IT significantly effected spinal angles. For example, progressively greater head tilt angles were recorded for desktop, laptop and book reading.

2.2.2 Neck and shoulder muscle activity in children using IT

In a parallel study [11], EMG was collected from the left and right upper trapezius and cervical erector spinae muscles of the same subjects performing the same reading tasks. EMG was band pass filtered (20-500Hz) and RMS calculated over 100millisecond periods using the Physiometer (PreMed, Norway) system. Amplitude normalisation was performed using standard maximal and 30% maximum ramp contractions for each muscle.

The type of IT used significantly effected muscle activity levels, though in a different pattern to spinal posture. For example, cervical erector spinae activity was least during reading from a desktop compared with reading from a laptop or book.

2.2.3 Summary of laboratory study evidence

The early evidence from laboratory studies suggests different forms of IT do cause different physical stresses. What is yet to be determined is whether these different stresses are worse or not.

3 Conclusion

Limited evidence evaluating the risk of children developing musculoskeletal disorders from IT use is available. However the early epidemiological and laboratory studies support the view that children are at least as much as risk as adults.

This is highly significant as this generation of children will live in a world where computer interaction is an essential component of normal work and leisure life. The handicap created by an inability to use computers will be enormous for the individual and will impact significantly on the community at large.

Our current and future research is aimed at providing evidence upon which to base guidelines for wise use of computers by children.

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