School of Physiotherapy

Musculoskeletal outcomes in children using computers – A model representing the relationships between user correlates, computer exposure and musculoskeletal outcomes

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Declaration

To the best of my knowledge and belief this thesis contains no material previously published by any other person except where due acknowledgement has been made.

This thesis contains no material which has been accepted for the award of any other degree or diploma in any university.

Results of this thesis have been presented, in part, in the following publications and at the following scientific meetings (Please see Appendix F, G, H, I and J for copies of these works):

Harris, C., Straker, L., Pollock, C. & Trinidad, S. (2005). Musculo-skeletal outcomes in children using information technology – the need for a specific etiological model. *International Journal of Industrial Ergonomics*. *35*, 131-138.

Harris, C., Straker, L. & Pollock, C. (2007). Children's exposure and use of information technology. *Proceedings of the Human Factors and Ergonomics Society of Australia's (HFESA) National Conference*, Perth, November 2007.

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Abstract

The etiology of musculoskeletal outcomes associated with the use of information technology (IT) has predominately been defined by studies of adults in their work environments. Theories explaining the causation of work related musculoskeletal disorders have identified individual user (biomechanical, physiological and psychosocial), task demand, work organization and environmental risk factors. Models based on these theories have subsequently been developed to investigate the causal relationship between IT exposure and outcomes experienced by the user.

Computers are an important IT type used by children, and computer use by children is rapidly growing in both school and home environments. Recent literature demonstrates an increase in children's reports of computer related musculoskeletal outcomes. Children's computer use appears to be different to adult's work related computer use. Thus, although many potential risk factors for children may be similar to those for adults, it is proposed that risk factors and models of causal relationships between computer use and musculoskeletal outcomes may vary for children.

The main aims of this study were: (1) to investigate children's computer exposure in their usual occupational environments of school and home; and (2) to develop and test a multivariable model that would assist in understanding relationships between child user correlates, computer exposure and computer related musculoskeletal outcomes.

1351 students (792 boys and 559 girls) from eight primary and five secondary schools in Perth, Australia, participated in the study in 2006. Convenience sampling was undertaken within stratified groups, to ensure the sample had the required range of participants from different socioeconomic status (SES) backgrounds, both genders and school Years 1, 6, 9 and 11(approximate ages 6, 9, 14 and 16 years).The study design was cross sectional involving the completion of a questionnaire survey by participants, and for younger participants their parents. Questionnaires contained items relating to the participant and their activity exposure as an individual, within a family context, and within their neighbourhood. Physical measures of height and weight were also collected.

The results showed that 100% of children had access to computers at school, and at home 98.9% of children had access to computers, with 95.9% reporting home internet access. The use of different exposure measures demonstrated that at school 97.8% of children had used a computer in the last month, for an average of 2.4 hours per week, commonly for 30-60 minutes in one sitting. At home 95.7% of children had used a computer in the last month, for an average of 7.2 hours per week, commonly for 60 - 120 minutes in one sitting. Computer activities performed more frequently at school were surfing the internet, learning programs and multimedia. At home the most frequent computer activities were surfing the internet and email. Children with bedroom computer access were found to have nearly 50% greater mean weekly hours of use. The use of a range of computer exposure measures (frequency, usual and longest duration, mean weekly hours and frequency of computer activities) provided better characterization of the amount *and* nature of children's school and home computer exposure.

Age and gender were associated with children's school and home computer use. Computer use was greater with age for both boys and girls, and boys had greater use than girls across all Year levels for all exposure measures except school usual duration. Children with greater computer exposure were shown to experience less computer anxiety; reported more somatic complaints; had used a broader range of computer activities; had greater exposure to other IT activities (electronic games, TV, mobile phone) and moderate vigorous physical activity. SES was associated with computer exposure, with children from low SES backgrounds having greater home computer exposure, and children from high SES backgrounds having greater school computer exposure.

Computer related musculoskeletal outcomes were reported by 10% of children for school computer use and 20% for home computers. The most commonly affected body locations were the neck and back, and 30% of those children reporting outcomes limited their activity participation, 10% took medication and 7% consulted a treating health professional. The use of a range of outcome measures allowed for a better understanding of the impact of children's computer related musculoskeletal outcomes.

Given the significant findings of different relationships between children's computer exposure patterns at school and home, two models were developed and tested, with one model for school computer exposure and one model for home computer exposure.

Path analysis modeling, accounting for user correlates, tested direct relationships and indirect relationships via computer exposure for a range of user correlates. The final school computer exposure model showed direct relationships between gender, somatic complaints, computer exposure and musculoskeletal soreness; and indirect relationships, via computer exposure, between age, computer flow, TV exposure, SES and musculoskeletal soreness. The final home computer exposure model showed direct relationships between gender, age, somatic complaints, computer exposure and musculoskeletal soreness; and indirect relationships, via computer exposure, between age, computer flow, computer anxiety, TV exposure, SES and musculoskeletal soreness.

In conclusion, the child specific model tested within this study demonstrated direct relationships between children's computer exposure and musculoskeletal outcomes. Additionally, direct and indirect relationships were also shown between a range of user correlates, the environment and musculoskeletal outcomes. These findings will assist researchers, teachers and parents to understand the range of potential risk factors for computer related musculoskeletal outcomes. This will also allow researchers to target interventions to child users and their computer environments to ensure children's computer use is performed in a safe and productive manner.

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List of Abbreviations

IT	information technology
SES	socioeconomic status
VDT	visual display terminal
MSS	musculoskeletal soreness
YAQ	Young people's activity questionnaire
YAQ-II	Young people's activity questionnaire – version 2
YOAQ	Year one's activity questionnaire
sd	standard deviation
NSES	neighbourhood socioeconomic status
MVPA	moderate vigorous physical activity
n	number
BMI	body mass index
TV	television
DVD	digitial video device
MSD	musculoskeletal disorder
MSDs	musculoskeletal disorders
ABS	Australia Bureau of statistics
USA	United States of America
UCB	USA census bureau
UK	United Kingdom
CDC	Centres for Disease Control and Prevention
NSP	neck and shoulder pain
LBP	low back pain
K - 7	kindergarten (first year of formal school) to year seven
SAR	student attention rate
ICSEA	Index of community socio-educational advantage
IRSAD	Index of relative socioeconomic advantage and disadvantage
WLSMV	Weighted Least Squares estimation with Mean and Variance
NH&MRC	National Health and Medical Research Council

1.0 Introduction

The aim of this chapter is to provide background information relating to a conceptual framework for the study's models of musculoskeletal outcomes associated with children's computer use. Background information discussed includes current theories and models representing the relationships between exposure to potential risk factors and musculoskeletal outcomes. These potential risk factors relate to adult work tasks and include office based computer use. The models presented in this chapter are based on adults in their work environments as no child related models investigating relationships between exposure to risk factors and related musculoskeletal outcomes were available.

Adult models and theories presented in this chapter demonstrate the multivariable nature of the relationships between exposure to potential risk factors and the precipitation of musculoskeletal outcomes. Variables (or correlates) shown to have a relationship with task exposure and related musculoskeletal outcomes are both external (work demands, organizational factors) and internal (psychosocial profile, morphology) to the individual. Directions of the relationships between these internal and external correlates are also represented in the presented models and aim to demonstrate the potential causal relationships.

Limitations of applying the presented models and theories to explain the relationships between children's computer use and related musculoskeletal outcomes are also discussed in this chapter. The limitations show that children using computers are different from adults in work environments, thus demonstrating the need for a child specific model. The adult models did provide valuable guidance on which variables (or correlates) to consider in a child specific model and thus the child literature to review. This provided the rationale for the main purpose of the thesis; to develop a child specific multivariable model of the relationships between user characteristics, computer exposure and musculoskeletal outcomes. A slightly modified version of this Introduction chapter was published in The International Journal of Industrial Ergonomics (2005) and is provided in Appendix F.

Following this introductory chapter, the second thesis chapter reviews literature concerning children's computer exposure and related musculoskeletal outcomes. This review discusses children's school and home computer environments, characteristics of the child computer user and the impact of computer exposure on children's health and development, including musculoskeletal outcomes. This literature review highlights potential risk factors associated with children's computer exposure, and thus provides evidence for potential correlates related to children's computer related musculoskeletal outcomes. Based on the information reviewed in both of these chapters the study's aims and specific objectives are presented. These objectives relate to investigating the relationships between the proposed correlates, computer exposure and related musculoskeletal outcomes.

1. 1 BACKGROUND TO STUDY

Computer use by children is rapidly growing. Children are using computers in their education, leisure pursuits and communication, in both school and home environments. Research on the ergonomics of children's computer use has begun to investigate the potential effects of computer use on a child's health, satisfaction and productivity (Straker and Pollock, 2005). Several studies have suggested children using computers may be at risk of the development of musculoskeletal problems (Royster and Yearout, 1999; Bennett, 2002; Gillespie, 2002; Rowe and Jacobs, 2002).

The etiology of musculoskeletal outcomes associated with the use of information technology (IT) has predominately been defined by studies of adults in their work environments. Risk factors identified in the literature as being associated with musculoskeletal outcomes include: individual factors (eg. genetics, age, gender, anthropometry, psychosocial profile, cognition, physiology); physical environment and biomechanical factors (eg. force, posture, movement and vibration) and task demands / work organization (eg. repetitive paced tasks) (Armstrong *et al.,* 1993; Mathiassen, 1993; Kuorinka and Forcier, 1995; Li and Buckle, 1999; Kumar, 2001). Additionally, models have been developed to investigate this causal relationship between IT use and musculoskeletal outcomes experienced by the user. These models also provide IT users with the basis for workplace guidelines to assist in controlling some of the associated risks for musculoskeletal outcomes.

When examining children's computer use it is evident that their use is different to adults in the work environment. Even though many risk factors may be similar, due to the nature of children and their environments, it is proposed that potential risk factors and models of causal relationships between IT use and outcomes would differ for children.

Developing a model that assists in understanding the relationships between computer exposure, potential risk factors and musculoskeletal outcomes in children is thought to be necessary so that academics, teachers and parents can develop a better understanding of the risk factors for children's computer use. This will support the development of recommendations for effective use of computers by children, which in turn will encourage children to use this valuable resource in educational, recreational and communication environments in a safe and productive manner.

1.2 GENERAL MODELS / THEORIES FOR MUSCULOSKELETAL OUTCOMES WITH IT USE BY ADULTS

While there is no study to date that has demonstrated a clear and indisputable causal or dose response relationship between any of the risk factors and injuries (Kumar, 2001), results from epidemiological studies have contributed to evidence of causality in the relationship between workplace risk factors and musculoskeletal outcomes.

Bernard and contributors (1997) developed a framework for evaluating evidence for the causality of workplace risk factors and musculoskeletal outcomes. In their review of epidemiological studies they found that evidence for associations between musculoskeletal outcomes and risk factors varied from "strong evidence" to "no evidence". Specific risk factors of repetition, force, posture, vibration or a combination of risk factors were shown to have associations with musculoskeletal outcomes. For example, they found strong evidence that neck musculoskeletal disorders (MSDs) were related to prolonged durations of static contraction of neck / shoulder musculature (posture). Additionally they found strong evidence for musculoskeletal outcomes associated with a combination of risk factors, for example upper limb posture and force. Work related risk factors most consistently identified included: repetitive (monotonous) hand work, high physical load, static load, vibrating tools with hand and elbow pain, and increasing intensity or duration of exposure. There were also reports that stress may predict musculoskeletal outcomes.

Models have been developed that attempt to represent the relationships between exposure to risk factors and precipitation of musculoskeletal outcomes (Armstrong *et al.*, 1993; Mathiassen, 1993; Sauter and Swanson, 1996; Kumar, 2001). Although varied, these models show that musculoskeletal outcomes are linked to the interaction of a number of risk factors, and it is thought that musculoskeletal outcomes can follow a dose – response relationship (Armstrong *et al.,* 1993). Most of these models suggest that musculoskeletal outcomes cannot be fully explained through physical causes alone, and that psychological, social and environmental factors will also influence the precipitation of musculoskeletal outcomes. This multidimensional perspective is illustrated in the following three current theories of musculoskeletal outcome precipitation.

1.2.1 Adult Models

The Multivariate Interaction Theory of Musculoskeletal Injury Precipitation by Kumar (2001) demonstrates how a musculoskeletal injury is an interactive process between genetic, morphological, psychosocial and biomechanical factors. Within these categories there are many variables that may affect precipitation of a musculoskeletal injury.

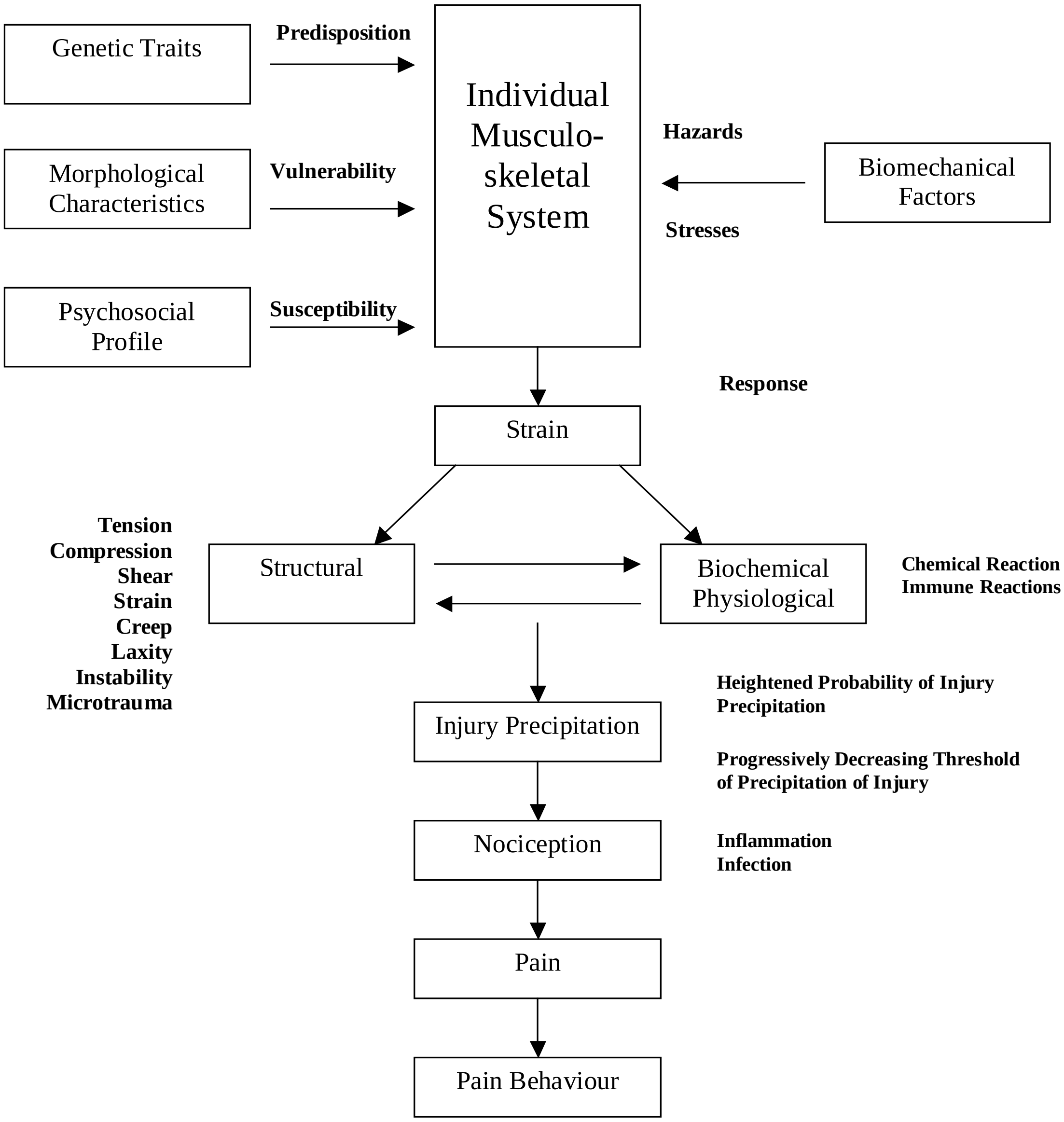


Figure 1.1 Multivariate intervention theory of musculoskeletal injury precipitation (Kumar 2001)

The Exposure-effect model, as discussed by Mathiassen (1993), shows how the interaction of external (outside the individual) and internal (within the individual) exposure variables interact to result in a response. Initially the response is acute, either during the activity or after the activity, and can lead to chronic effects. The model demonstrates how the acute response provides continued internal exposures.

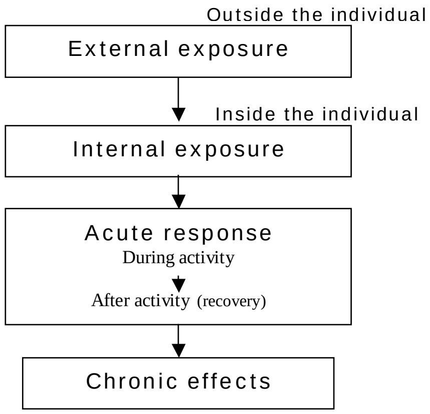


Figure 1.2 Exposure-effect Model (Mathiassen 1993)

Specific models discussing risk factors and outcomes associated with an individual's exposure to computers are limited. One model is the Ecological model of MSDs in Visual Display Terminal work proposed by Sauter and Swanson (1996). This model discusses the relationships between psychosocial factors and musculoskeletal outcomes in office work. As computer work is a major task in office environments this task is incorporated into the model. This model has detail on how cognitive processes such as detection and awareness of musculoskeletal outcomes may be affected by psychosocial processes. The model is specific to office work and computers in offices only.

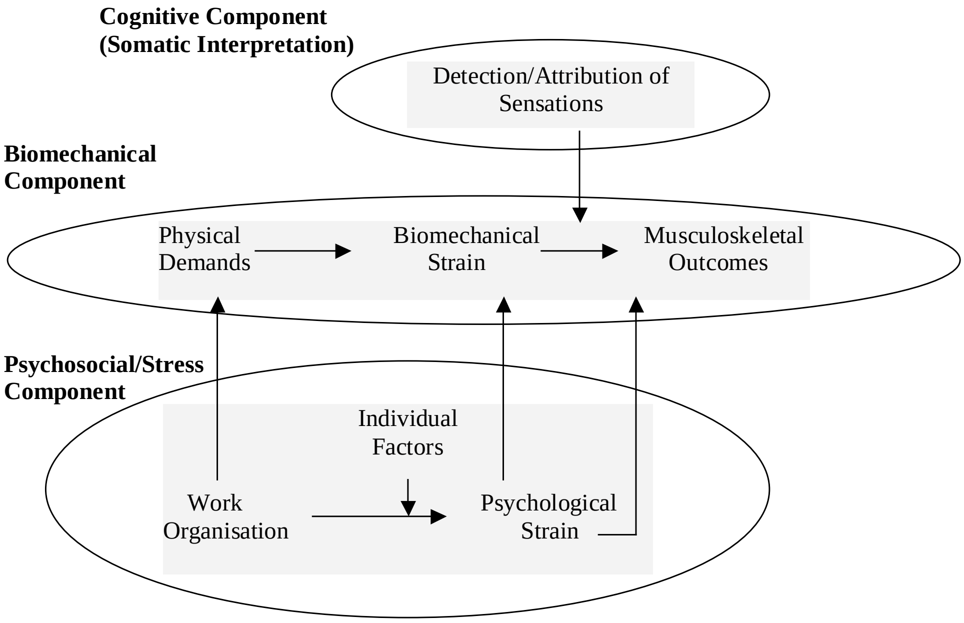


Figure 1.3 Ecological model of musculoskeletal disorders in VDT work (Sauter and Swanson, 1996)

1.3. LIMITATIONS OF THE CURRENT THEORIES AND MODELS

Many of the risk factors affecting the adult working population would be similar to issues facing children, for example prolonged static seated postures during computer tasks, manual handling, biomechanics of work station design and individual factors such as height. However, growing children interacting with a range of computer types and activities in different environments, for a variety of purposes, will have unique risk factors associated with their computer use.

These three models based on adults performing work related tasks in work environments, typically offices, are limited. They do not address children or computers specifically, and they do not investigate computer use as a leisure task or in different environments (Wahlström, 2005). The models may therefore *not* be appropriate when applied to different user groups in different environments performing different tasks, eg. childrens' school and home computer use.

1.3.1 Children are different

Children and adult musculoskeletal systems are different. The New Zealand Department of Labour (1991) acknowledges that young workers are at a greater risk of manual handling injuries than adults because they are still developing physically (Whitfield, Legg and Hedderley, 2001). Perhaps this is due to children being less able to withstand stresses that are usual to the adult spine (Grimmer and Williams, 2000).

Age is reported to affect the postures adopted for computer use, and the age related postural differences are likely to be at least partially a function of the height of the child (Briggs *et al.,* 2002). Briggs *et al.* (2002) report that age of the user influences the posture assumed for head tilt, neck flexion and downward gaze angle during a reading task, but had no significant influence on trunk position. Additionally, Breen *et al.* (2007) following their observational study on children's (n=90, mean age 9.5 years) school computer exposure and postures, reported that children did not appear to use computers in the same way as adults in the workplace. The nature of children's use resulted in varied postures, particularly when more than one student was assigned to each computer.

1.3.2 Children's computer use is different

Risk factors pertaining to computers such as computer types used, computer activity purpose and physical computer environment are currently not discussed in the existing models. These factors are emerging in recent literature as important risk factors that may affect musculoskeletal outcomes with children's computer use. The type of computer used has been shown to influence the user's posture. Briggs *et al.* (2002) in their study of sitting posture with different computer types found that head tilt varied according to IT type. Additionally, Greig *et al.* (2005) demonstrated in their study on EMG activity of cervical erector spinae (CES) and trapezius muscles that muscle activity varied according to IT type being used. When reading books and using laptops CES and trapezius activity was significantly greater than for desktop computer use.

In regards to physical computer environments it is generally reported that to minimise discomfort during computer use adjustability within the workstation is required (Jacobs and Bettencourt, 1995). Individual adjustable workstations for computer tasks are often seen in office work environments. However this is not often evident in school and home environments. Murphy (1999) found in their study of children from grades six to eight that 35% of students could not find a chair that was congruent with their body dimensions. Additionally, within the home environment Jacobs and Baker (2002) found 50% of children (n=152, 6th grade children) reported they did not have suitable workstations for computer use (Jacobs and Baker, 2002).

Observations of Australian and North American school environments show school chairs are usually non-adjustable and do not take into consideration children's growth spurts. They are mostly bucket seats or stiff backed chairs. Monitor heights are reported to be non-adjustable and not of correct height (Gates, 1998). School lighting is usually reported to be designed for paperwork on desks rather than computer workstations (Gates, 1998).

Adults and children use computers for leisure but this is not considered in current models. It was shown in a longitudinal cohort study with children that there is a relationship between increased computer use and decreased weekend vigorous activity (Straker *et al.,* 2006). This research may support the proposal that computer use for leisure could result in a decrease in fitness levels, as the continuation of IT engagement requires potentially prolonged static sedentary postures. Additionally children may be at risk of musculoskeletal problems because many of the activities they engage in at school and after hours have similar postural requirements. Royster's (1999) survey reveals that many students are regularly involved in similar activities out of school hours, for example, playing a musical instrument, playing video games and using a computer.

IT activities can be performed in a range of environments, eg home, work and school. The portability of some computers also allows for use outdoors, whilst travelling in vehicles, on holidays, during excursions or "anywhere" (Harris and Straker, 2000). Therefore with the use of computers in non-traditional settings there is a potential for different risk factors, depending on environmental conditions, available workstation equipment and postures utilised.

1.3.3 Possible interaction between children and IT use

This potential for different risk factors is also demonstrated with the interaction of children using a range of computers for different purposes in various environments. For example, children are reported to be more flexible than adults, allowing them to adopt postures for computer use that an adult worker may not use, for example lying prone on the floor or kneeling on the floor using a bed as a desk.

The purpose of the computer activity affects the motivation to engage in the activity. The purpose of computer activity will often dictate the duration required for the activity, the work posture and environment it is performed in. In regards to children, a student required to complete an assignment, or engrossed in a computer game, may adopt an awkward posture for prolonged periods in order to complete the required activity (Gillespie, 2002).

The authors' observations of children using computers show that computers can thoroughly engage children even though they are reportedly experiencing pain. Harris and Straker (2000) found in their study that 26% of participants they surveyed reported that if they experienced discomfort with computer use they would still continue on with the activity. Due to the involvement in the computer process children are able to ignore these soreness and may not be aware of minimising injury by taking breaks and resting (Gates, 1998; Royster and Yearout, 1999).

It is clear that existing models based on adults' performance of work related tasks do not take into consideration all issues related to children's performance of computer activities. Similarly, the models are limited in providing a useful understanding of causal links between risk factors and outcomes with children's computer use. It is therefore necessary to develop a model specific to children and their computer use to help understand how exposure to this IT affects the child user.

1.3.4. Physical and psychosocial risk factors relating to children's use of IT

Risk factors reported in the literature that are pertinent to children, computer activities and the development of potential etiological models, include physical and psychological / social factors.

Physical risk factors reported include: prolonged sitting, computer laboratory arrangements, mismatch between student size and school furniture, lack of awareness of posture in school, non-traditional postures utilised, manual handling and duration of computer use (Troussier *et al*., 1994; Royster and Yearout, 1999; Grimmer and Williams, 2000; Harris and Straker, 2000).

Evidence for these risk factors is however limited. Harris and Straker's (2000) study on school children aged 10 –17 years found an association between increased time in one session and reports of musculoskeletal discomfort. This association between MSDs and duration of exposure to computers is supported in the literature pertaining to adults, for example Buckle (1999) states there is epidemiological evidence of shoulder and neck MSD with adult IT use when exposure exceeds four hours.

In regards to psychosocial risk factors etiological mechanisms are poorly understood, however there is increasing evidence that psychosocial factors related to home and work environments play a role in the development of MSDs (Bernard, 1997). Adult psychosocial factors that have been linked to upper extremity MSDs, include: perceived increases in work demands, monotonous work, dissatisfaction, limited job control, low job clarity, low social support, and conditions such as depression, stress and anxiety (Bernard, 1997; Moon and Sauter, 1996). Some of the psychosocial factors discussed in the literature pertaining to children include student behaviour and the attitudes of educationalists and parents (Royster and Yearout, 1999).

In theory, these factors may act biologically through increased muscle tension and exacerbate task-related biomechanical strain, physiological vulnerability, or symptom attribution and reporting (Moon and Sauter, 1996; Bernard, 1997; Buckle and Devereux, 1999).

Zandvliet and Straker (2001) suggested tentative and emerging links between the physical and psychosocial learning environments for children when using new computers. They reported that psychosocial factors may influence student's satisfaction and productivity in learning environments. Psychosocial factors proposed to be important for educational productivity with computer use include: student cohesion and autonomy, involvement, task orientation and co-operation (Zandvliet and Straker, 2001).

1.4. CHARACTERISTICS OF A MODEL OF MUSCULOSKELETAL OUTCOMES ASSOCIATED WITH CHILDREN'S USE OF COMPUTERS

Recent evidence demonstrates that musculoskeletal outcomes are affected by a range of risk factors including physical, psychosocial and environmental factors. Therefore a model of musculoskeletal outcomes associated with school children's use of computers needs to be multidimensional. Fuchs and Wößmann (2005) demonstrated the importance of the use of multivariate analysis compared to bivariate analysis when investigating the relationship between computer exposure and children's health and development. Bivariate analysis was reported to be commonplace, however as it did not take into consideration the effect of other related variables, results were found to be biased. Multivariate analysis which could extensively control for variables such as family background characteristics, demonstrated reversed statistically significant results.

It would be useful to incorporate factors related to both the individual user, and the computer environment in a model of potential risk for musculoskeletal outcomes. For a multivariable model correlates relating to the user would need to encompass physical, psychological and social aspects. User physical factors could include pre-existing MSDs, age, gender, stature and physical and other sedentary activity levels. Recent literature demonstrates relationships between these correlates, computer work station fit and computer exposure patterns (Briggs *et al.,* 2002; Greig *et al.,* 2005; Breen *et al.,* 2007). These correlates are thus seen as potential risk factors for musculoskeletal outcomes. User psychological factors could include sustained attention, computer anxiety, internalisation and control. Adult literature demonstrates that these correlates for adults have been associated with adult's report of musculoskeletal outcomes and user's motivation to engage in computer use, and hence their exposure to computers (Csikszentmihalyi, 1991; Webster *et al.*, 1993; Sauter and Swanson, 1996, Bernard, 1997; Gillespie, 2002). User social factors of socio-economic status relates to a child's access and exposure to computers, school attended, access to leisure options and parental / family involvement, support and regulation (Lowe *et al.,* 2003; Wilson, 2003; Bozionelos, 2004; Calvert *et al.,* 2005).

Computer environment factors include physical aspects, task aspects and social aspects of computer exposure. Physical environment factors could include location (eg. school and home) and workstation set-up. These factors have been demonstrated in recent literature to be related to the user's posture and comfort with computer use (Reneman *et al.,* 2006; Breen *et al.*, 2007; Murphy *et al.*, 2007; El – Metwally *et al.*, 2007; Kelly, 2009; Kimmerly and Odell, 2009). Computer environment factors could include the amount (access, frequency and duration) and nature (computer purpose, computer types and range of computer activities) of computer use (Troussier *et al*., 1994; Royster and Yearout, 1999; Grimmer and Williams, 2000; Harris and Straker, 2000). The amount of time on task has been shown to effect the user's discomfort (Harris and Straker, 2000; Jacobs and Baker, 2002; Hakala, *et al.,* 2006). Other computer activity factors are related to the amount of time on task and postures and locations assumed for computer use. Social computer environment factors could include working alone or with others, including peers, parents / carers and teachers (Orleans and Lacey, 2000; Zandvliet and Straker, 2001; Kent and Facer, 2004).

Outcomes associated with the interaction of risk factors include musculoskeletal symptoms, musculoskeletal disorders (MSDs) and loss of function.

1.5. SUMMARY

This introduction chapter has demonstrated that current models depicting musculoskeletal outcomes associated with adult's work environments are not adequate for understanding potential risk factors associated with children's computer exposure. Thus, the purpose of the thesis is to develop a child specific multivariable model. This introduction presented a multivariable conceptual framework for this study to use to investigate the relationships between children's computer use and related musculoskeletal outcomes. Factors presented for inclusion into a model related to the user, the computer exposure environment and musculoskeletal outcomes.

The following chapter reviews child literature related to these proposed factors and provides support for the aims of this study. The objectives of the study are outlined in Chapter 2 including a proposed model, based on findings from chapter 1 and 2 findings, depicting the potential relationships between the user, computer exposure and related musculoskeletal outcomes.

2.0 Literature review on children's computer use

The aim of this chapter is to further review information presented in the Introduction of this thesis and critically review literature related to the overall aim and objectives of the study.

This chapter is presented in five sections. The first section evaluates the importance of computer exposure in children's lives today, and includes how the computer environment can impact on exposure. Furthermore, characterization of computer exposure and how this has previously been measured is discussed.

The second section discusses how the individual characteristics of the child user relate to their computer exposure. Individual characteristics include age, gender, somatic complaints, computer anxiety, sustained attention (flow), exposure to other activities and socioeconomic status (SES). The third section reviews evidence of the impact of children's computer exposure on their health and development, including psychosocial, cognitive, physical and general health.

Section four discusses literature related to children's musculoskeletal outcomes. This includes an overview of general musculoskeletal outcomes as characterized by the frequency, anatomical body location and impact of these outcomes, and also the associations between user characteristics and these outcomes. Additionally, a definition for better characterization of musculoskeletal outcomes in children is discussed. Lastly, recent literature highlighting potential risk factors and measurement issues related to children's computer related musculoskeletal outcomes is reviewed. Potential risk factors are summarised in a model which also suggests further research opportunities.

Finally, the specific aims and objectives of the thesis are presented in the fifth section.

2.1 OVERVIEW OF CHILDREN'S COMPUTER EXPOSURE

The proliferation of computers and the internet is reportedly changing societies in many ways. Changes in education, required job skills, how businesses function and how individuals interact, shop, find employment, pay bills, research information and spend their leisure time are evident (Wilson, 2003; Rideout *et al.*, 2010). Globally, policy makers are attempting to ensure schools are equipped with information technology (IT) not only to reportedly "raise educational standards" (Facer *et al.*, 2001, p.200), but to ensure the next generation is a computer literate workforce. Additionally, parents who are trying to ensure children are educationally equipped for the future are providing their children with IT at home (Facer *et al.*, 2001). IT in this thesis refers to a range of information technologies including old technologies, such print material including books and pen and paper, and new technologies, such as computer and electronic games.

Today in western societies, IT plays a central role in children's lives (Roberts, *et al.*, 2005). Marshall *et al.* (2006), in their systematic review of adolescent computer exposure covering 90 international studies across 539 independent samples (1985 – 2004), report findings that children are likely to use IT such as television (TV), computer and electronic games for 25% of their waking hours. Laptops, cell phones, handheld electronic games, in addition to TVs, are now considered to be indispensible by many families (Kappos, 2007). Recommended daily guidelines for using IT (computers, internet, TVs, gaming devices and mobile phones) have been established based on available evidence (Commonwealth of Australia, 2004). These guidelines recommend children should limit IT use to a maximum of two hours per day for leisure purposes (Straker *et al.,* 2010b). Several studies have shown that a large proportion of Australian children regularly exceed the recommended daily limit (Hardy *et al*., 2006; Hesketh, *et al.,* 2007).

Computer use in particular has been found to be an important type of IT with children using desktop and laptop computers to play games, write documents, complete learning programs, work with pictures and music in multimedia programs, surf the internet and communicate by email and chat rooms (Straker *et al.,* 2010a) .

Computer use by children has been found to be growing rapidly (Ramos *et al.,* 2005; Rideout *et al.*, 2010). With increasing access to computers and the internet at home and school, the proportion of children using computers and their daily exposures have reportedly increased. For example, according to the Australia Bureau of Statistics (ABS, 2009), between 1998 and 2008-09, household access to the internet more than quadrupled from 16% to 72%, while access to computers increased from 44% to 78%. Internationally this trend is also evident, for example in Finland the proportion of adolescents who had a home computer increased from 72% to 92% between 2000 and 2005 (Lajunen *et al.,* 2007). Within the USA, 87% (parents with high school or less education) to 97% (parents with college education) of homes, with children aged between 8 and 18 years, had a computer in 2008/2009 (Rideout *et al.*, 2010).

Within Australia the increased proportion of children using computers is seen by their use of computer related activities such as internet use. According to the ABS (2009) children's internet use increased from 64% of children in 2003 and 2006 to 79% of children in 2009. In relation to daily exposure, Marshall *et al.* (2006) through their systematic review of studies published before 2006, found that on average young people use computers for 30 minutes per day. Rideout *et al*. (2010) found that computer leisure exposure for USA children aged 11 to 14 years had continued to increase from 27 mins/day in 1999 to 62 mins/day in 2004, and to 89 mins/day in 2009.

The range of computer activities being used is also expanding, with Roberts *et al.*(2005) reporting that 50% of the types of computer activities surveyed in 2004 were not even surveyed in 1999 (instant messaging, graphics and online gaming) and are now used daily by many children. Additionally, in their follow on 2009 study, the two most popular computer activities, social networking eg. MySpace$_{TM}$ and Facebook$_{TM}$ (average 22 mins/day) and watching videos on YouTube$_{TM}$ (average 15mins/day), were not included in the 2004 survey (Rideout *et al.,* 2010).

Children's computer use is increasing as evidenced by greater computer and internet access and an increased proportion of children engaging with computers for a range of activities. However, to further understand children's computer exposure a review of literature that takes into consideration children's computer environments is required.

2.1.1 Children's computer exposure environment

Children use computers in a variety of environments, with school use (Sotoyama *et al*., 2002, Kent and Facer 2004; Li *et al.*,2006; Olds *et al.,* 2006; Sommerich *et al*., 2007; Breen *et al*., 2007) and home use (Orleans and Laney, 2000; Moseley *et al.*, 2001; Kerawalla and Crook , 2002; Kent and Facer, 2004; Borzekowski and Robinson, 2005; Roberts *et al*., 2005; Li *et al.,* 2006; Olds *et al.,* 2006; Jacobs *et al*., 2009; Kimmerly and Odell, 2009) reported throughout the literature. Nearly all children in affluent communities use computers at school and the majority use computers at home. The USA Census Bureau found that 92% of children enrolled in school used a computer at school (UCB, 2008) and in Australia 90% of school aged children used a computer at school (ABS, 2009). As mentioned previously, within the home environment 78% of Australian households had access to a computer, with 72% also having internet access (ABS, 2009). The USA Census Bureau reported that, in 2003, 76% of households with school children had computer access and 67% had internet access (UCB, 2008).

School and home computer use has been found to differ in both *exposure* (frequency and duration) and *nature* of computer use. Most studies have found that children use computers more at home (Moseley *et al.*, 2001; Kerawalla and Crook 2002; Kent and Facer 2004), with longer durations (Ramos *et al.,* 2005). Moseley *et al.* (2001), in their combined UK studies (n=164, aged ~ 9-11 years) investigating time estimates per week of school and home computer use, report a school use of 98 minutes, compared with home use of 145 minutes. Ramos *et al.* (2005) in their USA study (n=476, aged 5 - 14 years), found both frequency and duration of computer exposure were greater at home than school. Computer use was found to be most often only once a week at school and daily at home. School durations were reportedly 30-60 minutes, and most often 60-120 minutes for home use (Ramos *et al.,* 2005). Studies by Kerawalla and Crook (2002) (n= 33 aged 7-11years, and n=1800) and Kent and Facer (2004) (aged 9 -18 years) demonstrated differences in the nature of school and home computer exposure patterns by investigating exposure to specific software and specific school and home computer activities. These studies together investigated computer exposure patterns across a range of ages, and used different exposure measures. However a large representative sample investigating both the amount (using a combination of measures), and nature of computer exposure at one time would be beneficial to better understand children's computer exposure patterns.

In terms of the *nature* of computer use, common computer activities performed at school include word processing, searching for information on the web, using charts, graphs, educational software and electronic books (Kerawalla and Crook 2002; Kent and Facer 2004). Children regularly use home computers for playing games, communication (email, messaging and online chat), word processing and data entry, web surfing, downloading music (including peer-to-peer file sharing) and commercial purposes (Straker *et al.,* 2010a).

Kerawalla and Crook (2002) found, through their study involving a series of interviews with children (n=33, aged 7 – 11years) and their parents, that home and school computer use was very different. While the majority of parents reported providing computers at home primarily to support school work (Kerawalla and Crook, 2002), home computer use was actually found to be more social and involved a greater use of email, playing games and surfing the internet in addition to homework assignments. School computer use was found to include the above mentioned activities along with other educationally based activities such as learning programs and writing activities (Kent and Facer, 2004).

These studies have demonstrated the range of activities and nature of children's computer exposure in different environments, however the amount of exposure to these activities at school and home is not clear. Further studies showing both the amount and nature of computer exposure patterns at school and home will assist to further understand children's computer patterns and thus potential risk factors for their health and development.

The nature of computer use and the types of activities performed have been reported to be influenced by who children are with when they are using computers. For example, Orleans and Lacey (2000) observed home computer use by 32 children over four, one hour occasions during a period of four months. Within this environment their findings showed that children whose parents were less involved in their children's computing were more likely to socialize using the computer. Who children are with when using computers at home and school has also been found to differ in each environment. Home computer use has previously been found to involve parents, siblings, friends or students on their own (Orleans and Lacey 2000; Olson *et al.,* 2007), Parental support and regulation of computer exposure has been found to be positively associated with children's computer exposure patterns and their beliefs of the value of computers (Vekeri, 2010). In contrast, school computer use has been shown to involve peer group communication and support with direction from teachers (Kent and Facer, 2004). The above mentioned studies appear to only investigate the real environment of school and home computer exposure. However, as many educationalists believe that learning takes place in a social context (Moseley *et al.,* 2001), then research investigating the social environment of children's computer exposure is important to consider. Given that the computer exposure can involve the real *and* virtual social environment, these two environments are important to investigate in future research to fully understand the relationships between the social context of children's computer use and their exposure patterns.

Finally, within the home computer environment, the actual IT location has been found to influence exposure patterns. For example, Kappos's (2007) review of literature on the influence of IT on children, with special reference to German children, cite results from Feierabend and Klinger's (2001) study that show children with their own TV watch on average 30 minutes more TV than those children without their own access. Roberts (2000) and Olson *et al*. (2007) found similar results with bedroom based electronic games and computers. Additionally, the nature of IT use is reported to be different with bedroom based IT. Olson *et al.* (2007), in a large study (n=1254) of adolescent (12-14 years) gaming (video and computer), found that children with bedroom access were more likely to use IT with inappropriate or unrated content. As research suggests a relationship between own bedroom access and exposure (amount and nature), recent literature has examined how this impacts on children's health and development. Findings from Borzekowski and Robinson's (2005) study of 410 3rd grade students (mean age 8.5 years) include that bedroom TV access was negatively associated with school academic performance. Additionally, general home computer access was positively associated with academic performance. In this study however, the location of the home computer was not determined so it was not possible to examine the relationship between bedroom computer access and health and development.

2.1.2 Characterization of computer exposure

Recent literature on children's computer exposure patterns has demonstrated the use of various methods to evaluate and describe computer exposure. Many studies have described children's patterns of computer exposure by using a single aspect of exposure, for example access to computers or frequency or duration. Frequency of computer exposure has been measured as daily and weekly frequency (Li *et al*., 2006), monthly frequency (Kent and Facer, 2004), or yearly frequency (Fuchs and Wößmann, 2005). Duration of computer exposure has been measured as mean duration in one sitting (Ramos *et al*., 2005), mean daily hours over a week (Burke *et al*., 2006), total computer hours per week (Hardy *et al*., 2006; Chou and Tsai, 2007) and daily and monthly duration of different software use / activity type (Kerwalla and Crook, 2002; Roberts *et al*., 2005; Rideout *et al*., 2010). Additionally, recall time of computer use varies between studies. For example, 24 hour recall on school and non-school days (Olds *et al*., 2006), previous day (Roberts *et al*., 2005), over the last 7 days (Burke *et al*., 2006), over the last month (Kerawalla and Crook, 2002), and over the last year (Fuchs and Wößmann, 2005).

Given that children use computers in a range of environments for different activities, using only a single aspect of exposure may not adequately characterize children's computer exposure. This may therefore limit our understanding of children's computer exposure patterns and effects.

The importance of investigating more than one aspect of children's computer exposure was demonstrated in Fuchs and Wößmann's (2005) study. In this study the impact of home and school computers on academic performance differed depending on the exposure measures used. Access to computers versus frequency of use in each environment was associated with negative, positive and no change in performance outcomes depending on the measure and computer environment. Furthermore, when Harris and Straker (2000) studied children's frequency and duration (usual and longest) of laptop computer use, the relationship with musculoskeletal outcomes was different for these three exposure measures. Similar results were also found by Jacobs and Baker (2002) with duration rather than frequency of computer exposure being associated with children's reports of musculoskeletal discomfort.

As research has indicated that computer exposure can impact on children's health and development (Harris and Straker, 2000; Jacobs and Baker, 2002; Fuchs and Wößmann, 2005; Ramos *et al*., 2005; Li *et al.,* 2006; Straker *et al.,* 2006; Sommerich *et al.,* 2007; Jacobs *et al.,* 2009), adequately characterizing computer exposure will assist in understanding children's computer exposure patterns and therefore assist in identifying risk factors.

2.1.3 Summary of children's computer exposure

Recent literature has demonstrated that children have substantial exposure to computers. Evidence of children's computer exposure is however complex. Literature demonstrates varied use of a range of exposure measures, for example access to computers and internet, frequency and/ or duration of use. Duration of use has included usual and longest durations in one sitting and /or mean daily, weekly or monthly hours. These exposure measures have been used to show that the majority of children from western societies are using IT, including computers, for up to 25% of their waking hours, with many children exceeding recommended daily limits. The nature of children's computer exposure has been shown to be changing with new technologies. The use of exposure measures in studies that attempt to explain children's exposure patterns have not always been comprehensive, potentially leading to inadequate characterization of computer exposure, and an unclear understanding of exposure patterns.

What is however clearly demonstrated from the literature is the impact of children's computer environments on their exposure, particularly in terms of both the amount and nature of exposure. Within the computer environment issues such as access to the internet, who they are with when using computers and the location of computers were shown to be related to computer exposure. It is therefore recommended that future research aimed at understanding children's computer exposure patterns should involve specific aspects of both school and home environments and utilize uniform exposure measures to adequately characterize exposure therefore assisting in identifying potential risk factors for children's health and development.

2.2 RELATIONSHIPS BETWEEN USER CHARACTERISTICS AND COMPUTER EXPOSURE

As previously discussed children's computer exposure is influenced by factors such as access and environment. Additionally, literature reports that characteristics of the user including factors such as age, gender, psychological attributes (somatic complaints, computer anxiety, sustained attention), general activity participation and their neighbourhood are also associated with their activity patterns, including computer exposure. The following section discusses literature pertaining to this study's objectives of understanding user characteristics and how these relate to children's computer exposure.

2.2.1 Relationships between age and computer exposure

Age / school year level has been shown to be associated with computer exposure, with most studies reporting an increase in exposure with age (Kent and Facer, 2004; Ramos *et al.*, 2005; Roberts *et al.*, 2005; Wake *et al.*, 2003; Hardy *et al.*, 2006; Marshall *et al.*, 2006; Olds *et al.*, 2006; Olds *et al.,* 2008; Sommerich *et al.,* 2007; Rideout *et al.* 2010). Studies have often included a single age range, such as preschool (Straker *et al.,* 2005; Li *et al.*, 2006), primary years (Jacobs and Baker 2002; Kerawalla and Crook, 2002; Ramos *et al.,* 2005; Wake *et al.*, 2005; Breen *et al.*, 2007; Jacobs *et al.*, 2009), late primary to secondary years (Kent and Facer, 2004; Hardy *et al.*, 2006; Olds *et al.,* 2006; Olds *et al.*, 2008; Brewer *et al.,* 2009), or upper secondary (Fuchs and Wößmann's 2005; Lajunen *et al.,* 2007; Sommerich *et al.,* 2007). No study has studied a full range of school aged children, eg 5 – 17 years, therefore limiting evidence on the relationships between school aged children and computer exposure.

As IT exposure patterns have been shown to impact the health and development of children from as young as 5 years (Straker *et al.,* 2006) through to late adolescence (Olds *et al.,* 2008) the inclusion of the whole range of school aged children in exposure studies is warranted, particularly when using cross sectional designs as is the case for the majority of above mentioned studies (Harris and Straker, 2000; Jacobs and Baker, 2002; Fuchs and Wößmann, 2005; Ramos *et al*., 2005; Wake *et al.,* 2005; Hardy *et al.,* 2006; Olds *et al.,* 2006; Sommerich *et al.,* 2007; Breen *et al.,* 2007; Brewer *et al.,* 2009).

Studies investigating the *nature* of computer exposure further demonstrate the influence of age on computer exposure. For example Olds *et al*.'s (2008) found that screen time (TV and computer) peaked at around 12 – 14 years, declining fairly rapidly thereafter. However, non-gaming computer use activity increased from 5% - 9% of a 7 year olds total screen time to 11 – 21% of a 16 year olds total screen time. The increase in non-gaming computer activities suggests the changing nature of computer exposure with increased age. The types of non-gaming activities that may be used with increased age could be related to school work or the increased social networking of adolescents.

2.2.2 Relationships between gender and computer exposure

In relation to gender many studies indicate that boys are more likely to have greater exposure to computers than girls (Kent and Facer, 2004; Ramos *et al.*, 2005; Wake *et al*., 2005; Willoughby, 2008; Burke *et al.,* 2006; Olds *et al*., 2006; Chou and Tsai, 2007; Mathers *et al.,* 2009). However as in Chou and Tsai's (2007) study, children's computer exposure was often targeted at gaming activities only, which traditionally has been shown to be used more by boys than girls, and has been identified to be the computer activity that is influenced the most by gender (Orleans and Lacey, 2000; Gillespie, 2002; Kent and Facer, 2004; Olds *et al.,* 2006; Inal and Cagiltay, 2007).

Similar to age, research involving the nature of computer exposure, including the types of computer activities children are using, allows for a better understanding of the relationship between gender and computer use. Research findings have however been mixed. Olds *et al*.'s (2006) study with children and exposure to TV, video games, non-game computer and cinema found boys to have higher exposure to TV and gaming , whereas girls were found to use the computer more for non-gaming computer activities such as internet, chat and homework. Additionally, girls have been found to use computers more for weekly writing (Kent and Facer, 2004). Conversely, Kent and Facer (2004) also report that, when comparing the amount and nature of young people's home and school computer activities, activities such as "fiddling on the computer" (p.443), sending emails and using the internet for revision or information for school were not influenced by gender. Differences in results are potentially due to research design, with Olds *et al*.'s (2006) study participants (n= 1939 ages 10-13 years) undergoing a two day, 24 hour activity diary, and Kent and Facer's (2004) study participants (n = 3289 ages 9 -17 years) participating in surveys and school based peer group and home based family interviews and observations.

2.2.3 Relationships between the interplay of age *and* gender and computer exposure

The interplay of age and gender has been shown to influence children's computer exposure, however is less well examined. The interplay of age and gender has also been found to be associated with the amount (frequency and duration) and nature of children's computer exposure.

Evidence for different gender exposure patterns with adolescents has been demonstrated in the following two studies. A recent large Australian representative study (n=6024, 10 -18 years) (Olds *et al*., 2008) investigating the relationship between school day activity patterns and age and gender showed that although at every age boys were found to have greater overall screen time IT exposure (TV, video game and computer) there was no difference in computer time, only types of computer activities, between boys and girls. These findings could be attributed to data being collected on a single school day only, with computer time defined as only non-game computer use (computer game use has previously been shown to be used more by boys (Ramos, 2006). Punamaki *et al.* (2007), in their large representative Finnish study (n=7292) of adolescent's computer and mobile phone usage also showed the interplay of age and gender. Boys and girls aged 12 years were found to have similar computer usage for writing, emailing and internet surfing, however digital gaming (computer, video and console games) was performed more frequently by boys. Results for all other adolescent age groups (14, 16 and 18 years) showed boys had greater usage patterns for both gaming and other computer activities. Girls had greater ownership and frequency of mobile phone use, and at 14 years of age, the duration of mobile phone usage of girls exceeded that of boys.

Research investigating the interplay of age and gender on children's computer exposure patterns is however limited. The studies previously discussed are on mainly late primary school and adolescents, even though research has demonstrated preschool children have increasing exposure to computers. Gaps in research also include the relationship between the amount and nature of school and home computer exposure patterns and the interplay of age and gender.

2.2.4 Relationships between somatic complaints and computer and IT exposure

Somatic complaints investigated within general childhood and computer exposure literature have included headache and abdominal pain, and have often been called psychosomatic complaints when grouped with other factors such as feeling sad or down, sleeping difficulties and tiredness (El-Metwally *et al.,* 2007; Kappos, 2007; Hakala *et al.,* 2006; Murphy *et al.,* 2007; Punamäki *et al*., 2007). Some studies with large representative child samples have demonstrated a relationship between somatic complaints and computer exposure.

Hamer *et al.'s* (2009) large (n=1486) UK study of children (4 to 12 years, mean 8.5), investigated the relationship between the somatic issue of distress and children's activities. Somatic complaints in this study were measured by parent responses to the Strengths and Difficulties Questionnaire (Goodman, 1997) which has a subscale of emotional symptoms that includes questions on children's complaints of headaches, stomach ache or sickness. The results from this study demonstrated that somatic complaints increased with IT exposure. This study was based on parent self reports only. While this may be seen as being more reliable, a combination of parent and child self reports may have been more valid.

Punumaki *et al.*'s (2007) large (n=7292) Finnish study measured somatic complaints by reports on eight stress symptoms including headache, stomach ache, feeling nervous/tension, irritable/temper tantrums, difficulties with sleeping, trembling hands, feeling tired / weak/ and dizzy. The number of weekly symptoms were tallied and reported as evidence of perceived general health. This measure has also been used by Hakala *et al.* (2006) in their large (n=6003) study with 14 -18 year olds when investigating relationships between computer and electronic games and low back and neck pain. Structured equation modeling found different results for relationships between somatic complaints and IT use for girls and boys. Intensive mobile phone use by girls was both directly and indirectly associated with somatic complaints (as a component of perceived poor health), and boys intensive computer use, including internet and digital gaming, were associated with somatic complaints (as a component of perceived poor health). Other studies demonstrating further links between increased child reports of somatic complaints have been related to TV exposure (Tazawa and Okada ,2001; Toyran *et al.*, 2002).

The above mentioned child related IT exposure studies have however used limited measures of somatic complaints. As seen in Hakala *et al.* (2006) and Punamäki *et al*. (2007) studies' somatic complaint questions have been grouped with other questions measuring general psychological health to form a general perceived health measure. In these studies it is therefore not clear whether the relationships between health-related variables and exposure are specifically related to somatic complaints. Additionally, analysis of the relationship between the amount and nature of computer exposure, and somatic complaints are not evident. It is therefore not clear from recent literature what aspects of children's IT related exposure are associated with reports of somatic complaints.

2.2.5. Relationships between computer anxiety and computer exposure

Computer anxiety has been reported to negatively impact on the amount of time people spend using computers (Arrowsmith, 2002; King *et al.,* 2002). Factors reported to be associated with computer anxiety include past computer experience (Todman and Monaghan, 1994; Arrowsmith, 2002; King *et al.,* 2002), age and gender (Arrowsmith, 2002; King *et al.,* 2002), general psychological traits (Todman and Monaghan, 1994), and the level of anxiety and confidence of the computer instructor (Brosnan, 1998; Bozionelos, 2004).

People who have been exposed to computers from a younger age (Todman and Monaghan, 1994) or have had more experience with computers (Rozell *et al.,* 1999; Arrowsmith, 2002) are reported to usually have less anxiety during computer use. However a previous study has shown that prior computer experience may not effect anxiety at all, or may not diminish anxiety as people with negative past experiences have been found to have increased anxiety (Todman and Monaghan, 1994).

Mixed findings have also been reported for the influence of age and gender on computer anxiety (Bandalos and Benson, 1990, Rozell *et al.,* 1999, Todman and Monaghan, 1994). However, as many of these studies are now dated and performed with college / university students or adult working populations, the findings may now not be relevant for children today. The participants in these studies would have had less access to computers when younger, and the integration of computers into everyday life was not at the level that it is today.

King *et al.*'s (2002) large representative Australian study with 910 students from school Years 7, 9 and 11 more recently examined the interplay of age and gender related to computer anxiety. Results from this study showed a small overall difference in anxiety between males and females, with males more anxious. However, at each Year level a different pattern emerged. Females were found to be more anxious at Year 7, no difference between genders at Year 9, and males were more anxious at Year 11. It was not clear as to why there were differences in anxiety between genders at each Year level. Suggestions for the differences included that by Year 11 more social and communication activities were performed via computers. As girls have been found to use computers for these activities more over the years than boys, then their computer experience in the nature of these activities may assist in reducing their anxiety. Boys

however were found to use computers more for gaming in Year 7. By Year 11 these types of computer activities were diminished. At Year 11 as boys needed to use computers for school work and communication, their experience was more likely related to gaming activities. Boys may therefore experience more anxiety with a change in the nature of their activity. What is however clear from this study is that experience in the nature of the computer activities was related to levels of computer anxiety.
The influence of the computer teacher has been seen to be related to student's computer anxiety levels (Brosnan, 1998; Bozionelos, 2004). Bozionelos (2004) and Brosnan (1998) report that levels of computer anxiety, computer confidence and enthusiasm of those responsible for introducing computers to students is critical in the student's development of computer anxiety. This finding indicates that the computer learning environment is an important consideration in controlling computer anxiety.

As computer use is an important component of children's school and home life, it is important to minimize children's computer anxiety levels to allow them to attain necessary skills in an increasingly technological world (King *et al*., 2002). When considering factors relating to children's computer exposure, children's computer anxiety levels are likely to be important.

2.2.6 Relationships between sustained attention (flow) and computer exposure

Flow theory as defined by Csikszentmihalyi (1991) involves complete absorption or engagement in an activity. Furthermore, this activity engagement is characterized by a narrowing of the focus of awareness so that irrelevant perceptions and thoughts are filtered out and engagement results in a flow experience. The flow experience is then reportedly the main reason for the participation in the activity.

In relation to computer use, flow theory is reported to relate to the user's sense of control over the computer interaction, their perception of focused attention on the computer interaction, their curiosity being aroused during computer use and whether the computer use is intrinsically interesting (Webster *et al.,* 1993). Additionally, flow experience reportedly occurs when the activity challenge is pitched at a suitable level for the individual. If the challenge becomes too demanding it may in itself produce anxiety, and if the challenge too easy, boredom may result (Webster *et al.,* 1993).

Arrowsmith (2002), in his study with children aged 9 – 12 years (n=143), used survey questionnaires to investigate the occurrence of flow with children's computer use. Findings in this study showed a positive relationship between children's flow experience and computer exposure. These findings support adult studies that suggest greater computer exposure and more positive work outcomes are associated with positive flow experience (Webster *et al.,* 1993). Futhermore, these findings demonstrate the importance of considering flow experiences when investigating children's computer exposure.

2.2.7 Relationships between other IT exposure and computer exposure

Recent literature suggests that heavy users of one type of IT are often heavy users of other types (Borzekowski and Robinson, 2005; Roberts, 2005; Rideout *et al*., 2010). Furthermore, children have often been found to 'multi-task', using multiple IT simultaneously. For example simultaneous use of computer programs for written work, instant messaging via computer, mobile phone messaging and audio media such as iPods (Roberts, 2005; Rideout *et al.,* 2010).

Recent literature (Marshall, 2006) has suggested that children's overall IT use has remained relatively stable over the past 50 years. As new IT activities have been introduced to children it is thought that a substitution effect operates in which contemporary forms of IT, eg. computers, have replaced more traditional IT such as comic books.

Studies investigating children's exposure to a variety of IT have shown some associations between different IT activities. For example, Cummings *et al.* (2007) found that adolescent video game players spent less time with paper based IT such as reading and homework. Conversely, Borzekowski *et al.* (2005) reported a positive relationship between younger students use of different IT activities. Students using a range of electronic IT (including computers) reported more time doing paper based IT and homework. However, associations were reportedly weak to moderate and were based on parent and child self reports (Borzekowski *et al.,* 2005).

The following section discusses literature findings on the relationships between other electronic based IT activities such as electronic games, TV, mobile phones, and computer exposure.

2.2.7.1 Relationships between electronic game exposure and computer exposure

Exposure patterns for electronic games and computers have been shown to differ depending on the children's age, gender and environment. Overall exposure to computers generally continues to increase with age for both genders into late adolescence (Rideout *et al.,* 2010). In contrast, electronic games use, including console and hand held players, has been found to peak at 11 - 14 years of age (Olds *et al.,* 2008; Rideout *et al.,* 2010).

Studies investigating children's use of electronic games and computers (Subrahamyam *et al.,* 2001; Ramos *et al.,* 2004; Gillespie, 2006; Hardy *et al.,* 2006; Olds *et al.,* 2006; Hesketh *et al.,* 2007) have investigated exposure patterns and relationships between these IT and specific factors such as age, gender, health and development. Many of these studies report findings related to a composite of electronic IT exposure, or sedentary activity patterns. For example Olds *et al.* (2006) in their study with 10 -13 year olds (n=1039) showed findings of 73% of overall screen time was devoted to TV, 19% to video games and 6% to non-game computer use.

These studies however have not investigated the relationships between different IT type's exposure patterns. To further investigate children's computer exposure, understanding the relationship of user's other IT activity patterns with computer exposure is required.

A recent study by Cummings and Vandewater (2007) investigated the relationship between adolescent's (10 to 19 year olds, n=1491) video game use and time spent with friends, parents, reading, homework and sport / active leisure. Within the homework variable, computer use was included. Although computer use was only one aspect of homework, video game play on weekdays was related to 34% less homework by girls.

2.2.7.2 Relationships between TV exposure and computer exposure

TV watching has been shown to still be the most popular IT activity of children (Rideout et al., 2010). The German Shell Youth Study, which used a large representative sample of 2500 adolescents, showed that TV watching was the main leisure activity of 58% of participants, with the next most popular activities being internet surfing 38%, video watching 26% and computer game playing 20% (Hurrelmann *et al.,* 2006). Recent research in the USA (Rideout *et al.,* 2010) however has found that while traditional TV set viewing has reduced, overall viewing of TV content has increased.

This has occurred due to children's increased use of mobile media (iPod, and cell phones) for access to TV and other IT programs.

The relationship between TV and computer exposures is however not clear. Limited studies have demonstrated that while TV often constitutes the largest proportion of total IT time, an association with computer exposure is not evident. Studies such as Olds *et al.* (2008) (n=6024 ages 10 – 18 years) found that over a single school day TV constituted 69% (males) and 75% (females) of total screen time, whilst non-video game computer exposure was only 17% (boys) and 16% (girls). While this information assists in understanding some aspects of children's activity exposure patterns, it does not provide information on the relationship of the exposure of these IT to each other, and how this relates to children's overall computer exposure.

2.2.7.3 Relationships between mobile phone exposure and computer exposure

Mobile (cell) phone access has been found internationally to mirror computers in terms of increased access. A recent Finnish study, found that the proportion of 17 year olds with a personal mobile phone increased from 78% to 99% across 2000 to 2005 (Lajunen *et al*. 2007). Within the USA, Rideout *et al.* (2010), report the proportion of 8 to 18 year olds owning mobile phones in their sample population (n=2002) of has increased from 39% in 2004 to 66% in 2009.

With the increased proportion of children accessing mobile phones, recent studies (Madell and Muncer, 2004; Rideout *et al*., 2010) have seen a change in the nature of computer, internet and TV use. Madell and Muncer (2004) through their study with English adolescents, report that the significant positive relationship between the use of email and text messaging indicates that mobile phones may now supplement some of the previous functions of computer and internet use. However, no direct investigation of the relationships between mobile phone use and computer use appears to have been conducted.

2.2.8 Relationships between neighbourhood socioeconomic status (NSES) and computer exposure

Globally, access to computers has not been universal, creating a 'digital divide' between those countries with high rates of access and those with low rates of access. Figure 2.1 shows computer penetration rates for different countries.

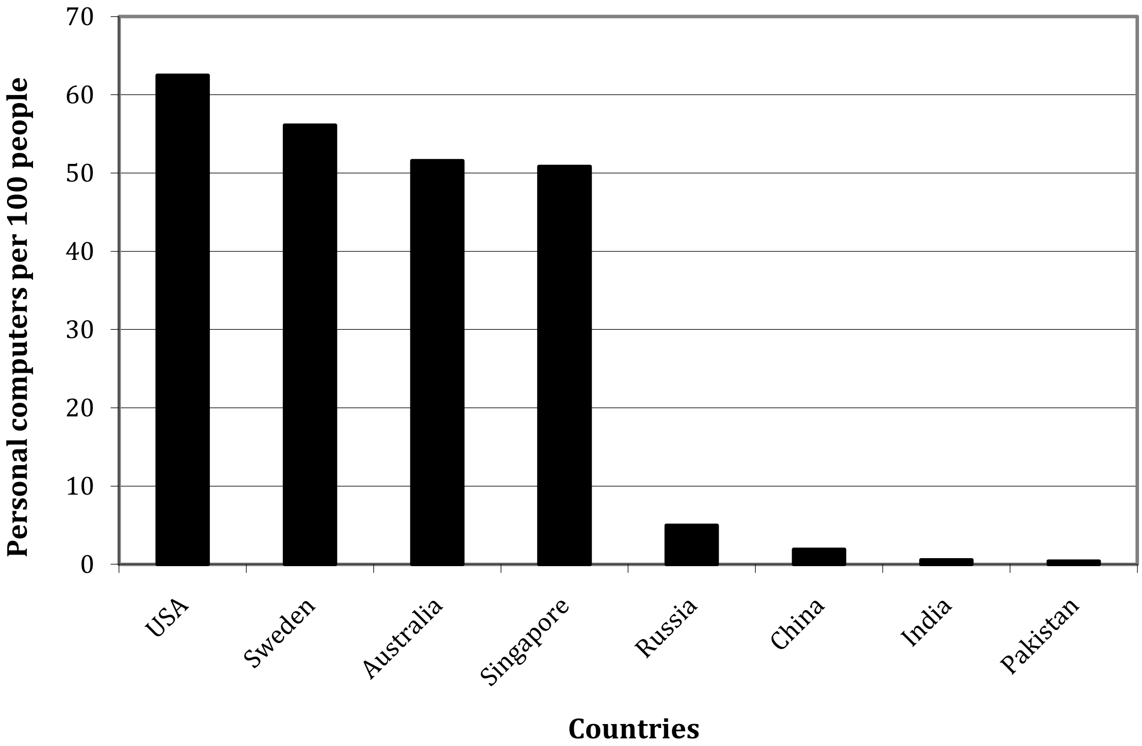


Figure 2.1 Selected country computer penetration rates [data from International Telecommunications Union (2001) and Chinn and Fairlie (2007)]

Within individual countries, including those with high levels of computer access, there is also evidence of a "digital divide" between different regions, areas and neighbourhoods. For example, North American urban residents (including students) are more likely to have access to computer services than their rural counterparts (Wilson, 2003). Additionally, access has been found to be related to socioeconomic status (SES) factors which cluster in neighbourhoods, such as family income, parental level of schooling and parental job category (Roberts, 2000; Wilson, 2003; Calvert *et al.,* 2005).

2.2.8.1 Relationships between NSES and school and home computer access

In relation to children, there is evidence of inequitable neighbourhood access to computers within both school and home environments. Access to computers at school is influenced by educational bureaucracies, politics, resource allocation, curriculum development and school priorities resulting in some schools in low SES neighbourhoods having less access to computers (Lowe *et al.,* 2003). Conversely, students from higher SES neighbourhoods are reported to be more likely to attend schools with better computer equipment and have teachers with better computer skills (Bozionelos, 2004).

At home, families who live in areas with higher SES factors such as household income and parental education were more likely to have access to computers, digital devices and the internet than families from low SES areas (Nakhaie and Pike, 1998; Wilson *et al*., 2003; Calvert *et al.,* 2005; Roberts, 2005,). Lowe *et al.,* (2003) report that of all factors associated with home computer ownership and use, the influence of SES appeared to be the most important. Furthermore, when computers are available at home, it is the SES status of the family that (through educational level, support and parental encouragement) contributes the most to the acquisition of computer experience by children (Bozionelos, 2004).

The influence of parental involvement with children's computer use was further demonstrated in Vekiri's (2010) study with Greek children (n= 345, school years 5 -6) when investigating links between SES status and children's IT value beliefs. This study examined parental involvement in the areas of psychological support as an expression of parental values, the learning opportunities provided by the parents, and parental regulation of children's computer activities. Findings showed that while most parents from a range of SES backgrounds did not know how to guide their children's home computer use to facilitate learning, perceived parental support correlated highly with children's IT values beliefs.

Within the home environment the likelihood of finding TVs, video recorders and video game systems in children's bedrooms is inversely related to household income. Children who attend schools in low income communities are substantially more likely than those who attend schools in high income communities to report having their own TV (73% vs 56%), their own video camera recorder (44% vs 31%), and their own video game system (50% vs 40%) (Roberts *et al.,*2000, 2005). Furthermore, Vekiri

(2010) reports that children from low SES families are more likely to have a computer in their own bedroom as these parents are less likely to use computers, and the computer was usually bought for the children.

Governments have recently responded to the inequities in neighbourhood access with policies to equalize school and home access to computers. For example the Australian government has proposed to equip all secondary students from year 9 - 12 with a computer and assist in funding high speed broadband internet services to 98% of all homes (Putland, 2008). Similarly, in England the government has committed to all children having home computer and internet access for school and college work (DCSF, 2008).

Despite policy measures being put in place to assist with the inequities of computer *access*, the influence of neighbourhood may still be evident with IT use. In countries such as Australia, where there is minimal digital divide with nearly universal school and home computer access for children, a 'digital divide' may still exist within the *nature* of computer use.

2.2.8.2 Relationships between NSES and the amount and nature of school and home computer exposure

Recent evidence for a relationship between NSES and the amount and nature of children's computer use is unclear. While some research has found no correlation between neighbourhood SES related factors and IT use (Anand and Krosnick, 2005; Olds *et al.,* 2006) other studies have reported both positive and negative relationships. For example, the likelihood of ever using a computer has been found to be positively correlated with neighbourhood SES factors of parental income and education (Calvert *et al.,* 2005; Roberts *et al.,* 2005). Additionally, the use of home computers by high school students for educational activities (work processing and technical uses), was positively associated with higher NSES (Lowe, 2003). Furthermore, children's computer exposure time has been found to be negatively related to the income level of the communities in which respondents attended school (Roberts, 2000), therefore suggesting an increase in IT use with children from lower SES neighbourhoods.

In summary, research shows some common trends for greater home computer access and use of school related computer activities for children from high NSES areas, but greater general computer exposure for children from low NSES areas are evident.

While these results show some trends, relationships between NSES and computer exposure remain unclear, thus requiring further investigation.

2.2.9 Summary of relationships between user characteristics and computer exposure

A review of the literature pertaining to the relationship between children's user characteristics and computer exposure has demonstrated some evidence for relationships between the user characteristics of age, gender, psychological factors, other activity exposure (eg TV), NSES and the interplay of some of these variables, and *both* the amount and the nature of school and home computer exposure. Together with adult literature and exposure models and theories as outlined in the Introduction of the thesis, this supports the use of a multidimensional perspective in future studies with children. Thus to meet this study's objectives of testing a model of potential risk factors associated with children's computer related musculoskeletal outcomes, user variables will need to be included in the model. Furthermore, a review of literature relating to the reported impact of computer exposure on children's health and development, including musculoskeletal outcomes, will further identify important potential risk factors for children's computer exposure.

2.3 OVERVIEW OF THE POTENTIAL IMPACT OF COMPUTER EXPOSURE ON CHILDREN'S HEALTH AND DEVELOPMENT

Recent studies have shown that the impact of computer exposure on children's lives is multi-dimensional and can be both positive and negative (Subrahmanyam *et al*., 2000; Moseley *et al.,* 2001; Fuchs and Wößmann's 2005; Roberts *et al*., 2005; Chow and Tsai 2007; Straker *et al* 2010).

Positive effects associated with computer exposure as discussed in recent literature include increased socialization (Orleans and Lacey, 2000; Kent and Facer, 2004); enhanced cognitive development (improved learning and academic skills)(Borzekowski and Robinson, 2005; Li *et al.,* 2006); and enhanced physical development (improved fine motor / eye hand co-ordination skills) (Yuji, 1996).

Negative effects associated with computer exposure reportedly include; poor psychological development (aggressive behavior, violence, addiction, depression, attention deficits, somatic well being)(Subrahmanyam *et al.*, 2000; Olson *et al.*, 2007; Hamer *et al.,* 2009); poor physical development (reduced activity levels, obesity and musculoskeletal outcomes) (Harris and Straker, 2000; Burke and Peper, 2002; Wake *et al.*, 2003; Olds *et al.*, 2006; Coleman *et al.*, 2009) and general health issues (sleep disturbance and reduced nutrition)(Dworak *et al.,* 2007).

2.3.1 The potential impact of computer exposure on psychosocial health and development

Computers are reportedly becoming central in children's social interactions with others (Straker *et al.,* 2010a). With increased social use of computers, children's psychosocial function is reportedly changing. Recent findings have shown increased aggressive behavior with violent game playing (Olson *et al.,* 2007); and issues with social relationships, loneliness and psychosocial well being related to videogames and internet use (Subrahmanyam *et al.*, 2000; Mathers *et al.,* 2009). Additionally, higher levels of screen time entertainment (including TV and 'screen entertainment' (not defined)) interact with low physical activity levels to increase psychological distress (Hamer *et al.,* 2009).

Conversely, Orleans and Lacey (2000) suggested that home computer use provides an opportunity for positive socialization through the use of chat rooms, internet and online gaming. This is particularly important for those who may usually lack social skills or opportunity due to geography or physical limitations (Straker and Pollock, 2005). This is further supported by Roberts *et al.* (2000) who tracked new users of the internet over a 6 month period and found the use of chat rooms led to a reduction in social anxiety and an increase in perceived social skills by the user. Other positive psychosocial effects of leisure computing reported by Durkin (2002) involved promotion of personal well being, social cohesion and improved mood.

Findings from these studies however are limited. As discussed by Durkin (2002), many of these study's findings are from using only simple correlation statistics, cross sectional research designs. These research methods provide only weak causal evidence.

2.3.2 The potential impact of computer exposure on cognitive health and development

Improved cognitive development in areas such as critical thinking, problem solving, visual attention, academic performance and spatial representation skills have been associated with computer exposure including gaming (Subrahmanyam *et al.,* 2000, 2001; Borzekowski and Robinson, 2005; Li *et al*., 2006; Straker and Pollock, 2005; Fiorini, 2010). Other literature has however reported mixed findings, for example, declines in verbal memory performance with computer gaming (Dworak *et al.,* 2007).

Cognitive skills have been shown to improve with the nature and frequency of children's computer use, rather than just access. This is demonstrated by Fuchs and Wößmann's (2005) study where they analyzed data from 15 year olds in 32 countries (n= 174000 for literacy and n= 96855 for mathematics). Findings indicated that when they controlled for family and school characteristics, home computer access was negatively related to student performance in literacy and mathematics, and no significant relationship was found between school computer access and academic performance. They did however find positive relationships between students' school performance and home computer activities involving internet communication and education software activities, and also with the frequency of school computer use.

Additionally, Li *et al.'s* (2006) randomised control study with 122 American primary school children found positive associations. Both home and school computer use was associated with school readiness and some aspects of cognitive development, even though measures of exposure were limited to frequency only. Conversely, Moseley *et al*. (2001) found a significant negative correlation between mathematics attainment and school computer use. This cross sectional study however was based on a very small sample (n=117) of primary school children from years 4 to 6 only.

2.3.3 The potential impact of computer exposure on physical health and development

Concerns have been raised of a negative effect of computer exposure on children's general activity participation and subsequent motor development, general health and obesity. One aspect of children's activity participation includes moderate vigorous physical activity (MVPA). MVPA is defined as moderate –to – vigorous physical intensity aerobic activity, usually at 50 – 85 percent of the maximum heart rate. Regular activity performed at this intensity is reported to result in long term physical and mental health benefits (Hussey, 2007), including reducing obesity and overweight. A recent American cross-sectional study with adolescents (n=421, even gender and black/white race) found that participants who engage in relatively large amounts of vigorous exercise (measures – uniaxial accelerometer for 7 days) were found to be fit (measures – multistage treadmill test) and lean (measures BMI, %body fat by x-ray absorptiometry)(Gutin *et al.,* 2005).

Children's physical activity participation is reported to be affected by a multitude of environmental, personal, social and cultural factors (Booth *et al.,* 2002; Poulsen and Ziviani, 2004; Burke *et al.*, 2006; Van der Horst *et al.,* 2007). Parental beliefs relating to their children (Kimiecik and Horn, 1998) and their own physical activity involvement (Norton, et al., 2003) have been shown to influence children's physical activity patterns. Additionally, for younger children, when a school environment is supportive of MVPA (less structured play equipment, low use of electronic IT, and large play areas), children were found to have > 60 minutes of this activity per day compared with < 60 minutes of activity per day in less supportive school environments (Dowda *et al.,* 2009).

It has been suggested that children's computer use and / or screen time, a component of sedentary activities, may displace physical activity leading to a reduction in the amount of time spent in MVPA participation (Olds *et al.,* 2006, Straker *et al.,* 2006) therefore potentially contributing to increased childhood obesity rates (Marshall *et al.,* 2004; Kautiainen *et al.,* 2005, Hesketh *et al.,* 2007, Lajunen *et al.,* 2007).

With increased reports of childhood obesity and knowledge that cardio-vascular risk factors that begin in childhood often track into adulthood, attention to children's health and physical activity levels are prominent in recent literature (Norton *et al.*, 2003; Gutin *et al.*, 2005; Lajunen *et al.,* 2007). Research findings linking sedentary activities to a reduction in MVPA, and associated health impacts have however shown mixed results (Biddle *et al.,* 2009), with systematic reviews finding no evidence of an association (Sallis *et al.,* 2000; Van Der Horst, 2007) and stating that sedentariness is not the opposite of MVPA, as it comprises of several types of behavior requiring further investigation (Van Der Horst, 2007).

Given the mixed findings in recent literature, Marshall *et al.*'s (2004) meta–analysis of data based on 52 independent samples pertaining to IT use, body fatness and physical activity in children demonstrates the complexity and limitations of this research. The majority of studies reviewed were cross-sectional designs, utilizing self report measures of sedentary behaviours and a variety of measures for actual exposure times/ use, and recall time periods. Additionally, most research available addressed TV viewing, rather than computer use. This led the authors to report that any trends for associations were likely to be confounded, masked or cancelled out. Furthermore, reports of any relationship between sedentary behaviors and health were unlikely to be explained by single markers such as video/ computer or TV use. These findings were further supported by Burke *et al.* (2006) in their research with Australian adolescents (n=602, mean age=12 years). This study investigated relationships between adolescents IT use, fitness and "fatness" and found that children spent reduced time outdoors; fitness was a significant predictor of "fatness"; IT use (TV, electronic games, computers) had mixed associations with fitness; and logistic regression analysis found predictive relationships between computer related discomfort and both psychosocial and physical factors. Burke *et al.* (2006) concluded that IT use did not provide a single marker explanation for adolescent's fitness and "fatness", and that relationships may differ for different types of IT and different users.

Additionally, further research investigating these relationships between children's sedentary and physical activities, and health outcomes have shown that the relationships differ for individuals and can be dependent on the types of IT being used.

While screen time activities may displace physical activity for some children, this is not necessarily associated with increased Body Mass Index (BMI) and/or obesity (Hardy *et al.*, 2006). Additionally, reports of heavy IT users spending more time being physically active have also been found (Roberts *et al.,* 2005). Biddle *et al.* (2009) when researching the relationship of temporal and environmental patterns between adolescent's (n=1564) sedentary and active leisure time found that both these components of leisure had different temporal patterns and that adolescents could be highly involved in *both* sedentary and physically active lifestyles. Within this study, participants recorded activity participation every 15 minutes over 4 days (3 weekday out of school hours, and 1 weekend day) in self report dairies. The use of the ecological momentary assessment diary to record behaviors and locations of activities in this instance reportedly assisted with self report bias (Biddle *et al.,* 2009).

Research has also proposed that sedentary activities replace low intensity physical activity such as walking and playing instead of more vigorous activities such as sport and running (Van Der Horst, 2007). Furthermore, Wake *et al*. (2003) and Burke *et al.* (2006) found no relationship between computer use and electronic gaming and BMI, proposing that the physical nature of many games result in some increased energy expenditure. This is further supported by Burke *et al.* (2006) and Straker *et al.* (2010a) who report that with technological advances and variations with input devices that require gross motor activity for activation (eg dance mat, PlayStation$_{TM}$, EyeToy$_{TM}$ and Nitendo Wii$_{TM}$) have resulted in increases in energy expenditure, heart rate and ventilation volume when compared to traditional interfaces.

As previously discussed, children have only so much time to spend each day on various activities. Recent literature suggests that time spent on using new IT is substituted from time spent previously on old IT or on MVPA, including sport (Olds *et al.*, 2006). 'High-screen users', appear to have re-structured their time to reduce their amount of sleep and therefore increase time available for IT exposure. For example, Olds *et al.* (2006) found that for every hour of screen time, high-screen users reduced their sleep by 10 minutes. The impact of reduced sleep has been demonstrated by Punamaki *et al.* (2007) in their large Finnish study with 12- 18 year olds (n=7292). This study further investigated the perceived health effects attributed to adolescent's IT use as mediated by unhealthy sleeping habits and subsequent increased waking-time tiredness. Findings indicated that the effect of intensive IT on poor perceived health was mediated by sleep. The measures of perceived health status were ratings of general health status, health complaints and musculoskeletal health. Additionally, measures for an overall satisfaction rating, frequency of any of 8 somatic type complaints, and neck-shoulder and/ or low back pain over the last 6 months were used. These perceived health measures however, as stated by the authors themselves, were found to have poor validity. Additionally the authors did not investigate relationships between perceived health and actual health, and the weak measures were used in the context of a cross sectional study.

Other reported general health issues potentially linked with children's computer exposure include epileptic seizures, nausea and headache, fatigue and fever and impaired eye function including accommodation changes and myopia (Gillespie, 2002). Additionally, another negative effect reportedly associated with computer exposure includes computer related musculoskeletal outcomes. Musculoskeletal outcomes have been reported with children using and carrying laptop and tablet computers (Harris and Straker 2000; Sommerich *et al.,* 2007) and with school and home computer use (Jacobs and Baker 2002, Breen *et al*., 2007; Jacobs *et al*., 2009). A review of literature in relation to computer related musculoskeletal outcomes is detailed fully in Section 2.4.3.

A positive effect reportedly associated with children's computer exposure includes fine motor skills development involving the coordination of visual perception and upper limb movements has been found to be assisted with exposure to electronic games in kindergarten and college students (Yuji, 1996)

2.3.4 Summary of the potential impact of computer exposure on children's health and development

The literature reviewed has demonstrated relationships between children's computer exposure and their health and development. The impact has been shown to be both negative and positive in a range of areas including: psychosocial, cognitive and physical health and development. Understanding the multi-dimensional impact of computer exposure on children's health and development will assist to understand the potential risk factors with their computer use. As an objective of this study is to investigate the relationship between children's computer exposure and computer related musculoskeletal outcomes, section four of this literature review will explore musculoskeletal outcome literature in more detail.

2.4 MUSCULOSKELETAL OUTCOMES IN CHILDREN

The term 'musculoskeletal outcomes' refers to outcomes associated with muscles, bones and joints. Within the literature the term 'musculoskeletal outcome' often only refers to the associated pain or discomfort. However, as seen in the following review of recent literature this is a narrow view of the outcome, as literature now often discusses the symptoms, disorders, and impact (loss of function, health professional utilization, and activity lost time).

To meet this study's objective of understanding the relationship between computer exposure and musculoskeletal outcomes a wider definition of musculoskeletal outcomes has been used. This definition includes the frequency of soreness, locations of soreness, intensity of soreness and impact of soreness.

The following review discusses literature relating to (a) children's general musculoskeletal outcomes ; (b) the relationship between user characteristics and children's musculoskeletal outcomes; (c) general computer related musculoskeletal outcomes ; and (d) children's computer related musculoskeletal outcomes, taking into consideration the wider definition as outlined. Lastly, (e) specific literature on children's computer related musculoskeletal outcomes is discussed to show evidence for associated risk factors and outcome measurement issues.

2.4.1. General musculoskeletal outcomes in children

The following section discusses literature relating to children's *general* musculoskeletal outcomes. A review of this literature will assist in identifying the potential risk factors and variables associated with general musculoskeletal outcomes in children. The following review of outcomes includes the measures of prevalence, location and impact of children's general musculoskeletal outcomes.

2.4.1.1 Overview of the prevalence of musculoskeletal outcomes in children

Musculoskeletal outcomes have been identified as an important public health problem among children and adolescents (Roth-Isigkeit *et al.,* 2005), with suggestions that a tendency for childhood "musculoskeletal pain" predisposes individuals to problems in adulthood (Brewer *et al.,* 2009).

Recent evidence suggests that a substantial proportion of children experience musculoskeletal outcomes. For example 83% of German children (n= 749, children aged 13 and 15 years) reported they had experienced pain within the preceding 3 months (Roth-Isigkeit *et al.,* 2005). 78.2% of Icelandic children (n=2173, children aged 11 – 16 years) reported monthly "headache", "stomach and / or back pain" (Kristjánsdóttir, 1997) and 32.1% of Finnish children (n=1756, primary school aged children mean age 10.8yrs) identified weekly musculoskeletal "pain" (El-Metwally *et al.,* 2004). Furthermore, results of a systematic review of 56 epidemiological studies relating to adolescent "spinal pain" found that lifetime prevalence figures ranged from 4.7% to 74.4% (Jeffries *et al.,* 2007). The variation of musculoskeletal outcome reports in the above mentioned studies could be due to many factors, including sampling methods, age and location differences of the samples, general vs specific body locations, and use of different outcomes measures (eg. frequency, locations, intensity and impact of symptoms) (Watson, 2002).

2.4.1.2 Anatomical body locations of musculoskeletal outcomes in children

Musculoskeletal outcomes are often discussed in terms of the percentage of subjects reporting outcomes in specific body locations. For example, low back (4.7% - 74.4%), neck/ shoulder (3% - 8%) and thoracic outcomes (9.5 – 72%) (Jefferies *et al.,* 2007). Other studies report prevalences of approximately 20 – 30% upper and low back "pain" (Balague *et al.,* 1995; Gillespie, 2002; Watson, 2002; Ramos *et al.,* 2005; Murphy, 2007); and 27% - 35% neck "pain" (Murphy, 2007); and 32% general "discomfort"(El-Metwally *et al.,* 2004). Other musculoskeletal outcome anatomical body locations reported by participants have included hands (10.7%), head (9.6%), thumb (6.1%) and fingers (16.8%) (Ramos *et al.,* 2005).

Limitations in these findings once again are dependent on outcome measures used within the studies. In particular, the number and type of anatomical body locations used with the measures, as well as prevalence, frequency, duration and intensity of outcomes assessed.

2.4.1.3 Impact of musculoskeletal outcomes in children

Musculoskeletal outcomes in children are reportedly acute or chronic and traumatic or non traumatic (El-Metwally *et al.,* 2007). Outcomes may also result in further disability with variations in impact or loss of function. Although studies on the impact of musculoskeletal outcomes in children are limited, reports of the impact of outcomes have shown up to 50% of children reporting absence from school (Mikkelsson *et al.,* 1997). Additionally, studies have demonstrated impacts to include activity limitations, health practitioner intervention, use of medication, changes in the child and their families' quality of life, and negative effects on children's physical and emotional well-being (Burton, 1996, El-Metwally *et al*., 2007; Coleman, 2009).

Evidence of the impact of musculoskeletal outcomes is dependent on the measures and research design of each study. The following review of specific research demonstrates types of reported musculoskeletal outcome impacts. The first two studies discuss child reports of overall "pain", and the studies by Moore (2007) and Ramos *et al.* (2005)

report on musculoskeletal outcomes related to specific child activities of carrying back packs and computer and game use.

Roth- Isigkeit *et al.* (2005) in their study on German children (n=749) and general adolescent pain found that these children reported headache (60.5%), abdominal (43.3%), limb (33.6%) and back (30.2%) pain. These pain reports resulted in the following impacts; sleep problems (53.6%), inability to pursue hobbies (53.3%), eating problems (51.1%), school absence (48.8%) and inability to meet friends (46.7%). Additionally treatment was sought in terms of medication (51.5%) and professional help (50.9%).

Watson *et al.'s* (2002) study on general low back pain in 1446 English children aged 11-14 years, found 24% of children reported low back pain, with 94% of these reporting some disability. The high percentage of children reporting disability was probably due to the measure used to indicate back pain. Children had to experience pain for greater than a one month period. Additionally, nearly all of those reporting low back pain indicated at least one limited activity due to symptoms, with the most common disability or impact reported was difficulty with carrying school bags.

Moore (2007), when researching the impact of back packs on children's discomfort found that 13.4% of their participants reported lost time in one or more activities due to reported discomfort, 21.5 % had sought chiropractic treatment and 2.3% other medical treatment. Additionally, Ramos *et al.* (2005) when researching school children's (n=476) computer and electronic game exposure found 65.2% of children reported computer related discomfort that was "just aches"; 16.2% reported the discomfort was "enough to make me take breaks"; 9.4% reported discomfort that " makes me stop"; and 9.1% reported discomfort that was "enough to make mistakes".

A review of the literature demonstrates that a moderate proportion of children report impacts associated with musculoskeletal symptoms. The types of impact involve children stopping their activities, reporting loss of function, and needing to seek treatment. Depending on the continuation of these impacts there is the potential to influence children's ongoing school and community involvement, and economic losses for the family. In an adult working population similar absences from work and associated treatment and workforce costs would account for large economic losses to workplaces.

2.4.2 Relationships between user characteristics and musculoskeletal outcomes in children

The following literature demonstrates the relationship between musculoskeletal outcomes and user characteristics of age, gender, pre-existing musculoskeletal outcomes and general health, physical activities and environment and social / familial factors.

2.4.2.1 Relationships between age and children's musculoskeletal outcomes

The prevalence of children's musculoskeletal outcomes is reported to increase with age (Burton, 1996; Kristjánsdóttir,1997) and with age reported to be predictive of musculoskeletal outcomes (El-Metwally *et al.,* 2004). Watson (2002) found that 22% of the younger subjects (11-12.7 yrs) reported "low back pain" compared to 32% of older subjects (12.75+yrs). A similar pattern of younger subjects (7-10yrs) "low back pain" reports compared to older subjects (14-16yrs) was found in Taimela *et al*.'s (1997) study. Additionally, as Taimela *et al.* (1997) found the proportion of recurrent and continuous "low back pain" in children increased with age, it indicated that both the prevalence and severity of "low back pain" also increases with age.

2.4.2.2 Relationships between gender and children's musculoskeletal outcomes

Findings on the relationship between gender and the prevalence of general musculoskeletal outcomes in young people have been mixed. Some studies report a higher prevalence for females (Kristjánsdóttir, 1997; Watson, 2002; El-Metwally *et al.,* 2004), however other studies have found either no gender differences with prevalence only (Taimela, 1997), or higher reports for boys (Burton, 1996).

The differences in findings may be due to study designs, outcomes measured and the age of the study participants. Those studies reporting a relationship between female gender and general musculoskeletal outcomes were of a cross sectional design (Kristjánsdóttir, 1997; Watson, 2002). They also included varied outcomes measures, including general musculoskeletal pain (El-Metwally *et al*., 2004), headaches, stomach and low back pain (Kristjánsdóttir, 1997), and low back pain (Watson, 2002).

Taimela (1997), who found no relationship between children's gender and prevalence of low back pain, did however find a greater percentage of girls reporting more recurrent or chronic pain. In this cross sectional study with children (n= 1171) aged 7 – 16 years of an even gender mix, the main outcome measure used for prevalence was an incident of low back pain over the last 12 months that interfered with school work or leisure activities, as well as measures on recurrent or chronic low back pain. By use of more than one outcome measure, the relationship between gender could be further understood.

Burton *et al.* (1996), reported a higher prevalence of musculoskeletal outcomes (low back pain) with boys 15+ years. This research was a 5 year longitudinal study, commencing with 216 eleven year old children. Data was collected via interviews and questionnaire based surveys over the 5 year period. This study looked at low back pain only and objectives included the influence of sport participation. Boys were found to have significantly greater exposure to sport than girls in this sample and sport was found to be a significant predictor of low back pain prevalence for boys.

Consistent findings for a relationship between gender and musculoskeletal outcome reports are reported for the prevalence of recurrent and continuous symptoms, and the impact attributed to the outcomes. Females have been found to report a higher recurrence and greater impact of musculoskeletal outcomes than males (Taimela, 1997; El-Metwally *et al.,* 2004; Roth-Isigkeit *et al.,* 2005).

2.4.2.3 Relationships between pre-existing MSDs and children's musculoskeletal outcomes

Literature has demonstrated that children with a previous experience of musculoskeletal outcomes are more likely to have future outcomes (Balague *et al.,* 1999). For example, El-Metwally *et al.* (2004) found children with persistent pre-adolescence musculoskeletal outcomes had three times higher risk of "pain" reoccurrence. This study supports other findings of an early incidence of musculoskeletal outcome such as "spinal pain" being a strong predictor of future outcomes (Murphy *et al*., 2004; Jefferies 2007).

2.4.2.4 Relationships between physical factors and children's musculoskeletal outcomes

Physical factors reported to be associated with children's musculoskeletal outcomes include tasks such as specific types of physical activities such as sport, after school work, carrying back packs (Grimmer and Williams, 2000) and increased sedentary activity patterns (Hakala *et al.*, 2006). Additionally, environmental factors such as the location, workstation set-up and amount of activity exposure have been shown to be associated with musculoskeletal outcomes (Reneman *et al.,* 2006; Murphy *et al.*, 2007; El – Metwally *et al.*, 2007; Kelly, 2009).

Studies investigating observed postures in school environments (Breen *et al.*, 2007; Kelly *et al.,* 2009) have found relationships with postures and musculoskeletal outcomes. Poor work station design was reported to be related to unacceptable postures. Additionally, significant associations between exposure to seated computer activities and increased musculoskeletal discomfort were evident. Whether the musculoskeletal outcomes were due to the poor sitting postures or the computer exposure could not be determined in these cross sectional studies.

Within the home environment, Kimmerly and Odell's (2009) small (n=26) cross sectional study based on observation, typing tests, questionnaires and interviews found similar results at home. Physical computer factors of children's behaviors, postures and work station were observed to place children in awkward computer postures, potentially resulting in musculoskeletal outcomes.

2.4.3 Summary of general musculoskeletal outcomes in children

Musculoskeletal outcomes have been shown to be prevalent in children. Recent literature has demonstrated the significance of the impact of children's musculoskeletal outcomes, showing that children's experiences of musculoskeletal outcomes are not trivial.

Understanding the amount and nature of children's general musculoskeletal outcomes, as well as relationships with user characteristics is required to understand and identify potential risk factors associated with children's experience of these outcomes. Furthermore, understanding the relationship of factors associated with general musculoskeletal outcomes will assist investigating and understanding factors related to computer related musculoskeletal outcomes in children.

2.4.4 Definition and characterization of computer related musculoskeletal outcomes

Literature discussing musculoskeletal outcomes related to children's computer exposure uses a range of terminology and definitions. In regards to the physical nature of outcomes the following terms have been found; cumulative trauma disorder (Burke and Peper, 2002), discomfort (Kelly *et al.,* 2009), musculoskeletal complaints (Jacobs *et al.,* 2003), musculoskeletal disorders (Legg *et al.,* 2008), musculoskeletal pain (Brewer *et al.,* 2009), musculoskeletal problems (Crawford, 2007), musculoskeletal symptoms (Gillespie, 2002), and repetitive strain injury (Kimmerly and Odell, 2009).

Definitions include names of specific *outcome measures* used within the study. For example studies using the Visual Analogue Scale to assess the intensity of the 'pain' or 'discomfort' report on pain or discomfort (Breen, 2007). Hakala *et al.* (2006) in their survey questionnaire asked "Have you had neck or shoulder pain during the past half a year?" then reported on neck and shoulder pain terminology.

Some studies use definitions based on set *criteria* of reported outcomes. In adult literature, Marcus *et al.* (2002) described workers as having "musculoskeletal symptoms" if they scored at least a 6 on the VAS and had any medication use for symptom control. Participants who met these criteria were then assessed by a treating practitioner using a standard protocol to determine if they met the case definitions of certain "musculoskeletal disorders". What is also relevant from this study is the use of more than one type of measure to evaluate the musculoskeletal outcome.

'Pain' or 'discomfort' are multidimensional in nature and based on subjective reports of individual's perception relative to their experience and personality. Pain is often described in terms of sensory and affective properties, therefore involving an unpleasant sensation coupled with an associated emotional experience (Gatchel *et al.,* 2007). The *affective* component of pain can include, but not limited to depression and anxiety, and has been shown to predispose people to experience pain, modulate the pain experience, be a consequence of the pain and / or perpetuate the pain (Gatchel *et al.,* 2007).

Crombez *et al.,* (2000) in their systematic review on the concept of somatisation in studies on pain, investigated somatisation as the psychological explanation for physical complaints. While there is evidence for psychological variables influencing existing pain, in terms of altering and/or exacerbating pain reports and/or leading to a clinical syndrome, there is no evidence for their role in generating pain. Additionally, reports of somatic complaints have been reported to be considered as a marker of genetic vulnerability to musculoskeletal pain (Crombez *et al.,* 2000).

Some studies have however included a broader scope of defining musculoskeletal outcomes. This has occurred by researchers including outcomes relating to the impact on children's normal daily activity patterns as well as the nature and types of treatment to assist with reported outcomes (Coleman *et al.,* 2009). By defining and characterizing outcomes more broadly a greater understanding of the computer related outcome is achieved (Ramos *et al.,* 2005).

Computer use is a rapidly growing activity for many children with recent literature demonstrating associations between computer exposure and child physical, mental and social health and development. To further understand musculoskeletal outcomes in children and the potential risk factors, a review of literature relating to computer related musculoskeletal outcomes are presented in the following section.

2.4.5 Musculoskeletal outcomes related to children's computer exposure

Children's computer exposure is reportedly increasing, as are reports of musculoskeletal outcomes associated with their use. For example, Ramos *et al.* (2005) found that 58.2% of their study participants reported feeling some type of discomfort related to computer exposure. Burke and Peper (2002) reported school child discomfort with computer use based on anatomical body location with 15% (back) to 30% (wrist pain) of participants reporting this discomfort. Harris and Straker (2000) reported 60% of children experienced discomfort with laptop computer use, and Coleman *et al.*'s (2009) study identified musculoskeletal outcomes with nine IT related activities.

Conversley, findings from Diepenmaat's (2006) study of Dutch 12-16 year old students (n=4515), found no association between "musculoskeletal pain" and computer exposure. One likely reason for the absence of an association with computer exposure is the required duration of symptoms. To meet the researchers' neck/shoulder, low back, or arm pain criteria participants had to experience pain for ≥ 4 days per month in the neck/shoulder, low back, or arm area. Many adolescents therefore could have experienced discomfort of shorter duration with computer based activities or physical activity. Additionally, as proposed by the researchers, there could have been an association between computer use and musculoskeletal pain, however if pain was experienced the adolescents were likely to use the computer less than they did before they experienced pain. This self limiting computer exposure may have impacted on meeting the criteria, and due to this study's cross sectional design, this remains unclear.

The following discussion shows recent literature that has demonstrated an association between children's computer exposure and related musculoskeletal outcomes. These studies identify potential risk factors for computer related outcomes associated with children's computer exposure, including prolonged durations of use, repetitive use, and the nature of computer activities. Limitations of these studies are also presented.

Prolonged periods of uninterrupted computer use have been shown in adult literature to be a risk factor for musculoskeletal outcomes (Berqvist *et al.,* 1994, Gerr *et al.,* 2006). Jacobs *et al*. (2009), when investigating 12-15 years olds (n=353) reports of neck and upper limb computer related outcomes, found an association between computer use *duration* (home computer hours) and prevalence of symptoms, but *not* the frequency of symptoms. Results were collected over a three year period, and during the first year of the study increased prevalence of symptoms were reported. Exposure measures were however limited to hours of use on a "typical" day (0-2hours, 2-4 hours, 4-6 hours, 6-8 hours, 8+hours). As previously discussed limiting measures to only a single aspect of exposure may not adequately characterize the exposure and therefore limit the understanding the relationship between children's home computer exposure and related outcomes.

Harris and Straker (2000), in their study with 342 students involved in a school laptop computer program, found the mean times for maximum periods of laptop computer use at one sitting were for periods up to 101.9 minutes. This *prolonged duration* (but not frequency of computer use) was significantly associated with student's reports of low back musculoskeletal discomfort. Although this study demonstrated evidence of computer related discomfort and the value of using a range of exposure measures to fully understand exposure patterns and potential risk factors, the study was limited to only laptop use. As recent literature demonstrates children are exposed to various IT types in a range of environments these results are limited. Further research investigating children's computer exposure with a range of computer types in different environments is therefore suggested.

Research by Hakala *et al.* (2006) has taken the limitations with computer types into consideration. When researching the relationship of 14 – 18 year old adolescents (n=6003) digital gaming (including computer gaming) and computer exposure with neck / shoulder pain and low back pain they found a link between *frequent* computer exposure and NSP and LBP, and between digital gaming and LBP. Additionally, Hakala *et al.* (2006) controlled for confounding variables such as age, gender, SES (parent education), academic performance, puberty, physical activity and somatic complaints. While this study used a large sample across a range of adolescent ages, and investigated a range of user variables for a variety of IT types, the exposure and musculoskeletal outcome measures were limited. For example, survey questions regarding exposure to IT were limited to one aspect of duration (average daily hours and mean weekly hours) and only two anatomical body locations sites – neck/ shoulder and low back. The musculoskeletal outcomes (NSP and LBP) were defined only by frequency of pain over the last 6 months. As stated by the authors, pain intensity and disability caused by symptoms might have provided a more thorough picture (Hakala *et al.,* 2006). A 6 month prevalence measure also would have allowed for a higher percentage of symptom reports than monthly prevalence used by other researchers.

Studies investigating the relationship between the nature of children's computer use and related musculoskeletal outcomes have investigated the nature of children's exposure in different computer environments of school and home.

Ramos *et al.* (2005) investigated the relationships between the *nature* of the IT use and the location, impact and frequency of musculoskeletal outcomes. This study investigating 5 to 14 year olds (n=476) showed descriptive findings relating to the types of computer activities at school and home and how they were related to user variables of age and gender. Additionally, findings showed significant relationships between school and home computer use and musculoskeletal discomfort. This study's primary use of descriptive statistics, with limited analysis to investigate or control for confounding variables, limited the findings. Additionally, further analysis on the relationships between specific school and home computer activities and computer related musculoskeletal outcomes would have provided a greater understanding of the relationship between the nature of children's computer exposure and related outcomes.

In summary, these child related studies show relationships between potential computer exposure risk factors and related musculoskeletal outcomes. There are however gaps in these studies. Gaps include limitations with study designs, including a range of user correlates, outcomes measures, and data analysis. Small sample sizes with reduced age ranges do not allow for a good understanding of children's exposure patterns. Additionally, this limits the analyses performed with some studies using descriptive statistics only. Single aspects of exposure and musculoskeletal outcome measures also do not allow for a greater understanding of children's computer exposure patterns and related outcomes, including the impact of the outcomes. Additionally, the nature of children's computer exposure has not been fully investigated in these studies, therefore limiting the understanding of the relationships between the nature of children's school and computer exposure and related musculoskeletal outcomes.

2.4.6 Summary of musculoskeletal outcomes in children

The prevalence of musculoskeletal outcomes in children has been shown to be significant, and the use of a wider definition of musculoskeletal outcomes including the measures of frequency, location, intensity and impact of symptoms has demonstrated that this is not a trivial issue for children.

Computer exposure has been shown to be an important part of children's lives with an increase in the amount of exposure evident along with a changing nature. This exposure has been shown to be associated with both positive and negative aspects of psychosocial, cognitive, physical and general health and development.

Taking into consideration limitations shown in previous studies related to children's computer related musculoskeletal outcomes, the literature does provide evidence for associated risk factors. User characteristics such as age, gender, other activity exposure, psychological and NSES factors have reported to be associated with both computer exposure and musculoskeletal outcomes in children. Computer exposure as characterized by a range of measures was also found to be associated with musculoskeletal outcomes. What however is not clear in the review of literature is whether user factors have direct or indirect effects on musculoskeletal outcomes, and whether they are associated with outcomes via computer exposure.

The model shown in Figure 2.2 depicts the proposed relationships between user correlates, computer exposure and computer related musculoskeletal outcomes. This proposed model has been developed based on findings on relationships between potential risk factors for child related computer outcomes, as discussed throughout the literature review. This proposed model will be tested in the current study.

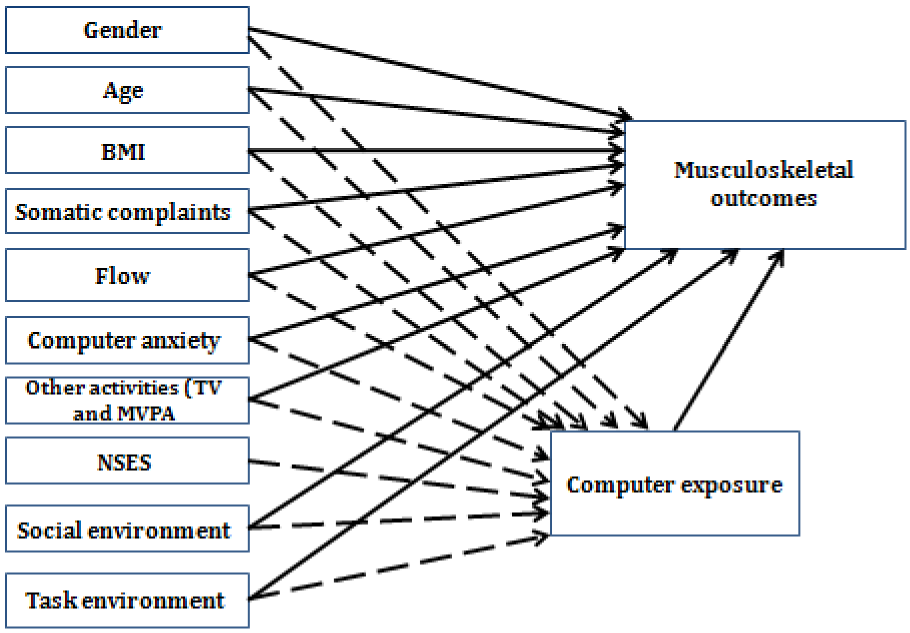


Figure 2.2 Proposed model of the relationships between user correlates, computer exposure and musculoskeletal outcomes in children

2.5 PURPOSE, AIMS AND OBJECTIVES OF THE STUDY

In summary, the literature reviewed in Chapter 1 of the thesis provided background evidence for the purpose of the thesis, and literature reviewed in Chapter 2 provided evidence for the detailed aims and objectives of the thesis.

To better understand the relationships between these user correlates and exposure related outcomes further investigation to address some of the limitations of previous studies is required. Further investigation should also aim to gain a sound understanding of children's exposure patterns, the impact of this exposure and potential risk factors associated with children's computer exposure. This understanding is a prerequisite to managing the potential risk factors associated with computer exposure and children's health and development. Given the gaps identified, the main aims of this study were therefore: (1) to investigate children's computer exposure in their usual occupational environments of school and home; and (2) to develop and test a model that would assist in understanding relationships between child user correlates, computer exposure and computer related musculoskeletal outcomes. Given the findings from the child related literature review as explored in this chapter, the following objectives were therefore developed for the thesis:

1. To investigate children's computer exposure patterns. Chapter 4 describe these data.

2. To further evaluate, and better characterise, different aspects of children's computer exposure patterns by comparing different exposure measures. Chapters 4 and 9 describe these data.

3. To investigate the relationships between children's computer exposure and the computer environment, including school and home. Chapters 4 and 9 describe these data.

4. To investigate the relationships between children's computer exposure and user correlates of age, gender, BMI, pre-existing MSD, somatic complaints, psychological factors and other activity exposure. Chapters 5, 6 and 9 describe these data.

5. To investigate the relationships between children's computer exposure and their other activities. Chapter 5, 6 and 9 describe these data.

6. To investigate the relationships between children's computer exposure and neighbourhood socioeconomic status (NSES). Chapters 5, 6 and 9 describe these data.

7. To identify musculoskeletal outcomes associated with children's school and home computer exposure. Chapters 7, 8 and 9 describe these data.

8. To compare different musculoskeletal outcome measures to evaluate, and better characterise, computer related musculoskeletal outcomes. Chapters 7 and 9 describe these data.

9. To understand the relationships between children's computer related musculoskeletal outcomes and user correlates of age, gender, BMI, pre-existing MSD, somatic complaints, psychological factors and other activity exposure. Chapters 7, 8 and 9 describe these data.

10. To test a model of direct and indirect effects of potential risk factors (including user correlates and computer exposure) for musculoskeletal soreness in children using computers. Chapter 9 describes these data.

3.0 Methods

The main aim of the study was to test a model of the relationships between user correlates, computer environment, computer exposure and children's computer related musculoskeletal outcomes.

One large survey of 1351 children was conducted. The study design allowed for the use of survey questionnaires and physical measures to collect data to test the model.

The use of the questionnaires also allowed for the other objectives of the study to be met, which included using a combination of measures for evaluating computer exposure and musculoskeletal outcomes related to children's computer exposure.

This chapter describes the sample population, survey tool and procedures, data analysis and ethical considerations employed to conduct the research.

3.1 STUDY DESIGN

The study design involved a large cross-sectional survey of children, with younger participant's parents also being involved. A survey tool, rather than observations and time diaries, was used within this study to allow for a large sample of data to be collected given the power requirements for statistical path analysis to test the study's model. Data was collected during the months of August to November, 2006.

3.2 SAMPLE

1351 students (792 boys and 559 girls) from eight primary and five secondary schools (10 schools in total as some schools had both primary and secondary) in Perth, Australia, participated in the study.

A sample size of 1200 students was determined from *a priori* power analysis (power of 0.8 at an alpha level of .05) to be sufficient for the number of correlates tested in the model and the type of statistical path analysis required. Power analysis was undertaken using the Proposed model as depicted in Figure 2.2. Given the number of independent variables in the proposed model (and the proposed survey measures) the number of degrees of freedom *(df)* to be used in the power calculations were up to 25. Power estimates for tests using close model of fit (0.80) therefore required a sample size of approximately 500 (MacCallum et al., 1996). A larger sample size was gained to ensure that there was sufficient sample size for model refinement.

Inclusion Criteria for participation included informed consent from school principals, child assent and also guardian's consent for younger participants. Participants diagnosed with disorders, including visual disorders, that affected musculoskeletal systems were not excluded from participation, but were monitored and assisted by the classroom teacher and researcher to complete the survey. Participants with an inflammatory complaint (such as juvenile arthritis) on the day of participation as determined by the class teacher were withdrawn from the study.

3.2.1 Recruitment

Students were recruited, via stratified sampling methods. Schools were firstly selected based on NSES categories, to ensure a range of children from different NSES backgrounds participated in the study. As selected schools within these NSES categories agreed to participate, certain year levels and genders were then targeted to represent a range of SES, both genders and ages of 6 to 17 years. 19 schools from 3 school systems (Government, Catholic and Independent) in Perth, Western Australia were contacted. 12 schools were willing to meet the researcher to discuss the project and 10 of these schools participated. Table 3.1 details characteristics of the schools that were recruited to the study.

Table 3.1 Characteristics of participating schools

School Sample Characteristics							
School	School system	School type	Year range	Total enrolments	SAR+	School ICSEA ++	Percentage of study participants (n)
1	Independent	Primary, co-educational	K – 7	145	94%	974	2.7 (37)
2	Catholic	Combined boys only primary/ secondary	7 - 12	675	94%	1072	12.1 (164)
3	Catholic	Combined, co-educational	K – 12	1468	93%	1190	22.6 (305)
4	Independent	Combined, co-educational	K – 12	1226	88%	990	13.1 (177)
5	Catholic	Combined, co-educational	K - 12	1474	90%	976	25.7(347)
6	Catholic	Primary, co-educational	K -6	181	92%	1138	2.5 (34)
7	Government	Primary, co-educational	K – 7	268	95%	1053	2.4 (32)
8	Catholic	Combined, co-educational	K – 12	2517	96%	1060	10.0 (135)
9	Catholic	Combined, co-educational	4 – 12	1228	96%	1090	2.1 (29)
10	Catholic	Primary, co-educational	K – 7	431	91%	1123	6.7 (91)

+ Student attendance rate

++ Index of Community Socio-educational Advantage (an Australian national measure developed for the My School Website (http://www.myschool.edu.au) that includes SES characteristics of the small area where students live (based on ABS data), school location of remote or regional, proportion of indigenous students. The average ICSEA value is 1000, the majority of schools score between 900 – 1100).

Participating schools were asked to allow a certain number of classes in years 1,6, 9 and 11 to participate. Year 12 classes were not included in the sample as they were approaching their final school examinations and were not regularly at school during the data collection period. The intention was to have 150 Year 1 children and 350 children from each of Years 6, 9 and 11. A smaller number of Year 1 children were planned due to requiring the participation of parents to assist with completing the questionnaire. Participating child numbers and mean (sd) ages are shown in Table 3.2.

Table 3.2 Sample demographics

School Year	Sample		Age (years)	
	proposed	actual	mean	sd
Year 1	150	146	6.8	0.7
Year 6	350	350	11.3	1.0
Year 9	350	563	14.2	1.2
Year 11	350	292	16.3	1.2

Discrepancies between proposed and actual numbers were due to four Year 1 questionnaires not being returned and some children being absent on the day of testing. Additionally some Year 11 students had other commitments on the day of testing, some students did not adequately complete questionnaires (n= 7), and one boys school requested all (rather than the 4 classes as planned) Year 9 classes be surveyed. With height and weight measurements 8 boys and 17 girls who completed the questionnaire did not want either height or weight measurements taken, and 7 girls wanted only height measurements taken.

3.3 SURVEY PROCEDURES

Once participating schools were identified meetings with principals and relevant IT staff and class teachers were conducted. These meeting were to familiarize the staff with the research objectives, survey tool, informed consent requirements, to discuss and show parent and teacher information letters, and to make arrangements for teacher and parents research project education forums. Logistics for data collection days, including questionnaire completion and then measuring children for height and weight, were discussed and planned.

Prior to testing, information sessions were offered to be presented at the schools, however no school accepted this invitation. Parent information and consent forms were given to the school for students to take home, and for inclusion into school newsletters. These information forms contained information about the survey, including contact numbers for the researchers and the survey dates (Appendix A, B and C).

On the survey day, for participants in Years 6, 9 and 11 classes, the researcher attended classes with the participants. Participants were provided with a quiet working area within their usual classrooms, common study and/or meeting areas, writing implements and the questionnaire. Instructions from the researcher were then presented verbally to the participants. Many of these instructions were also provided in written format on the front of the questionnaire (Appendix D and E). Question time was made available to clarify any concerns. Participants then completed their questionnaires. As the researcher was present during the questionnaire completion, questions could be asked of the researcher at any time. As each participant completed their questionnaire, they handed their completed questionnaire to the researcher. At this time participants' height and weight measurements were taken and recorded on their anonymous, completed questionnaire.

Those students that presented with a request to withdraw form (Appendix A) or chose to opt out of the survey were given other work to participate in during the survey time.

Following preliminary information being sent home, Year 1 questionnaires were given to the classroom teachers to send home with the children to give to their parents. The parents then completed the questionnaire at home with their child, and returned the questionnaire to their teachers. The researcher collected the questionnaires from the class teacher approximately 2 weeks after the surveys were sent home. On this collection day the researcher measured the children's height and weight recording this data on their anonymous completed questionnaire.

3.4 SURVEY TOOL

3.4.1 Introduction to the Young People's Activity Questionnaire (YAQ-II)

The survey tool used with this study was based on the Young People's Activity Questionnaire (YAQ) (Harris and Straker, 2000) with the addition of extra questions regarding other activity types and computer activities at school and home. This YAQ-II was completed by children in Years 6, 9 and 11, with a simplified version (Year One's Activity Questionnaire-YOAQ), being completed by Year 1 parents. The survey tool was piloted prior to the study being undertaken with each age group to assess the suitability of the questions, instructions and layout, appropriateness of reading level required and time taken to complete the questionnaire. As a result minor formatting changes were made to the instructions and questions. Table 3.3 provides a summary of the items in each questionnaire.

Table 3.3 Details of YAQ-II and YOAQ survey content and number of items

Section	Content	YAQ-II	YOAQ
1	Questions about user and school	18	18
2	Questions about general activities	22	17
3	Questions about playing electronic games	11	8
4	Questions about MVPA	10	7
5	Questions about general computer access and school computers	39	26
6	Questions about home computers	42	32
7	Questions about computer anxiety	10	2
8	Height and weight measurements (completed by researcher)	2	2

Both questionnaires contained questions relating to the participant and their activity exposure as an individual, within a family context, and within their neighbourhood. Questions and measurement scales used throughout the questionnaires measured the study's independent and dependent variables. Data collected was used to meet the study objectives and test the model to identify factors associated with musculoskeletal outcomes associated with children's computer exposure.

The following information demonstrates how the survey tool measured the study's independent and dependent variables. Copies of the questionnaires are provided in Appendix D and E.

3.4.2 Computer and other activity exposure

Computer and other activity exposure measures used within the YAQ-II questionnaire included frequency (not at all, monthly, weekly, 2-3xweekly, daily) and usual and longest duration (<30 mins, 0-60 mins, 1-2 hours, 2- 5 hours, >5hours). Mean weekly hours were also collected for school and home computers. The simplified survey

(YOAQ) used for the Year 1 students contained simplified measures for school computer exposure as parents were assisting with completing the questionnaire and were unlikely to be able to answer these questions.

Exposure measures used within the YAQ have been used in previous studies. The use of the YAQ by Harris and Straker (2000) in their study with 314 laptop computer users demonstrated the importance of a range of exposure correlates in defining patterns of use. This has been further supported by Jacobs and Baker (2002) with duration rather than frequency of computer exposure being associated with children's reports of musculoskeletal discomfort. A recent study using both the YAQ and timed diaries showed evidence for the validity of using a survey to collect data based on self report patterns of exposure (Ciccarelli, 2008).

Additional information (types of computer activities, computer postures, ability to choose computer activities, who was usually with the user during computer activities, types of computers and computer environment, bedroom computer access) was collected via the questionnaire to assist in understanding school and home exposure patterns. This approach has been widely used for studies on children's IT use. Examples of survey questionnaires to gather data on children's IT exposure (including the amount and nature of use) include, 11-15 year old Australian adolescents (n=2750) small screen recreation (Hardy *et al.*, 2006); 5 – 14 year old American children's (n=476) computer and electronic game exposure (Ramos *et al.,* 2005); and 11 and 12th grade American adolescent's (n=77) tablet personal computer exposure (Sommerich *et al.,* 2007).

3.4.3 User characteristics

Questions on characteristics of the user (participant) included questions related to individual correlates such as participant's age, Year level, gender, other activities exposure, somatic complaints, flow, computer anxiety, height and weight.

Exposure measures (frequency, usual and longest duration) as detailed above, of other sedentary activities, eg. TV watching, writing, reading, using mobile phones, playing electronic games, and moderate vigorous physical activity (MVPA) were also collected in both the YAQ-II and YOAQ.

Age was measured by participants/parents stating their date of birth. Chronological age in years was calculated using the date of completing the survey. Students/parents also reported their Year level. Gender was measured by participants/parents stating male or female.

Somatic complaints were measured in the YAQ-II using questions on the frequency of headache and stomach pain over the last month as per prior child research (Murphy *et al*., 2007). A simplified question was used about general physical health with Year 1 children in the YOAQ given the children's age.

Flow was measured by the non diagnostic Flow measure by Webster, Trevino and Ryan (1993), and adapted by Arrowsmith and Pollock (2002). Arrowsmith (2002) when assessing the occurrence of flow with year 6 (mean age 11 years) children's computer use demonstrated use of the Webster *et al.* (1993) derived flow measure and the 10 item computer confidence subscale derived from Lloyd and Gressard (1984) Computer Anxiety Scale. Arrowsmith reported the flow measure was supported by 2 studies indicating construct validity of r= 0.97, and reliability study results of 0.82 and 0.72 (Arrowsmith, 2002). Given the age of the Year 1 children only the 3 simplest flow questions were used in the YOAQ.

Computer anxiety was measured by the non diagnostic Computer Anxiety Scale from Lloyd and Gressard (1984) as presented by Bandalos and Benson (1990). Reliability studies for the 10 item computer anxiety scale have also been reportedly of the magnitude to support the use of this subscale as a measure for computer anxiety (Arrowsmith, 2002). Given the age of the Year 1 children this measure was not used in the YOAQ.

Height and weight were measured by the researcher with a stadiometer for height and an electronic scale for weight using standard procedures. From these body dimensions BMI scores were calculated (CDC, 2008). Height and weight for BMI calculations have been widely used in recent studies with children (Wake *et al.,* 2003; Kautiainen *et al.,* 2005).

Questions assessing family correlates included access to home computers and internet, number/ type of home computers and parental computer use. Questions assessing neighbourhood correlates included school location and local area home post code.

NSES was assessed using local area postcodes of the participant's primary residence. The Australian Bureau of Statistics (ABS) calculates an Index of Relative Socioeconomic Advantage Disadvantage (IRSAD) based on postcodes from 2001 national census data. The IRSAD is a general socio-economic index based on 21 measures of both disadvantage and advantage including: annual household income, persons over 15 educational attainment, employment status, unskilled vs. skilled occupations, number of bedrooms in dwelling, percentage of one parent families, value of weekly rent, private dwelling with no car, ownership of residing dwelling, value of weekly mortgage repayments, private dwellings with internet and number renting from government or not for profit agency. Scores with low index values indicate areas of disadvantage and high values indicate areas of advantage. Recent studies have investigated the relationship between children's IT, physical activity exposure and NSES by using local area postcodes to measure SES (Booth *et al.*, 2002; Hardy *et al.,* 2006; Olds *et al.,* 2006).

3.4.4 Outcome measures

Musculoskeletal outcomes within this study have been measured by questions related to musculoskeletal soreness, including frequency, intensity, location and impact (activity limitation, use of medication and health professional practitioner visits). Body maps were used to help the participant identify location of soreness. The musculoskeletal outcomes questions were asked for both school and home computer exposure as well sedentary activities, electronic games and MVPA exposure.

Musculoskeletal symptoms or disorders in the general population have previously been measured using a range of methods. Additionally, different aspects of child computer related musculoskeletal outcomes have been measured with a range of outcome measures. Previous evidence for the use of a range of musculoskeletal outcome measures to better characterize exposure related musculoskeletal outcomes are demonstrated by the following studies:

1. Taimela *et al.* (1996) nationwide Finnish study on the prevalence of young people's low back pain used frequency, duration and location of low back pain.
2. Murphy *et al*. (2004) used frequency, location and impact (time off school and seeking medical treatment) measures with English adolescents for back and neck pain.

3. Ramos *et al.* (2005) used degree of impact and location of discomfort with children using computer and electronic games.
4. Sommerich *et al.* (2007) used frequency and location of discomfort with American tablet PC adolescent users.
5. Breen *et al.* (2007) used intensity and location of discomfort with school computer use.

Pilot testing with several groups of children including questionnaire completion and focus groups identified the preferred terminology of 'soreness' when asking participants about their experience of computer and other activity related musculoskeletal symptoms. As the term 'soreness' (a symptom) was used in the data collection, the outcome measure of musculoskeletal soreness (MSS) has been used in the results section. Additionally, using the term 'soreness' rather than 'MSD', as reported in recent literature (Breen *et al.*, 2007; Jacobs *et al.*, 2009), ensures that any symptoms reported by the participants are not misrepresented as a disorder. The use of the term MSD has previously been used to describe workers with musculoskeletal symptoms who have then been assessed by a treating practitioner for those symptoms (Marcus *et al.,* 2002).

3.5 DATA ANALYSIS

Descriptive statistics, frequency analysis and Spearman rank correlation coefficients (r_s) were used to describe the sample, exposure related outcomes, and to examine the direction and strength of bivariate relationships between correlates. T-tests *(t),* Wilcoxon Signed Rank tests *(W),* Kruskal-Wallis tests (*H*), McNemar Tests (x^2), Mann-Whitney U-tests (U), Spearman Rank Correlation Coefficients (r_s) and Chi squared (x^2) analysis were used to examine the relationships between computer exposure, user correlates and outcome measures. SPSS v17 were used for these analyses. These non-parametric statistical methods were used due to the non-normality of the outcome measures.

During analyses age and Year level were used interchangeably depending on the levels of measurement of the correlates under examination. For associations with nominal variables, Year level was used for the analyses, and for associations with continuous variables age was used.

Data preparation for modelling analysis reported in Chapter 10 was performed using StataIC Version 10.1 for Windows (Statacorp LP, College Station TX). Path analysis was performed with MPlus Version 5.21 (Muthén & Muthén 2007). Mplus estimates path analysis models using binary outcomes with probit regression, which is considered preferable over logistic regression due to the mathematical tractability of the multivariate probit distribution (MacKinnon 2007). Probit coefficients are approximately equal to 0.625 times the logistic regression coefficients. The estimation procedure used was WLSMV (weighted least square parameter estimates using a diagonal weight matrix and robust standard errors and variance-adjusted chi-square test statistic that use a full weight matrix) (Muthén & Muthén, 2007), which accounts for the non-normality of outcomes.

Overall, responses from 1351 children were used in the data analysis. However, due to missing data, 298 (school computer exposure) and 309 (home computer exposure) participants data was removed for the statistical modeling and path analysis, as only those cases with a full set of outcome and covariate correlates were included in modeling. Final samples of 1053 for the school computer exposure model and 1042 for the home computer exposure model were used.

All results are reported using up to 3 decimal places depending on the statistics methods used, with alpha probabilities also reported to 3 decimal places. A criterion alpha of .05 was used throughout the results.

3.6 ETHICAL CONSIDERATIONS

This study was approved by the Curtin University of Technology Human Research Ethics committee (Please see Appendix A for the initial application forms).

3.6.1 Informed Consent

The Curtin University of Technology Human Research Ethics committee granted that passive consent was a suitable method to use within this study. Passive consent allowed for all children within a participating school to complete the survey unless a parent or guardian had completed a withdrawal form requesting them to *not* participate. Passive consent was agreed to due to the nature of the survey, and that participation in the survey was seen to be within normal practices of school activities. Passive consent was discussed with all schools. One primary school did insist on active consent via written forms completed by each participant's parents (Appendix A).

Informed consent was therefore initially gathered from the participating school principals. Following this approval, procedures were developed to ensure all participating staff, students and parents/guardians were fully informed of relevant aspects of the study. This included informing participants on study aims, procedures (survey and weight and height measurements), confidentiality of information, there was no harm to the participants throughout the survey, that participation was voluntary, and participant's rights to withdraw at any stage throughout the survey procedures. Additionally, one school requested a short form Information form as many of the parents were from non-English speaking backgrounds (See Appendix B for the short form and accompanied Ethics Application form reflecting these changes).

Additional information sheets were distributed to each participating class and student for parental education. These information sheets were in plain language informing the reader of the study aims, procedures, rights, risks and benefits associated with their participation in the study. Procedures for opting out of the study at any time, and that participation was voluntary and that there was no risk, discomfort or cost to participants, only time to complete the questionnaires were also outlined. Investigator and Supervisor contact details, and confirmation that the study had been approved by the Curtin University of Technology Human Research Ethics committee were also stated. Please see Appendix B for copies of the consent form and Information sheet. Due to the initial consent form approved with the initial ethics application not containing sufficient information the information sheet (long form) was updated. Appendix C contains this form and accompanying Ethics Application for the updated form.

All questionnaires (please see Appendix D and E) contained an introduction section again explaining the aims of the study and that participation was voluntary and information collected confidential. There was no identifying information collected. Additionally, the researcher met with all participants prior to completing the survey and further explained procedures and that their involvement was voluntary. Those wishing to not take part in any or all of the study then handed in their withdrawal forms, or opted out. Completion of the questionnaire by the parents of the younger participants and by older participants themselves was taken as consent to participate.

3.6.2 Confidentiality

To ensure participants' confidentiality no identifying data was collected on the questionnaires at the time of survey. The names of participating schools have remained anonymous and each participating school was allocated a numbered code for use throughout the data analysis.

Completed questionnaires were coded using their school number and then additional coding for each questionnaire. Signed withdrawal and active consent forms containing parent signatures and participants name have been stored separately to questionnaires.

3.6.3 Data storage

Questionnaires and all information collected from the participants have been stored in a secure location at Curtin University.

All data collected for this study are the property of Curtin University of Technology and will be stored in a confidential and secure location for a minimum 5 years as specified by the NH&MRC guidelines. Stored data will only be accessible to the researchers.

4.0 Results – Computer Exposure

The main aim of the study was to test a model to understand risk factors associated with children's computer related musculoskeletal outcomes. The results of the study that achieve this aim are presented in the following chapters, commencing with descriptive and inferential statistics of computer exposure patterns at school and home. This chapter meets objectives 1, 2, and 3 of the study by investigating children's computer exposure patterns, showing results that better characterize exposure patterns, and investigating the relationship between computer exposure and school and home environments.

Results reported in this chapter include a general description of exposure, including access, frequency, usual duration and longest duration of computer use in each environment. Types of computers and computer activities, specific locations of use, postures utilised, user's control of activities and who is with the user when using computers in each environment are also shown. Finally, results on the comparison of computer use in school and home environments are shown.

The following results Chapters 5 – 8 report the analyses of the relationships between user characteristics including age, gender, BMI, other activity exposure, somatic complaints, psychological factors, NSES, and children's computer exposure.

Chapter 9 shows the results of the main aim of this study of testing the proposed children's model of risk factors associated with computer related musculoskeletal outcomes.

4.1 GENERAL COMPUTER USE

99.4% (1339/ 1351) of participants reported ever having used a computer. The mean age for when participants reported to have started using a computer was 7.0 years, ranging from 1.0 to 16.0 years.

4.2 SCHOOL COMPUTER EXPOSURE

4.2.1 Amount of school computer exposure

All participants had access to computers and the internet at school. Computers were reported to be used for 2.4(sd=3.3) hours per week at school by participants (Years 6, 9 and 11 only as durations of computer use at school was not reported by parents for Year 1 participants).

Weekly hours of school computer use were positively correlated with frequency (r_s = .555, p<0.001) and duration (usual duration, r_s = .218, p<0.001, and longest duration, r_s = .214, p<0.001) of school computer use.

97.8% of participants reported school computer use in the last month, with 87.2% reportedly using school computers weekly. Table 4.1 shows frequency of reported school computer use.

Table 4.1 Frequency of school computer use

Frequency	% of Participants (n)
Not at all	2.2 (29)
Monthly	10.6 (138)
Weekly	32.3 (419)
2 – 3 x weekly	42.6 (554)
Daily	12.2 (159)

Of those students having used a school computer over the last month, Table 4.2 shows for how long participants usually used a school computer each time (usual duration), and the longest time a school computer was used without a break (longest duration). The majority of students used a school computer for 30 – 60 minutes in one sitting. These results are not unexpected given the structured class time periods within this school environment.

Table 4.2 Usual and longest duration of school computer use

	% of Participants (n)	
Frequency	Usual duration	Longest duration
<30 minutes	30.3 (349)	22.2 (254)
30-60 minutes	58.3 (671)	62.0 (710)
1-2 hours	9.4 (108)	13.8 (158)
2-5 hours	1.1 (13)	1.7 (20)
>5 hours	0.8 (9)	0.3 (3)

4.2.2 Nature of school computer exposure

The most frequent school computer activity was surfing the internet (85.3% of participants at least monthly), followed by learning programs and multimedia (~65% of participants at least monthly). Social activities such as chat rooms and emails were the least frequently performed school computer activities (at least monthly for ~25% and ~57% of participants respectively). Table 4.3 shows the percentage of participants reportedly performing different computer activities on school computers over the last month for different frequencies.

Table 4.3 Percentage of participants using different school computer activities

Frequency of use	Play games	Multimedia	Write letters	Learning programs	Surf net	Email	Chat rooms	Other
Not at all	43.2	34.9	35.2	42.6	14.7	43.4	75.3	37.8
1 x month	22.5	25.7	34.7	22.5	20.8	21.7	12.8	20.7
1 x week	20.5	22.5	21.8	22.1	30.4	18.3	5.9	25.2
2-3 x week	9.7	12.8	6.9	11.0	24.2	11.7	2.9	11.5
Daily	4.1	4.2	1.5	1.8	10.0	5.0	3.2	4.9

4.2.3 School computer environment

School computer use over the last month was performed in laboratories by 82.2% of participants and normal classrooms by 62.7% of participants. Both laptop and desktop computers were used by 24.5%of participants, with 74.2% using only desktops and 1.3% using only laptops. None of the participating schools issued their students with their own computers, or required students to supply a laptop.

When using a school computer the posture reported to be predominately used by participants was sitting at a desk or table (90.8%). Table 4.4 shows postures adopted for school computer use.

Table 4.4 Percentage of participants using different postures for school computer use

Posture	% of Participants (n)
Sitting at a desk or table	90.8 (1227)
Sitting on the floor	1.2 (18)
Sitting on sofa or beanbag	1.2 (16)
Lying down	0.9 (12)
Standing	3.0 (41)
Other posture	3.2 (43)

When using a school computer most participants (75.9%) reported the teacher decided the computer activity. Table 4.5 shows the choice of school computer activity.

Table 4.5 Percentage of participants reporting who chooses the school computer activity.

Person	% of Participants (n)
Me	20.1 (271)
Friend	2.3 (31)
Teacher	75.9 (1025)
Other person	0.5 (7)

When asked how often the participant chose what to do when using a school computer, only 5.6% of participants reported that they could always choose what they wanted to do when using a school computer**.** Table 4.6 shows frequency of choice with school computer activities.

Table 4.6 Percentage of participant's frequency of choice with school computer activities.

Frequency	% of Participants (n)
Always	5.6 (70)
Usually	14.3 (179)
Sometimes	36.6 (459)
Rarely	35.7 (448)
Never	7.9 (99)

These results reflect recent literature (Moseley *et al.,* 2001; Kent and Facer, 2004) that has demonstrated the importance of investigating children's computer environments, as the environment has been shown to be associated with the amount and nature of participant's computer exposure. Results from this study demonstrate that a school environment with its planned curriculum, timetabling of classes and rooms and teacher input effects children's computer exposure. This has been demonstrated by the usual amounts of exposure being less than 60 minutes, the use of educationally based computer activities, participants' reports of teacher directed computer exposure, types of computer workstation, computer types and postures.

4.2.4 School computer social environment

The majority of participants (69.7%) reported usually being with friends when using computers at school, with only 5.7% reporting being alone. There were no associations between frequency of school computer activities and being alone, however trends for increased frequency for email ($x^2(4) = 8.6$ p=.073) and multimedia ($x^2(4) = 7.9$ p=.096) activities were evident. Table 4.7 shows who was usually with the user when using school computers.

Table 4.7 Percentage of participants reporting who was usually with the participant when using school computers

Person	% of Participants (n)
No-one	5.7 (77)
Friend	69.7 (941)
Teacher	25.9 (350)
Other person	4.1 (56)

82.8% reported usually talking with friends when using a school computer and 7.5% reported usually talking with teachers while using a computer at school. Table 4.8 shows who participants usually talked with when using school computers.

Table 4.8 Percentage of participants reporting who they usually talked with when using school computers

Person	% of Participants (n)
No-one	6.7 (91)
Friend	82.8 (1119)
Teacher	7.5(101)
Other person	1.7(23)

These results demonstrate that school computer use involves socialization and with the frequent use of internet activities friend interaction maybe real and / or virtual.

Additionally, school computer exposure includes exposure during recess and lunch. As school computers were also reported in library environments computer use during these out of class times may be inherently social and involve friends.

4.3 HOME COMPUTER EXPOSURE

4.3.1 Amount of home computer exposure

98.9% (1329/1351) of participants reported having access to a computer at home with 95.9% (n=1285) reporting internet/email at home. Computers were reported to be used for 7.2 (sd =9.6) hours per week at home.

Weekly hours of computer use at home was positively correlated with frequency (r_s = .704, p<0.001) and duration (usual, r_s = .632, p<0.001, and longest, r_s = .589, p<0.001) of computer use at home.

95.7% of participants reported home computer use in the last month, and 91.2% of participants reported using home computers weekly. Table 4.9 shows frequency of home computer use.

Table 4.9 Frequency of home computer use

Frequency	% of Participants (n)
Not at all	4.3 (58)
Monthly	4.5 (60)
Weekly	14.2 (190)
2 – 3 x weekly	33.9 (454)
Daily	43.1 (578)

Of those students having used a home computer over the last month Table 4.10 shows for how long participants usually used a computer at home each time (usual duration), and the longest time a computer at home was used without a break (longest duration). The majority of participants used a computer for 30 – 60 minutes for usual duration, and 1 – 2 hours for longest duration in one sitting.

Table 4.10 Usual and longest duration of home computer use

	% of Participants (n)	
Frequency	Usual duration	Longest duration
<30 minutes	20.1 (256)	16.5 (209)
30-60 minutes	34.9 (444)	24.0 (304)
1-2 hours	24.4 (310)	29.6 (375)
2-5 hours	14.6 (185)	19.9 (252)
>5 hours	6.0 (76)	10.0 (127)

4.3.2 Nature of home computer exposure

The most frequent home computer activity was surfing the internet (90.8% of participants at least monthly), followed by email and "other" (~80% of participants at least monthly). Learning programs and writing activities were the least frequent activities at home (at least monthly for ~35% and ~57% of participants respectively). Table 4.11 demonstrates the percentage of participants performing different computer activities on a home computer for different frequencies.

Table 4.11 Percentage of participants using different home computer activities

Frequency of use	Play games	Multimedia	Write letters	Learning programs	Surf net	Email	Chat rooms	Other
Not at all	29.4	29.1	43.3	65.0	9.2	19.3	34.9	11.1
1 x month	16.1	21.1	29.2	18.1	15.9	18.4	16.3	18.2
1 x week	19.3	20.0	17.1	10.4	16.7	15.8	9.1	21.6
2-3 x week	22.4	17.2	7.9	4.9	28.8	22.1	17.1	29.9
Daily	12.7	12.6	2.4	1.6	29.4	24.3	22.6	19.2

4.3.3 Home computer environment

Home computer use over the last month was reported to usually be performed in a shared room (eg living room, shared study) with 53.7% of participants reporting use of these areas. 26.3% of participants reported using a computer in their own bedroom or study area, and other areas were reported by 4.7% (no set area) – 10.3% (other).

The mean total number of desk top and laptop computers at home was reported to be 2.6 (sd=1.9), range 0 – 30 computers. A home desktop computer was reported to be used by 82.5% of participants, a laptop computer by 33.8%, and 2.1% reported using other types of computers.

When using a computer at home the posture reported to be predominately used by participants was sitting at a desk or table (87.7%). Table 4.12 shows postures adopted for home computer use.

Table 4.12 Percentage of participants reporting different postures for home computer use

Posture	% of Participants (n)
Sitting at a desk or table	87.7 (1185)
Sitting on the floor	2.6 (35)
Sitting on sofa or beanbag	5.6 (75)
Lying down	3.2 (43)
Standing	3.1 (42)
Other posture	3.0 (41)

When using a home computer most participants (79.3%) reported usually deciding what computer activity to participate in themselves, with parents (10.4%) deciding the computer activity for some. Table 4.13 shows the choice of home computer activity.

Table 4.13 Percentage of participants reporting who chooses the home computer activity

Person	% of Participants (n)
Me	79.3 (1072)
Friend	1.3 (17)
Parent	10.4 (141)
Other person	0.6 (8)

When asked how often the participant chose what to do when using a home computer, 61.3% of participants reported that they could always choose what they wanted to do when using a home computer. Table 4.14 shows frequency of choice with home computer activities.

Table 4.14 Percentage of participant's frequency of choice with home computer activities

Frequency	% of Participants (n)
Always	61.3 (788)
Usually	27.4 (352)
Sometimes	8.5 (109)
Rarely	1.9 (25)
Never	0.9 (11)

Participants who used a computer in their own bedroom (26.3%) had an increased frequency and duration of home computer use ($x^2_{(4)} > 44.7$, p<.010), and an increased frequency of all home computer activities except writing letters and learning programs. Weekly hours of home computer use was higher for those participants with a computer in their bedroom (10.8[sd= 13.0] hours) than those without (5.8[sd=7.4] hours)($t_{(411)} = 6.6$ p< 0.001). This difference was found to be significant for both boys (12.4 [sd=14.6] hours vs 6.4[sd=8.1] hours; $t_{(276)} = 5.7$ p< .001,) and girls (means of 7.8 [sd=8.8]hours vs 5.0 [sd=6.3]hours; $t_{(148)} = 3.2$ p< .001). Whilst increased use was related to age, and age was related to having a computer in their bedroom, access to a bedroom computer was found to have an additional effect over increased hours of use ($x^2_{(3)} = 50.2$ p<.001).

These results together with school computer exposure results demonstrate that children have a substantial exposure to computers across both environments. These results also show the impact of the home environment on participant's computer use. The home environment was seen to be potentially less structured with greater computer exposure in general (particularly with own bedroom access), and greater use of social computer activities and less learning programs. This has been demonstrated by participants using computers in a variety of computer postures, different computer work environments, different types and numbers of computers to use and increased personal choice of computer activity.

4.3.4 Home computer social environment

The majority of participants (58.0%) reported that no one else was usually with them when they used a home computer. Table 4.15 shows who was usually with the user when using home computers.

Table 4.15 Percentage of participants reporting who was usually with the participant when using home computers

Person	% of Participants (n)
No-one	58.0 (784)
Friend	6.5 (88)
Parent	11.3 (153)
Sibling	25.8 (349)
Other person	1.2 (16)

When using a home computer the majority of participants report talking with no-one (39.2%). 29.4% of participants did however report talking with a sibling, and 22.7% with a friend. Table 4.16 shows who participants usually talked with when using home computers.

Table 4.16 Percentage of participants reporting who they usually talked with when using school computers

Person	% of Participants (n)
No-one	39.2 (530)
Friend	22.7 (307)
Parent	12.1 (164)
Sibling	29.4 (397)
Other person	1.9 (25)

These results demonstrate that home computer use is predominately performed when participants are on their own, however socialization with friends, parents and siblings is evident. The frequent use of internet activities may also include virtual social interaction.

4.4 COMPARISON OF COMPUTER USE IN SCHOOL AND HOME ENVIRONMENTS

4.4.1. Computer exposure

Mean weekly hours of home (7.2, sd=9.6) computer use was greater than school weekly hours (2.4, sd=3.3) ($W= -21.23$, $p<.001$). This was true for Year 6 ($W= -8.17$, $p<.001$), Year 9 ($W= -15.75$, $p<.001$) and Year 11 ($W= -11.36$, $p<.001$) and for both genders at each Year level ($W > -12.1$, $p<.001$))

Spearman's rho correlations between measures of monthly frequency, duration (usual and longest) and weekly hours of computer use at school and at home ranged from

.704 (frequency of home computer use and total weekly duration of home computer use) to .081 (frequency of home computer use and longest duration use at school). All correlations were positive and significant at the .001 level and tended to be larger within each environment (home/school) and within the same exposure measure (frequency/duration/hours). The only exceptions were girl's school computer longest duration and home frequency (r_s = .057, p=.215) / number of weekly hours (r_s = .088, p=.065). Table 4.17 shows these Spearman's rho correlation results.

Table 4.17 Spearman's rho correlations of relationships between school and home exposure measures

	School computer exposure				Home computer exposure			
	Frequency	Usual duration	Longest duration	Mean weekly hours	Frequency	Usual duration	Longest duration	Mean weekly hours
School computer exposure								
Frequency								
Usual duration	.218**							
Longest duration	.264**	.567**						
Mean weekly hours	.555**	.327**	.356**					
Home computer exposure								
Frequency	.214**	.106**	.081**	.222**				
Usual duration	.158**	.175**	.117**	.161**	.504**			
Longest duration	.137**	.163**	.241**	.145**	.507**	.695**		
Mean weekly hours	.179**	.159**	.138**	.298**	.704**	.632**	.589**	

* = p<.05, ** = p<.001

4.4.2 Computer activities used in each environment

As illustrated in Figures 4.1 and 4.2, computer activities that could be deemed less structured and more social (surfing the internet, emailing, playing games, using multimedia and chat rooms) were performed at least monthly by more boys and girls at home compared with at school (x^2 >7.8, p<.010 except multimedia for boys p=.072 and surf net for girls p=.015). Learning programs and writing letters and letters were used at least monthly by more boys and girls in the school environment ($x^2_{(4)}$>10.33, p<.035).

In summary, these results demonstrate that the computer environment is related to both the amount and nature of children's computer exposure. Home computer exposure was greater than school computer exposure for all tested Year levels and both genders. The nature of the computer exposure as seen by reviewing children's computer activities at school and home was found to be more social in the home environment.

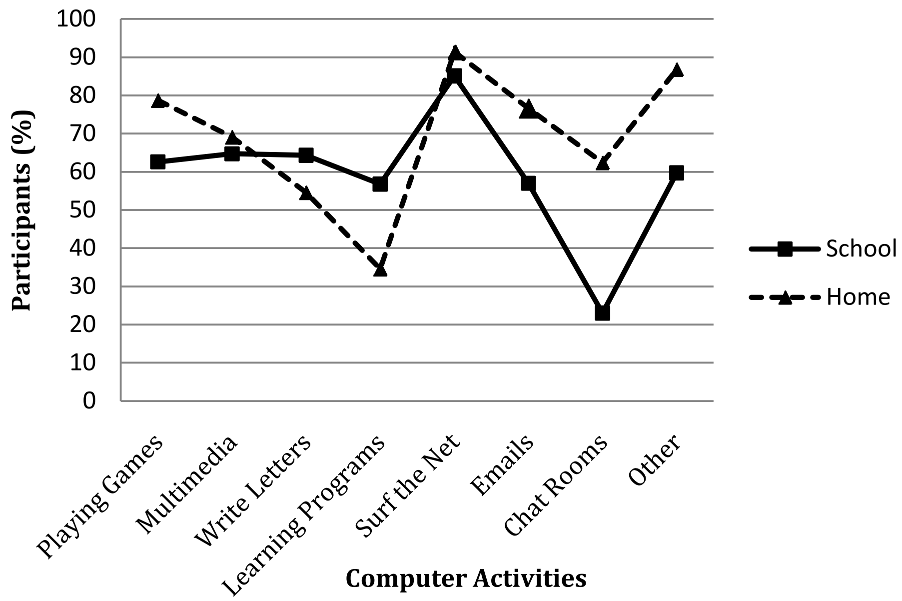


Figure 4.1 Percentage of boys performing school and home computer activities "at least monthly"

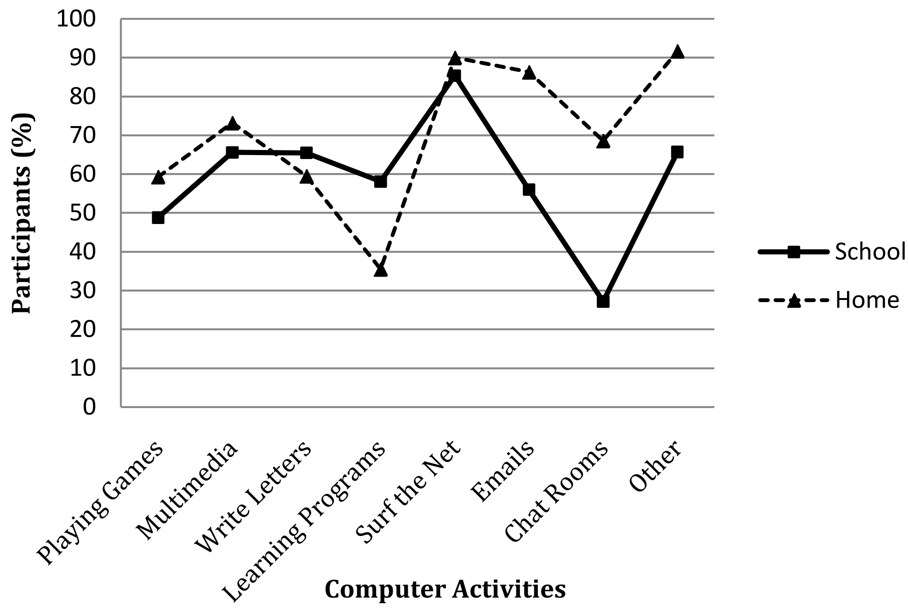


Figure 4.2 Percentage of girls performing school and home computer activities "at least monthly"

4.5 SUMMARY OF COMPUTER EXPOSURE

This chapter has detailed children's computer exposure patterns to meet objectives 1, 2 and 3 of this study. It is evident from this chapter that children have ready access to computers at school and home and are exposed to them frequently and for long durations.

In general, at school all children had access to computers with the majority of children using them at least weekly, on average for 2.3 hours/ week, and usually for 30 – 60 minutes in one sitting. At school, the computer environment was social, however activities were generally learning related and directed by teachers. At home, the majority of children had access to computers and the internet. Computer exposure was frequent, and with increased amounts of exposure. Mean weekly hours were 7.2 hours/week, usual duration 30 – 60 minutes and longest durations were usually 1 – 2 hours. Although home computer use was predominately performed by children on their own, parents, siblings and friends were involved, and computer activities were more likely to be social in nature. Children had greater access to a variety of computers, work stations and postures with home computer use.

The use of a combination of exposure measures, including access, mean weekly hours, frequency, usual and longest duration have provided results that allow for a greater understanding of children's computer exposure patterns.

The influence of the school and home environments on children's computer exposure has demonstrated evidence for differing amounts and nature of computer exposure in each environment. Given the different exposure patterns in each environment separate school and home computer exposure models were developed in Chapter 9.

The following Chapter 5 explores the characteristics of the study's computer users, with Chapter 6 and 7 further exploring children's school and home computer exposure in relation to user characteristics and computer related musculoskeletal outcomes.

5.0 Results – User Characteristics

The aim of this chapter is to show results related to user characteristics of the sample. The results included in this chapter include both descriptive and inferential statistics to describe the user characteristics. Firstly, general descriptive results of the participants user characteristics are reported for the age / Year level, gender, body dimensions, history of pre-existing MSDs, somatic complaints, psychological factors, family computer exposure, and neighbourhood socioeconomic status (NSES). Secondly, these user characteristics are used as correlates (user correlates) for the analyses investigating the relationships between activity exposure correlates of MVPA, electronic games, other sedentary IT activities and musical instruments *and* user correlates of age / Year level, gender, somatic complaints, psychological factors and NSES.

This chapter, together with future chapters, assists in meeting objectives 4, 5 and 6 of the study to investigate the relationships between individual user correlates and children's computer exposure, to investigate the relationships between NSES and children's computer exposure, and to investigate the relationships between children's other activities exposure and computer exposure.

Additionally, this chapter assists in understanding relationships between user correlates that may be potential risk factors for children's computer exposure. These results assist in meeting objective 10 of the study by identifying factors to be used in the final models.

5.1 AGE

Participant ages ranged from 6.2 to 17.9 years with a mean of 13.2 (2.8) years. 10.8% (146) of participants were Year 1, 25.9% (350) Year 6, 41.7% (562) Year 9 and 21.6% (292) Year 11. Table 5.1 shows Year level and gender of participants.

5.2 GENDER

41.3% of participants were female and 58.6% male. As previously mentioned, the larger number of Year 9 boys was due to one of the boys school requesting all of their classes be surveyed.

Table 5.1 Year level and gender of participants

Year Level	n of Participants (%)		Total
	Male	Female	
1	80 (10)	66 (11.8)	146 (10.8)
6	203 (25.6)	147 (26.3)	350 (25.9)
9	345 (43.6)	217 (38.9)	562 (41.7)
11	164 (20.7)	128 (22.9)	292 (21.6)
Total	792 (41.3)	558 (58.6)	1350 (100.0)

5.3 BODY DIMENSIONS

5.3.1 Height and Weight

Table 5.2 shows the mean(sd) height and weight body dimensions of participants.

Table 5.2 Mean(sd) height and weight characteristics of participants

Year Level	Height in cm	Weight in kgs
1	123.3 (5.4)	24.7 (4.8)
6	150.9 (7.2)	43.7 (10.2)
9	168.3 (8.5)	59.4 (11.1)
11	172.8 (8.6)	65.8 (12.1)

25 participants (8 boys and 17 girls) who completed the survey questionnaire did not want their either measurements taken, and 7 girls only wanted their height measurements taken.

5.3.2 Body Mass Index (BMI)

BMI cut offs used within this study were based on Cole *et al.,* (2007) recommendations. The majority (74.9%) of participants were within a normal weight range, with a BMI score in the range of 18.5 - <25kg/m^2. 4.9% of participants were underweight and these participants were those with thinness grades of -1 (BMI score 17<18.5 kg/m^2), -2 (BMI score 16 to <17 kg/m^2) and -3 (BMI score <16 kg/m^2) (Cole *et al.*, 2007). 9.1 % of participants were overweight (BMI scores were 25 - <30 kg/m^2), and 8.3% of participants were obese (BMI scores were >30 kg/m^2). Given that in 1995, 19.9% and in 2008, 25% of Australian children were either overweight or obese (AIHW, 2004; Dowling, 2008) and that obesity rates are reportedly increasing, this sample may be under representative for overweight and obese children. Refer to Table 5.3 for percentage of participants in each of these categories as defined by Cole *et al.* (2007). BMI was not significantly associated with participants Year level ($x^2_{(9)}$ =14.3, p=.112) or gender ($x^2_{(9)}$ =4.2, p=.238).

Table 5.3 Percentage of participants Body Mass Index

BMI Category	n of Participants (%)
Underweight	66 (4.9)
Normal	1012 (74.9)
Overweight	123 (9.1)
Obese	112 (8.3)

In summary, the user correlates of age, gender and body dimensions show the demographics of the study sample to include a range of ages from 6.2 to 17.9 years, a sample of both genders, and the majority of participants within a healthy weight range. As recent literature has demonstrated computer related musculoskeletal outcomes in children as young as 5 years (Straker *et al.,* 2006) and with both genders (Harris and Straker, 2000; Ramos *et al.,* 2005; Hakala *et al.,* 2006) a broad age range and both genders were important to include in the study.

5.4 PRE-EXISTING MUSCULOSKELETAL DISORDERS

48.3% (653) of participants reported ever having experienced a problem with their muscles, bones or joints. Having ever experienced pre-existing MSD was associated with Year level ($x^2_{(3)}$ =100.4, p<.001), and gender ($x^2_{(1)}$ =5.7, p=.019) with more reports in older and male participants.

5.5 PSYCHOLOGICAL ATTRIBUTES OF USER CHARACTERISTICS

5.5.1 Somatic complaints

5.5.1.1 Headache

In the last month, 73.5% of participants reported at least monthly frequency of headaches. 58.5% of participants experiencing headaches reported to have taken medicine to reduce headaches. Table 5.4 shows the percentage of participants experiencing headaches in the last month.

Table 5.4 Percentage of participants reporting frequency of headache in the last month

Frequency	% of Participants (n)
Not at all	26.5 (307)
Monthly	42.5 (492)
Weekly	18.0 (209)
2 – 3 x weekly	10.6 (123)
Daily	2.3 (27)

In further analysis, frequency of headaches and taking medicine to reduce headache were both associated with Year level (headache: $x^2_{(8)}$ =25.6, p=.001, medicine: $x^2_{(2)}$ =7.0, p=.031) and gender (headache: $x^2_{(4)}$ =24.9, p<.001, medicine: $x^2_{(1)}$ =6.5, p=.011). Year 11 participants were more likely to experience more frequent headaches, except for daily headaches in which Year 6 boys were more likely to experience headache. Girls were also more likely to experience headache for all frequencies greater than "not at all". Older participants and girls were found to be more likely to take medicine to reduce headache.

Frequency of headache and stomach pain were positively associated indicating an increased frequency of headache was associated with an increased frequency of stomach pain (r_s = .306, p<.001). Frequency of headache was also positively associated with school flow (r_s = .065 p=.028) and computer anxiety (r_s = .063, p=.034). This indicates that greater frequency of headaches is associated with greater computer anxiety and less computer flow. NSES was not associated with headache (r_s = -.030, p=.310) or taking medicine to reduce headache ($x^2_{(2)}$ =0.9, p=.645). Table 5.5 shows the relationship between headache frequency, flow, computer anxiety and NSES.

Table 5.5 Spearman's rho correlations of relationships between user correlates of somatic complaints, computer flow, computer anxiety and NSES

	Headache frequency	Stomach pain frequency	School computer flow	Home computer flow	Computer anxiety	NSES
Headache monthly						
Stomach pain monthly	.306**					
School computer flow	.065*	-.004				
Home computer flow	.041	-.026	.441**			
Computer anxiety	.063*	.127**	.151**	.298**		
NSES	-.030	.015	-.117**	.032	-.040	

* = p<.05, ** = p<.001

5.5.1.2 Stomach pain

In the last month, 49.8% of participants reported at least monthly frequency of stomach pain, and 32.0% of participants reported taking medicine in the last month to reduce stomach pain. Table 5.6 shows the percentage of participants experiencing stomach pain in the last month.

Table 5.6 Percentage of participants frequency of stomach pain in the last month

Frequency	% of Participants (n)
Not at all	50.2 (577)
Monthly	34.0 (391)
Weekly	10.0 (115)
2 – 3 x weekly	3.9 (45)
Daily	1.8 (21)

In further analysis Year level was not associated with stomach pain ($x^2_{(9)}$ =6.8, p=.560), or use of medicine to reduce stomach pain ($x^2_{(9)}$ =38.9, p=.111). Gender was associated with frequency of stomach pain in the last month ($x^2_{(4)}$ =9.7, p=.046) and the use of medicine ($x^2_{(1)}$ =14.1, p<.001) to reduce stomach pain. Girls were found to have an increased report for all frequencies of stomach pain except "not at all" and "daily". Girls were found to be more likely to take medicine to reduce stomach pain.

Frequency of stomach pain was associated with computer anxiety (r_s = .127, p<.001), indicating that greater frequency of stomach pain in the last month was associated with increased computer anxiety. There were no associations between frequency of stomach pain and school and home computer flow, refer to Table 5.5. NSES was not associated with stomach pain (r_s = .015, p=.618) or taking medicine to reduce stomach pain ($x^2_{(2)}$ =2.8, p=.252). Table 5.5 shows the relationships between stomach pain frequency, flow, computer anxiety and NSES.

5.5.2 School enjoyment

In the last month, 12.9 % of participants reported not enjoying school and 45.3% reported liking school. Table 5.7 shows the percentage of participants reporting school enjoyment over the last month.

Table 5.7 Percentage of participants reporting school enjoyment

Enjoyment category	% of Participants (n)
Really don't enjoy it	6.1 (81)
Don't enjoy it	6.8 (91)
So so	41.9 (561)
Like it	32.7 (437)
Really like it	12.6 (168)

School enjoyment was associated with Year level ($x^2_{(12)}$ =327.7, p<.001) and gender($x^2_{(4)}$ =36.8, p<.001), with younger participants and girls more likely to enjoy school in the last month. School enjoyment was associated with school computer flow (r_s =- .114, p<.001), computer anxiety (r_s = -.059, p=.043) and 'stomach butterflies' (r_s = -.074 p=.007). Participants who enjoyed school were more likely to have more school computer flow, less computer anxiety and experience a greater frequency of stomach butterflies.

School enjoyment was associated with NSES (r_s = .095, p=.001), indicating that participants from higher SES were more likely to enjoy school.

5.5.3 'Butterflies in the stomach'

In the last month, 28.3% of participants reported at least monthly frequency of 'butterflies in their stomach' when getting ready for school. Table 5.8 shows the percentage of participants reporting frequency of 'stomach butterflies'.

Table 5.8 Percentage of participants reporting frequency of 'stomach butterflies'

Frequency	% of Participants (n)
Don't	71.7 (956)
Monthly	17.6 (234)
Weekly	6.2 (82)
2 – 3 x weekly	2.6 (35)
Daily	2.0 (26)

Frequency of 'stomach butterflies' was associated with gender ($x^2_{(4)}$ =27.8, p<.001), but not Year level ($x^2_{(12)}$ =15.5, p=.218), with girls more likely to experience 'butterflies in their stomach' when getting ready for school over the last month.

Frequency of 'stomach butterflies' was associated with frequency of headache (r_s = .179, p<.001), frequency of stomach pain (r_s = .202, p<.001), computer anxiety (r_s = .117, p<.001) and school enjoyment (r_s = -.074 p=.007). Participants with greater frequency of 'stomach butterflies' were more likely to experience greater frequency of headaches and stomach pain, more computer anxiety and were less likely to enjoy school. Frequency of 'stomach butterflies' was not associated with NSES (r_s = .037, p=.179).

5.5.4 Sustained attention (flow)

5.5.4.1 School computer flow

School computer flow mean score was 44.3 (9.7), range 16.0 (more flow) to 76.0 (less flow). School computer flow was associated with age (r_s = .166, p<.001), Year level ($x^2_{(12)}$ =52.8, p<.001) and gender ($x^2_{(9)}$ =35.2, p<.001), with younger participants and males experiencing greater school computer flow.

School computer flow was also associated with home computer flow (r_s = .441, p<.001), and computer anxiety (r_s = .151, p<.001), indicating participants with greater home flow and less computer anxiety experienced greater school computer flow. School computer flow was negatively associated with NSES (r_s = -.117, p<.001), indicating participants from higher NSES experienced greater school computer flow. Table 5.5 shows the relationship between school computer flow, somatic complaints, computer anxiety and NSES.

5.5.4.2 Home computer flow

Home computer flow mean score was 38.2 (9.4), range 11.0 (more flow) to 71.0 (less flow). Home computer flow was associated with age (r_s = .133, p<.001), Year level ($x^2_{(12)}$ =50.9, p<.001) and gender ($x^2_{(9)}$ =70.8, p<.001) with younger participants and males experiencing greater home computer flow.

Home computer flow was also associated with computer anxiety (r_s = .298, p<.001) indicating greater home computer flow in participants with less computer anxiety. Home computer flow was not associated with NSES (r_s = .032, p=.278). Table 5.5 shows the relationship between home computer flow, somatic complaints, computer anxiety and NSES.

These flow results demonstrate a greater mean experience of flow with home versus school computer exposure which is possibly attributable to the home computer environment offering greater choice and a broader amount and nature of computer exposure. Results of less anxiety with greater computer flow are expected as children who are more engaged in their computer exposure are more likely to engage, enjoy and experience control of their activity (Webster *et al.,* 1993).

5.5.5 Computer anxiety

The mean (sd) score for computer anxiety was 22.2 (10.4) with a range from 10.0 (less anxiety) to 70.0(more anxiety). Computer anxiety was not associated with age (r_s = .011, p=.697) but was associated with gender ($x^2_{(5)}$ =31.0, p<.001), with girls being moderately anxious and boys generally less anxious. A small percentage of participants (3.0% of total participants) were found to be highly anxious. Computer anxiety was not associated with NSES (r_s = -.040, p=.173). Table 5.5 shows the relationship between computer anxiety and other user correlates.

5.5.6 Summary of psychological attributes of user characteristics

In summary, the majority of participant's reported experiencing pre-existing MSDs, headaches and stomach pain. These symptoms were found to increase with age and be associated with gender. Participants mostly enjoyed going to school with less than a third reporting 'butterflies in the stomach' when getting ready for school. Computer engagement at school and home, as measured by flow, was associated with participant's experience of computer anxiety, with reduced computer flow with greater computer anxiety. Only a small percentage of the sample were found to be highly anxious with computer exposure. Given these results demonstrating relationships between computer exposure and children's physical and psychological health correlates these variables appear to be important to include when investigating children's computer exposure. This is particularly important given that recent research is limited and not clear in understanding these relationships.

5.6 FAMILY CHARACTERISTICS

71.8 % (962) participants reported that both parents had used a computer, with 19.9% (266) reporting only one parent used a computer and 8.4% (112) reported neither/ didn't know if a parent used a computer.

Parents use of a computer was associated with participant's Year level ($x^2_{(3)}$ =9.09, p=.028), but not gender ($x^2_{(1)}$ =1.7, p=.227), with parents of Years 1 and 6 participants having greater use. Parents home computer use was associated with NSES, with more parents from higher NSES areas reported to use of a computer ($x^2_{(2)}$ =89.0, p<.001).

These results reflect the changes in access to computers over the last decade. Given these results of parents of younger children (ages < 11 years) and from higher NSES, perhaps reflecting younger parents and more highly educated parents being more likely to use computers.

5.7 NEIGHBOURHOOD SOCIOECONOMIC STATUS (NSES)

The mean NSES of the sample population based on IRSAD was 1035.4 (94.0), with a range from 869.9 to 1207.3. Table 5.9 shows the distribution of the sample IRSAD compared to the Western Australian and Australian distributions showing higher IRSAD values for the upper half of the sample.

Table 5.9 Distribution of Index of Relative Social Advantage and Disadvantage for the study sample, state and national populations

Percentile	Australia	Western Australia	Sample
Minimum	597	602	869
10%	880	909	924
25%	928	932	929
50%	990	957	1034
75%	1068	1008	1117
90%	1141	1077	1165
Maximum	1313	1301	1207

The sample distribution of NSES, including low, mid and high NSES categories, for Year level and gender is shown in Table 5.10. The over representation boys in high NSES for Year 9 is due to the independent boys school which requested all classes participate.

Table 5.10 Number of participants in NSES category for year level and gender

	Number of Participants						
	Low NSES		Mid NSES		High NSES		
Year Level	Male	Female	Male	Female	Male	Female	Total
1	16	17	20	14	43	35	145
6	31	20	39	32	133	95	350
9	111	93	77	36	157	88	562
11	27	32	39	28	98	68	292
Total	185	162	175	110	431	286	1349

NB: NSES category based on percentiles, low = <25th percentile, mid = 25th – 75th percentile, high= >75th percentile.

5.8 MODERATE VIGOROUS PHYSICAL ACTIVITY (MVPA) EXPOSURE

5.8.1 Amount of MVPA exposure

93.8% of participants reported participating in MVPA in the last month, with the majority performing MVPA 2 – 3 times per week. Table 5.11 shows the frequency of MVPA.

Table 5.11 Percentage of participant's frequency of MVPA participation

Frequency	% of Participants (n)
Not at all	6.2 (82
Monthly	3.4 (45)
Weekly	15.8 (210)
2 – 3 x weekly	46.9 (623)
Daily	27.7 (367)

Of those participants having participated in MVPA over the last month the majority usually performed MVPA for greater that 1 hour at a time, with similar results for longest duration. Table 5.12 shows for how long participants usually performed MVPA each time (usual duration), and the longest time MVPA was done without a break (longest duration).

Table 5.12 Percentage of participants MVPA participation usual and longest duration

	% of Participants (n)	
Frequency	Usual duration	Longest duration
<30 minutes	8.3 (102)	9.9 (123)
30-60 minutes	32.1 (393)	26.7 (332)
1-2 hours	40.9 (500)	32.6 (405)
2-5 hours	15.0 (183)	24.6 (306)
>5 hours	3.7 (45)	6.3 (78)

5.8.2 Relationships between MVPA exposure and user correlates

5.8.2.1 Relationships between amount of MVPA exposure and Year level and gender

Frequency of MVPA over the last month was associated with Year level ($x^2_{(12)}$ =35.6, p<.001) and gender ($x^2_{(4)}$ =57.8, p<.001), with frequency of use increasing to Year 9 level and then decreasing for Year 11. More boys had a higher frequency of MVPA than girls.

Duration of MVPA over the last month was associated with Year level for usual duration ($x^2_{(12)}$ = 91.2, p<.001) and longest duration ($x^2_{(12)}$ = 95.2, p<.001), and gender for usual duration ($x^2_{(4)}$ = 48.4, p<.001) and longest duration($x^2_{(4)}$ = 73.1, p<.001). Greater usual duration was evident with increasing with Year level to Year 9, and then decreasing for Year 11. Boys were more likely to have greater durations of MVPA. Longest duration of MVPA was more likely with increased Year level and boys.

5.8.2.2 Relationships between MVPA exposure, somatic complaints and psychological correlates

In bivariate analysis, frequency of headaches ($r_s = -.059$, $p=.046$) and stomach pain ($r_s = -.059$, $p=.049$) were negatively associated with MVPA frequency only, indicating that those participants with increased MVPA frequency experienced less somatic complaints.

In bivariate analysis, school ($-.024 < r_s > -.056$, $p > .064$) and home ($-.013 < r_s > -.026$, $p > .137$) computer flow were not associated with MVPA exposure measures. In bivariate analysis, computer anxiety was negatively related to MVPA frequency ($r_s = -.062$, $p=.034$) only, indicating that participants with increased MVPA experienced less computer anxiety.

5.8.2.3 Relationships between MVPA exposure and NSES

NSES was positively correlated with MVPA frequency ($r_s = .068$, $p=.014$) and longest duration ($r_s = .058$, $p=.041$), though not usual duration ($r_s = .001$, $p=.982$). This indicates that participants from areas of advantage participated in MVPA more frequently and for longer durations.

These MVPA results demonstrated that the majority of participants had at least weekly exposure to MVPA, with increased exposure for older participants and boys. MPVA exposure was also found to be associated with less somatic complaints and computer anxiety. While this association could be seen to be related to potential increased health benefits of MVPA, previous results of increased health and psychological complaints in girls may be the contributing factor.

5.9 ELECTRONIC GAMES EXPOSURE

5.9.1 Amount of electronic game exposure

81.5% of participants had access to electronic games, other than on a computer, at home. 67.4% of participants reported using electronic games in the last month, with the most common exposure being 2-3 times per week (See Table 5.13). TV console games such as Xbox $_{TM}$ (17.8% of devices reported to be used in the last month) and

Playstation TM (5.7%) and hand held games such as GameBoy TM (13.4%), PSP2 TM (Playstation Portable 2, 24.0%) and Nitendo DS TM (13.5%) were commonly used each month.

Table 5.13 Percentage of participant's frequency of electronic game use

Frequency	% of Participants (n)
Not at all	32.6 (430)
Monthly	19.1 (252)
Weekly	18.2 (240)
2 – 3 x weekly	21.0 (278)
Daily	9.2 (121)

Of those participants having used electronic games over the last month 64.8% of participants usually performed electronic games for more than 30 minutes at each sitting, with 48% of participants reporting longest duration > 1 hour. Table 5.14 shows for how long participants usually used electronic games each time (usual duration), and the longest time electronic games were used without a break (longest duration).

Table 5.14 Percentage of participant's electronic game usual and longest duration

	% of Participants (n)	
Frequency	Usual duration	Longest duration
<30 minutes	35.2 (320)	26.9 (245)
30-60 minutes	32.0 291)	25.1 (228)
1-2 hours	21.5 (195)	26.6 (242)
2-5 hours	8.0 (73)	14.5 (132)
>5 hours	3.3 (30)	6.9 (63)

5.9.2 Relationships between electronic game exposure and user correlates

5.9.2.1 Relationships between amount of electronic game exposure and Year level and gender

Frequency of electronic game use over the last month was associated with Year level ($x^2_{(12)}$ =79.9, p<.001) and gender ($x^2_{(4)}$ =245.9, p<.001), with frequency of use increasing with Year level and with boys.

Duration of electronic game use over the last month was associated with Year level for usual duration ($x^2_{(12)}$ = 54.4, p<.001) and longest duration ($x^2_{(12)}$ = 57.6, p<.001), and with gender for usual duration ($x^2_{(4)}$ = 105.0, p<.001) and longest duration($x^2_{(4)}$ = 137.4, p<.001). Increased duration was evident with increasing Year level and with boys.

5.9.2.2 Relationships between electronic game exposure, somatic complaints and psychological correlates

In bivariate analysis, frequency of headaches was not associated with electronic games exposure. Frequency of stomach pain was positively related to electronic game use for usual duration (r_s = .079, p=.026) only.

In bivariate analysis, school (-.081< r_s >- .174, p<.023) and home (-.175< r_s >- .185, p<.001) computer flow was related to all electronic game exposure measures, indicating that participants with more computer flow participated in electronic games more frequently and for greater durations.

In bivariate analysis, computer anxiety was negatively related to electronic game frequency (r_s =- .081, p=.006) and longest duration (r_s =- .083, p=.018) (and a trend was evident for usual duration (r_s =- .061, p=.081), indicating that participants with greater computer anxiety used electronic games less often and for shorter durations.

5.9.2.3 Relationships between electronic game exposure and NSES

NSES was associated with access to electronic games ($x^2_{(2)}$ = 9.5, p=.009), with participants from low NSES more likely to have access to electronic games. In bivariate analysis, NSES was negatively related to frequency (r_s = -.060, p=.030), usual duration (r_s = -.100, p=.002) and longest durations (r_s =- .069, p=.038) of electronic games, indicating that participants from an area of low NSES were more likely to use electronic games more frequently and for longer durations.

In summary, these results showed that electronic game use was an important IT type used by children. The majority of participants had access to and used electronic games typically 2- 3 times per week for durations of less than one hour. Older participants, boys and participants from areas of low NSES were more likely to use electronic games.

5.10 OTHER SEDENTARY ACTIVITY EXPOSURE

5.10.1 Amount of other sedentary activity exposure

Other sedentary activities surveyed in this study included watching TV shows and DVDs, writing and drawing with pens and pencils, reading books or magazines, using a mobile phone for calls or texts and playing a musical instrument. In the last month, nearly all participants (99.6%) watched TV or DVDs at least monthly, with the majority writing (95.9%) and reading (95.4%) at least monthly. TV or DVD watching was performed for the greatest durations. Table 5.15 shows other sedentary activity exposure for monthly frequency, usual and longest durations.

Table 5.15 Percentage (n) of participants sedentary activity exposure for monthly frequency, usual and longest durations of use in one sitting

	Watching TV/DVDs	Writing drawing	Reading	Mobile phones	Musical Instrument
Frequency					
Not at all	0.4 (6)	4.1 (55)	4.6 (62)	30.0 (404)	56.2 (757)
1 x month	1.6 (22)	5.1 (69)	8.4 (113)	8.6 (116)	5.4 (73)
1 x week	7.7 (104)	7.0 (94)	15.1 (203)	9.6 (129)	8.4 (113)
2-3 x week	24.7 (333)	15.4 (207)	27.1 (364)	18.4 (247)	11.7 (158)
Daily	65.5 (881)	68.4 (920)	44.8 (602)	33.4 (450)	18.2 (245)
Usual Duration					
Never	0.4 (6)	5.1 (69)	5.7 (77)	32.1 (430)	56.5 (759)
< 30 minutes	9.3 (128)	25.7 (345)	38.8 (521)	42.2 (566)	18.5 (248)
30-60 minutes	28.6 (384)	19.5 (261)	25.7 (345)	8.8 (118)	12.2 (164)
1-2 hours	33.2 (446)	15.1 (202)	15.3 (206)	6.1 (82)	6.1 (82)
2-5 hours	17.4 (234)	15.0 (201)	8.6 (115)	5.4 (73)	2.4 (32)
> 5 hours	11.1 (149)	19.6(262)	5.9 (79)	5.3 (71)	4.4 (59)
Longest Duration					
Never	2.1 (28)	7.1 (95)	8.2 (109)	35.0 (471)	56.4 (759)
< 30 minutes	12.7 (170)	26.5 (354)	35.5 (474)	41.5 (558)	16.2 (218)
30-60 minutes	19.9 (267)	28.8 (385)	27.2 (363)	9.2 (124)	13.7 (184)
1-2 hours	34.5 (462)	20.9 (280)	17.1 (228)	7.0 (94)	8.0 (107)
2-5 hours	23.4 (313)	10.8 (144)	8.6 (115)	4.8 (65)	4.0 (54)
> 5 hours	7.4 (99)	5.9 (79)	3.6 (48)	2.4 (32)	1.7 (23)

5.10.2 Relationships between other sedentary activity exposure and user correlates

5.10.2.1 Relationships between amount of other sedentary activity exposure and Year level and gender

Frequency of other sedentary activities over the last month was associated with Year level (28.2, p=.005 $<x^2_{(12)}<$636.0, p<.001) and gender (14.0, p=.007< $x^2_{(4)}$ =30.0, p<.001). Frequency of use of mobile phones increased with Year level, whereas reading was greater for younger participants. Writing and TV watching were bimodal with both Year 1 and Year 11 having increased frequency of use. Girls were shown to have greater frequency of mobile phone use, reading and writing.

Usual duration of other sedentary activities over the last month was associated with Year level (46.5 $<x^2_{(15)}<$555.8, p<.001) and gender (11.2, p=.047< $x^2_{(5)}$ =27.2, p<.001).

Usual duration of mobile phones, reading, writing and TV increased with Year level. Usual duration of using mobile phone use and writing were greater in girls, and reading with boys. Longest duration of other sedentary activity over the last month was associated with Year level (73.4 <$x^2_{(15)}$ <451.8, p<.001) and gender (16.3, p=.006< $x^2_{(5)}$ =24.5, p<.001). Longest duration of mobile phones, reading, writing and TV increased with Year level. Longest duration of mobile phone use increased with girls, and reading, writing and TV watching with boys.

5.10.2.2 Relationships between other sedentary activity exposure, somatic complaints and psychological correlates

In bivariate analysis, monthly headaches were related to mobile phone frequency (r_s = .158, p<.001), usual duration (r_s = .156, p<.001) and longest duration (r_s =.133, p<.001), writing usual duration (r_s =.084, p=.004) and longest duration (r_s =.094, p=.001), and TV watching longest duration (r_s =.063, p=.032). In bivariate analysis, stomach pain was related to mobile phone frequency (r_s = .082, p=.005), usual duration (r_s = .091, p=.002) and longest duration (r_s =.073, p=.013), and musical instrument usual duration (r_s =- .061, p=.037).

In bivariate analysis, school computer flow was associated with mobile phone frequency (r_s =.166, p<.001), usual duration (r_s =.123, p<.001) and longest duration (r_s =.122, p<.001), and reading frequency (r_s =- .090, p=.002) and longest duration (r_s =- .071, p=.016). Home computer flow was associated with mobile phone frequency (r_s =.137, p<.001), usual duration (r_s =.100, p=.001) and longest duration (r_s =.063, p=.033) and TV watching longest duration (r_s =- .100, p<.001).

In bivariate analysis, computer anxiety was related to reading monthly frequency (r_s =- .066, p=.024) and longest duration (r_s = -.122, p<.001), mobile phone frequency (r_s = .057, p=.050) and usual duration (r_s = .078, p=.008) and TV watching longest duration (r_s = -.084, p=.004).

5.10.2.3 Relationships between other sedentary activity exposure and NSES

In bivariate analysis NSES was negatively correlated (-.060< r_s < -.152, p<.038) with TV watching, mobile phones, and electronic games frequency, usual duration and longest duration (except longest duration of TV/DVD). This indicated that young people from an area of low advantage were more likely to use these IT more frequently and for longer durations. The positive bivariate relationship between NSES and reading (.072 <

$r_s < .130$, $p < .008$) indicates that young people from areas of advantage were reading more frequently and for longer durations.

Hierarchical multiple linear regression analyses were used to determine whether NSES could be used to predict the amount of other IT exposure in addition to individual and family correlates. Data were examined to ensure analysis assumptions were met.

Step 1 included individual user correlates of age, gender, BMI, computer anxiety, computer flow, frequency of computer choice and MVPA frequency. Step 2 included family correlates parental computer use, number of home computers, access to computer in own bedroom. Step 3 included NSES correlates of IRSAD index value based on home post code.

After inclusion of individual and family correlates, NSES significantly predicted frequency of electronic games, reading and mobile phone use; usual duration of electronic games, reading, TV/DVD and mobile phones; and longest duration of reading and mobile phone use. Additional analysis excluding the 55 participants without internet access resulted in the same pattern of NSES relationship.

Table 5.16 Influence of NSES on other IT exposure: 3 step prediction model statistics

Outcome variables – other IT types	Individual R squared change (Step 1)	Family R squared change (Step 2)	NSES R squared change (Step 3)	Overall model R squared	Overall Model F and p
Electronic game					
monthly frequency	.200**	.000	.006*	.454**	26.20, <.001
usual duration	.156**	.003	.007*	.167**	14.10, <.001
longest duration	.176**	.001	.003	.180**	15.46, <.001
Reading					
monthly frequency	.111**	.010*	.009*	.130**	15.09, <.001
usual duration	.027**	.008*	.004*	.038**	4.01, <.001
longest duration	.035**	.009*	.004*	.048**	5.13, <.001
Writing					
monthly frequency	.033**	.008*	.000	.033**	4.33, <.001
usual duration	.036**	.002	.001	.040**	4.12, <.001
longest duration	.024**	.002	.000	.026*	2.70, p= .002
TV/ DVD					
monthly frequency	.004	.001	.004*	.008	.852, p=.588
usual duration	.053**	.001	.007*	.062**	6.66, <.001
longest duration	.064**	.004	.000	.068**	7.30, <.001
Mobile phone					
monthly frequency	.404**	.003	.005*	.412**	70.64, <.001
duration	.254**	.005*	.009**	.268**	36.85, <.001
longest duration	.199**	.007*	.014**	.221**	28.52, <.001

Step 1 – individual correlates of age, gender, BMI, computer anxiety, home computer flow, frequency of computer choice, MVPA frequency
Step 2 – family correlates were parent computer use, number of home computers and home computer bedroom access
Step 3 - NSES IRSAD index values
* - significant R square, p<.05 ** - significant R square, p<.001

5.11 MUSICAL INSTRUMENT EXPOSURE

5.11.1 Amount of musical instrument exposure

43.8% of participants played musical instruments at least monthly, with the majority performing daily. Durations were usually less than 30 minutes for usual and longest durations. Refer to Table 5.15 above for frequency, usual and longest duration results for musical instrument exposure.

5.11.2 Relationships between musical instrument exposure and user correlates

5.11.2.1 Relationships between amount of musical instrument exposure and Year level and gender

Frequency of musical instrument use over the last month was associated with Year level ($x^2_{(12)}$ =96.6, p<.001), but not gender. Frequency of musical instrument use increased with younger participants, peaking with participants in Year 6.

Duration of musical instrument use over the last month was associated with Year level for usual duration ($x^2_{(15)}$ = 70.0, p<.001) and longest duration ($x^2_{(15)}$ = 107.2, p<.001), and gender for longest duration($x^2_{(5)}$ = 14.3, p=.014), and a trend for usual duration ($x^2_{(5)}$ = 10.1, p=.072). Increased durations were evident with increasing with Year level and boys.

5.11.2.2 Relationships between musical instrument exposure, somatic complaints and psychological correlates

In bivariate analysis, stomach pain was negatively related to musical instrument frequency (r_s =- .061, p=.037) only, indicating those students with increased stomach pain had less frequent exposure to musical instruments. In bivariate analysis, headaches were not related to musical instrument exposure.

In bivariate analysis, school computer flow was negatively associated with musical instrument frequency (r_s =- .070, p=.018) and longest duration (r_s =- .071, p=.016), indicating those students with increased exposure to musical instruments experienced greater school computer flow. Home computer flow was not associated with musical instrument exposure.

In bivariate analysis, computer anxiety was negatively related to musical instrument frequency (r_s = -.107, p<.001) usual duration (r_s = -.093, p=.001) and longest duration (r_s = -.103, p<.001), indicating that participants with greater exposure to musical instruments experienced less computer anxiety.

5.11.2.3 Relationships between musical instrument exposure and NSES

In bivariate analysis NSES was positively correlated with music frequency (r_s = .137, p<.001), usual duration (r_s = .143, p<.001) and longest duration (r_s = .144, p<.001), indicating that participants from areas of higher advantage had greater exposure to playing musical instruments.

These other activity results reflect current literature that reports that heavy users of one type of IT are often heavy users of other IT types (Borzekowski and Robinson, 2005; Rideout *et al.,* 2009). Results of other sedentary activities demonstrated that children engage in a range of activities frequently and for moderate durations. The majority of participants watched TV, wrote, and read books, 70% used mobile phones, and approximately 40% played musical instruments. The influence of age and gender on the frequency and longest duration of exposure differed depending on the activity, however usual durations of exposure typically increased with Year level. Similar relationships between NSES and computer use were reflected in the results of participants with these other activities. Participants from low SES areas were more likely to have greater exposure to mobile phones, and watching TV (social orientated activity), and those from higher NSES areas were more likely to have greater exposure to reading (school orientated activity).

5.12 SUMMARY OF USER CORRELATES

Chapter 5 results described the user characteristics of the sample. The sample ages ranged 6 to 17 years and included children from Years 1, 6, 9 and 11. More Year 9 children were included in the study at the request of one of the independent boy schools. The majority of participants were within a normal weight range with only 17.4 % overweight or obese.

Children were exposed to TV and DVDs more frequently and for longer durations than other activities. However activities such as MVPA, reading and writing had similar frequencies, with MVPA also having similar durations to TV/ DVD watching.

In regards to other electronic IT, 81.5% of participants had access to electronic games with 2/3rds reporting at least monthly frequency of use, similar to mobile phone frequency of use. Durations of electronic game use was shown to be greater than reading, mobile phone use and playing musical instruments.

75% of participants experienced headaches and 50% stomach pain, with over half of these participants using medication to control symptoms for headaches, and a third of participants using medication for stomach pain. Year level and gender relationships were evident with prevalence of somatic symptoms and use of medication.

Computer anxiety and school and home computer flow were associated, thus indicating that less computer anxious participants were more likely to experience computer flow at school and home.

The sample was found to be representative of a range of NSES categories across Year levels and gender with an over representation of higher NSES boys. This was due to an independent boys school requesting all of their Year 9 classes to be included in the study.

This chapter's results, together with further analysis in Chapter 6, assist with meeting study objectives 4, 5, and 6. Furthermore, the statistical analysis in this chapter demonstrated the relationships between user correlates of Year level, gender, somatic complaints, computer flow, computer anxiety, NSES and other activity exposure frequency and durations. These relationships demonstrate the importance of the inclusion of user correlates in modeling and path analysis, and these correlates will therefore be used in Chapter 9 to determine the relationship of potential risk factors for children's computer exposure.

6.0 Results – Relationships between Computer Exposure and User Correlates

The aim of this results chapter is to describe the analyses used to show the relationship between children's school and home computer exposure and user correlates of age / Year level, gender, other activity exposure, somatic complaints, psychological correlates and NSES. The results included in this chapter are predominately inferential statistics, but include some descriptive statistics.

This chapter is divided into 5 sections including; the relationships between the amount of computer exposure and age / Year level and gender; the relationships between the nature of computer exposure and age / Year level and gender; the relationships between computer exposure and other activity exposure; the relationships between computer exposure, somatic complaints and psychological correlates; and the relationships between computer exposure and NSES.

This chapter supports chapter 5 findings to meet objectives 4, 5 and 6 of the study to investigate the relationship between children's computer exposure and individual user correlates, to investigate the relationship between children's computer exposure and NSES, and to investigate the relationship between children's computer exposure and children's other activities.

6.1 RELATIONSHIPS BETWEEN AMOUNT OF COMPUTER EXPOSURE AND YEAR LEVEL AND GENDER.

As discussed in Chapter 4, this study has investigated computer exposure by the use of a range of measures. The relationships between computer exposure, age and gender in this chapter include frequency, usual and longest durations of children's computer exposure.

6.1.1 Relationships between computer frequency and Year level and gender

Frequency of school and home computer use over the last month was associated with Year level (school=$x^2_{(12)}$ =91.3, p<.001) (home=$x^2_{(12)}$ = 261.4, p<.001) and gender (school =$x^2_{(4)}$ =12.5, p=.014) (home=$x^2_{(4)}$ = 5.3, p=.004), with frequency of computer use increasing with Year level and boys.

6.1.2 Relationships between computer durations and Year level and gender

6.1.2.1 School computer exposure

Hours of computer use at school increased with Year level from 1.5(sd=1.8) hours/week in Year 6 to 2.4(3.5) in Year 9 and 3.3(4.1) in Year 11($H(2)$ = 71.4, p<0.001), and this was true for both boys ($H(2)$ = 52.0, p<0.001) and girls ($H(2)$ = 21.6, p<0.001). Across Years 6, 9 and 11, boys had greater weekly hours of school computer use (2.6 [sd=3.9] hrs) compared to girls (2.1[sd=2.2] hrs). Whilst the pattern was consistent across all years the difference was only significant at Year 9 (Yr6 U= 13761, p= .854; Yr9 U=28510, p=.012; Yr11 U=7983, p=.252).

Duration of school computer use over the last month was associated with Year level for usual duration ($x^2_{(8)}$ = 102.8, p<.001) and longest duration ($x^2_{(8)}$ = 60.5, p<.001), and gender for longest duration only ($x^2_{(4)}$ = 16.9, p=.002). Increased duration was evident with increasing Year level and boys for longest duration.

6.1.2.2 Home computer exposure

Hours of computer use at home increased with Year level from 1.8 (2.1) hours/week in Year 1 to 4.1 (6.1) in Year 6 to 8.0 (9.0) in Year 9 and 11.8 (13.1) in Year 11($H(3)$ = 278 p<0.001) and this was true for both boys ($H(3)$ = 153, p<0.001) and girls ($H(3)$ = 128, p<0.001). Across all Years boys had greater weekly hours of home computer use (8.2

[10.9]hrs) compared to girls (5.6[7.0] hrs) and this pattern was consistent at all Year levels (Yr 1 *U*= 1665, p= .054; Yr6 *U*= 10734, p=.036; Yr9 *U*=25418, p=.014; Yr11 *U*=6880, p=.002).

Duration of home computer use over the last month was associated with Year level for usual duration ($x^2_{(12)}$ = 163.2, p<.001) and longest duration ($x^2_{(12)}$ = 102.8, p<.001), and gender for usual duration ($x^2_{(4)}$ = 15.3, p=.004) and longest duration ($x^2_{(4)}$ = 25.6, p<.001). Increased duration was evident with increasing Year level and for boys.

6.2 RELATIONSHIPS BETWEEN NATURE OF COMPUTER EXPOSURE AND YEAR LEVEL AND GENDER

This section shows results of the relationships between user correlates of Year level and gender, and the nature of children's computer exposure. As shown in Chapter 4, the nature of computer exposure captured within the study included the types of computer activities used within school and home environments, frequency of own choice with school and home computer activities, and who the user was usually with when exposed to school and home computers. The following sections show the results for these relationships.

6.2.1 Relationships between types of computer activity frequency and Year level and gender

Year level was associated with frequency of all school computer activities ($x^2_{(12)}$>91.0, p<.001). The frequency of all computer activities at school increased with higher Year levels, except using learning programs where Year 6 participants had the highest frequency of use. More boys had a greater frequency of playing computer games ($x^2_{(4)}$>54.6, p<.001), using multimedia ($x^2_{(4)}$=9.7, p=.046), learning programs ($x^2_{(4)}$=10.3, p=.035), surfing the internet ($x^2_{(4)}$=10.2, p=.037) and other computer activities ($x^2_{(4)}$=10.6, p=.032) at school than girls.

All computer activities at home were associated with an increased frequency of activity with higher Year levels ($x^2_{(12)}$ >66.0, p<.001), except playing games and using learning programs which Year 6 participants had the highest frequency of use. Boys had a greater frequency of playing computer games ($x^2_{(4)}$ = 113.6 p<0.001) and surfing the internet ($x^2_{(3)}$ = 9.6 p=0.049) than girls; girls had a greater frequency of using email ($x^2_{(3)}$ = 23.4 p<0.001) than boys.

6.2.2 Relationships between frequency of own choice of computer activity and Year level and gender

Frequency of how often the participants could choose what they did when using a school and home computer was associated with Year level (school=$x^2_{(12)}$ =148.8, p<.001) (home=$x^2_{(12)}$ = 266.0, p<.001) but not gender (school=$x^2_{(4)}$ =8.0, p=.092) (home=$x^2_{(4)}$ = 7.7, p=.103), with frequency of own choice increasing with Year level. A trend for boys to have increased choice was evident.

6.2.3 Relationships between who you are usually with when on the computer and Year level and gender

At school, using a computer alone was associated with Year level, with Year 6 participants more likely to be alone ($x^2_{(3)}$=16.7, p<.001), but was not associated with gender (although a trend for more boys to be on their own at school was evident ($x^2_{(1)}$=2.8, p=.096). Being alone was not associated with frequency of computer activity type.

At home, using a computer alone was associated with Year level, with older participants more likely to be alone ($x_{(3)}$ = 205.7, p<0.001), but was also not associated with gender. There was a greater frequency of using multimedia ($x^2_{(4)}$=48.7, p<.001), writing letters ($x^2_{(4)}$=26.3, p<.001), surfing the net ($x^2_{(4)}$=123.40, p<.001), emailing ($x^2_{(4)}$=143.2, p<.001) and using chat rooms ($x^2_{(4)}$=124.2, p<.001) and a reduced frequency of playing computer games when participants were on their own ($x^2_{(4)}$=17.3, p=.002).

At home, sibling/ friend presence was associated with Year level, with younger participants more likely to be with friends or siblings ($x^2_{(3)}$ = 81.6 p<0.001), but was not associated with gender. Email ($x^2_{(4)}$=65.1, p<.001), writing letters ($x^2_{(4)}$=10.5, p=.003), chat room ($x^2_{(4)}$=42.3, p<.001), surfing the net ($x^2_{(4)}$=63.2, p<.001) and multimedia ($x^2_{(4)}$=20.5, p<.001) activities were less frequent when with others. There was no association between the frequency of playing computer games ($x^2_{(4)}$=3.4, p=.502), or using learning games ($x^2_{(4)}$=5.4, p=.253) and the presence of siblings or friends.

Parent presence with home computer use was associated with Year level, with younger participants more likely to report parents with them ($x^2_{(3)}$ = 253.9 p<.001), but was not associated with gender. Less parental presence was associated with increased frequency of playing games ($x^2_{(4)}$=48.6, p<.001), surfing the net ($x^2_{(4)}$=113.9, p<.001), email ($x^2_{(4)}$=145.0, p<.001), use of chat rooms ($x^2_{(4)}$=140.4, p<.001), writing letters ($x^2_{(4)}$=28.1, p<.001) and use of multimedia ($x^2_{(4)}$=48.5, p<.001). There was no association between learning activities ($x^2_{(4)}$=7.0, p=.136) and parent presence.

In summary, school and home computer exposure were greater for older participants and boys. The relationships between computer exposure and age and gender were seen when investigating the nature of the computer exposure in both school and home environments. Younger participants had greater computer exposure with school learning programs and learning programs and games at home. Boys used computer activities in both environments for greater frequencies than girls, except for email. These results are similar to exposure patterns of other IT types. Girls were found to be more involved in social communications such as email and use of mobile phones, whereas boys with gaming activities and internet computer activities. These results again demonstrate the importance of using a combination of exposure measures and including user correlates to assist in understanding the children's computer exposure and potential risk factors with computer use.

6.3 RELATIONSHIPS BETWEEN COMPUTER EXPOSURE AND OTHER ACTIVITY EXPOSURE

The following results demonstrate the relationships between computer exposure and other activities including screen based activities of TV, electronic games and mobile phone; paper-based activities of reading books and magazines and writing with pen and paper; and MVPA. Table 6.1 shows the Spearman's rho correlations for the analysis of the relationships between school and home computer exposure, including frequency, usual and longest durations and mean weekly hours, and other activities frequency and durations.

6.3.1 Relationships between computer exposure and other IT exposure

Frequency of school and home computer exposure were positively correlated to frequency of use of mobile phones and watching TV (see Table 6.1). Additionally, frequency of home computer use was negatively correlated to frequency of reading. There was no correlation between frequency of home or school computer use and frequency of electronic game playing or writing activities.

Usual and longest duration of home computer exposure was positively correlated to usual and longest durations for all other activities. A similar pattern was found for most other activities and school computer exposure. Weekly hours of home computer use was positively correlated to all electronic IT exposure, negatively correlated to reading frequency and not correlated with writing frequency.

Table 6.1 Correlations (Spearman's rho) between school and home computer exposure and other IT types in the last month

	School computer use				Home computer use			
	Frequency	Usual duration	Longest duration	Weekly hours	Frequency	Usual duration	Longest duration	Weekly hours
TV / DVD								
monthly frequency	.079**	.048	.058	.014	.166**	.122**	.089**	.124**
usual duration	.071*	.131**	.035	.101**	.231**	.334**	.219**	.251**
longest duration	.051	.048	.195**	.017	.191**	.246**	.399**	.239**
Writing and drawing								
monthly frequency	.046	.046	.059*	.034	.038	-.023	-.010	-.008
usual duration	.035	.138**	.112**	.066*	.092**	.129**	.084**	.071*
longest duration	.069*	.119**	.213**	.053	.066*	.084**	.188**	.060*
Reading								
monthly frequency	.040	-.030	.001	-.055	-.117**	-.160**	-.142**	-.186**
usual duration	.107**	.128**	.078**	.031	.033	.097**	.033	.041
longest duration	.087**	.061*	.168**	.013	.032	.070*	.159**	.063*
Mobile phone								
monthly frequency	.118**	.229**	.112**	.172**	.351**	.264**	.241**	.339**
usual duration	.115**	.251**	.134**	.179**	.338**	.316**	.267**	.359**
longest duration	.107**	.207**	.164**	.143**	.311**	.298**	.319**	.347**
Electronic games								
monthly frequency	.050	-.009	.012	-.020	.046	.088**	.127**	.067*
usual duration	.098**	.143**	.119**	.097**	.203**	.402**	.371**	.326**
longest duration	.093**	.090*	.187**	.055	.181**	.367**	.462**	.282**

* = p<.05, ** = p<.001

6.3.2 Relationships between computer exposure and MVPA exposure

In bivariate analysis, MVPA frequency was positively associated with school computer frequency (r_s = .060, p=.031) and negatively associated with home computer durations (usual r_s =- .088, p=.002; longest r_s =- .056, p=.047) and mean weekly hours (r_s =- .075, p=.010). Participants with greater frequency of MVPA were more likely to have greater frequency of school computer exposure and reduced duration of home computer exposure.

In bivariate analysis, MVPA of usual and longest duration showed similar patterns in relation to school and home computer exposures. MVPA durations were positively associated with both school usual (usual r_s = .139, p<.001; longest r_s =-.132, p<.001) and longest (usual r_s =.116 p<.001; longest r_s = .271, p<.001) durations. MVPA durations were also positively associated with home computer usual duration (usual r_s = .153, p<.001; longest r_s =.101, p<.001) longest duration (usual r_s = .116, p<.001; longest r_s =.257, p<.001) and mean weekly hours (usual r_s = .066, p=.029; longest r_s =.070, p=.020). These results show that participants with greater durations of MVPA were more likely to have greater durations of school and home computer exposure.

Again these results showing relationships between computer exposure and exposure to other activities demonstrate that often participants who have greater exposure to one type of activity also have greater exposures of other IT types. Relationships were generally positive for associations between school and home computer exposure and TV, writing, mobile phone use, and electronic games. Negative relationships were found with home computer exposure and reading and MVPA frequency indicating those participants engaged in home computer use performed less reading and MVPA. Investigating children's exposure to other IT types is important given potential risk factors are similar with greater exposure to a range of sedentary activities.

6.4 RELATIONSHIPS BETWEEN COMPUTER EXPOSURE, SOMATIC COMPLAINTS, FLOW, AND COMPUTER ANXIETY

6.4.1 Relationships between amount of computer exposure (frequency, usual and longest durations) and somatic complaints (headache and stomach pain)

In bivariate analysis, frequency of headaches were positively related to computer weekly hours (school r_s =.072, p=.017; home r_s =.157, p<.001), frequency (school r_s = .061, p=.038; home r_s = .125, p<.001), usual duration (school r_s = .088, p=.003; home r_s = .145, p<.001), and longest duration (school r_s = .091, p=.003; home r_s = .115, p<.001), indicating that participants with a higher frequency of headaches had greater exposure to computers.

Stomach pain was not associated with school computer exposure. However, frequency of stomach pain was positively related to home computer weekly hours (r_s =.086, p=.006), frequency (r_s = .071, p=.016), usual duration (r_s = .067, p=.026) and longest durations (r_s = .085, p=.005), indicating that participants with a higher frequency of stomach pain had greater exposure to home computers.

6.4.2 Relationships between amount of computer exposure (frequency, usual and longest durations) and flow

In bivariate analysis, school and home computer flow were negatively related to computer exposures of mean weekly hours (school r_s = -.141, p<.001; home r_s = -.185, p<.001), frequency (school r_s =- .147, p<.001; home r_s =- .180, p<.001), usual duration (school r_s - .069, p=.020; home r_s =- .178, p<.001) and longest duration (school r_s = -.073, p=.014; home r_s = -.222, p<.001). Participants with more flow had greater computer exposure.

6.4.3 Relationships between the amount of computer exposure (frequency, usual and longest durations) and computer anxiety

In bivariate analysis, computer anxiety was negatively related to school computer frequency (r_s =- .082, p=.005) only, indicating that participants with greater computer anxiety used school computers less frequently.

In bivariate analysis, computer anxiety was negatively related to home computer weekly hours (r_s = -.184, p<.001), frequency (r_s =- .222, p<.001), usual duration (r_s =- .118, p<.001), and longest durations (r_s = -.199, p<=.001), indicating that participants with greater computer anxiety had reduced home computer exposure.

6.4.4 Relationships between nature of computer exposure (computer activities) and somatic complaints (headache and stomach pain)

School computer activities of multimedia (r_s = .064, p=.033), writing letters (r_s = .071, p=.017), surfing the internet (r_s = .111, p<.001), chat rooms (r_s = .084, p=.005) and other activities (r_s = .081, p=.007) had a positive relationship with frequency of headaches, indicating that participants with a higher frequency of headaches had greater exposure to these computer activities.

School computer activities of playing games (r_s = .086, p=.004), surfing the internet (r_s = .092, p=.002), and chat rooms (r_s = .111, p<.001) had a positive relationship with frequency of stomach pain, indicating that participants with a higher frequency of stomach pain had greater exposure to these computer activities.

Home computer activities of multimedia (r_s = .110, p<.001), writing letters (r_s = .108, p<.001), surfing the internet (r_s = .140, p<.001), sending email (r_s = .168, p<.001), chat rooms (r_s = .096, p=.001) and other activities (r_s = .061, p=.044) had a positive relationship with frequency of headaches, indicating that participants with a higher frequency of headaches had greater exposure to these computer activities.

Home computer activities of writing letters (r_s = .070, p=.020), learning programs (r_s = .094, p=.002), surfing the internet (r_s = .100, p=.001), sending email (r_s = .079, p=.009), and chat rooms (r_s = .083, p=.006) had a positive relationship with frequency of stomach pain, indicating that participants with a higher frequency of stomach pain had greater exposure to these computer activities.

6.4.5 Relationships between nature of computer exposure (computer activities) and flow

For all school computer activities there was a negative bivariate correlation between flow and frequency of school computer activities ($-.060 < r_s > -.217$, $p<.043$), indicating that participants with reduced experience of flow reported less exposure to computers.

Home computer activities of playing games ($r_s = -.313$, $p<.001$), multimedia ($r_s = -.125$, $p<.001$), surfing the internet ($r_s = -.182$, $p<.001$), and chat rooms ($r_s = -.072$, $p=.015$) were negatively correlated with home computer flow, indicating that participants with reduced experience of flow reported less frequency of these home computer activities.

6.4.6 Relationships between the nature of computer exposure (computer activities) and computer anxiety

School computer activities of learning programs ($r_s = .067$, $p=.022$) and chat rooms ($r_s = .166$, $p<.001$) had a positive relationship with computer anxiety, indicating that participants with greater anxiety were more likely to use these school computer activities. Surfing the internet ($r_s =- .082$, $p=.005$) at school was negatively associated with school computer anxiety indicating that participants with greater anxiety were less likely to use this computer activity.

Home computer activities of playing games ($r_s = -.157$, $p<.001$), multimedia ($r_s = -.136$, $p<.001$), surfing the internet ($r_s = -.221$, $p<.001$), sending email ($r_s = -.124$, $p<.001$), and other activities ($r_s = -.133$, $p<.001$) had a negative relationship with computer anxiety, indicating that participants with greater anxiety were less likely to use these home computer activities.

As expected, those participants experiencing positive psychological experiences with computer exposure at school and home were found to have an association with greater computer exposure. Computer exposure was related in both the amount and nature of exposure. However those students experiencing a negative psychological experience were found to have reduced computer exposure. This was different to findings associated with somatic complaints. Participants experiencing greater frequency of these symptoms were found to have greater exposure to computers. These psychological and somatic complaints as previously reported were more likely experienced by girls, whereas greater flow was more likely reported by boys. As previous research with child related computer exposure has been limited, and findings on relationships between exposure and these user correlates unclear, these findings demonstrate the importance of investigating these relationships to understand potential risk factors for computer related outcomes.

6.5 RELATIONSHIPS BETWEEN COMPUTER EXPOSURE AND NSES

6.5.1 Relationships between the amount of computer exposure and NSES

Table 6.2 shows the distribution of school and home computer and internet access across NSES deciles. NSES was associated with both home access to computers ($x^2_{(9)}$ =17.04, p=.048) and the internet ($x^2_{(9)}$ =21.33, p=.011). Lower NSES deciles had slightly lower rates of home computer and internet access.

Table 6.2 Percentage of participants with access to school computers and internet by NSES decile

NSES		School		Home	
Decile	Values	computer	internet	computer	internet
<10th	<924.5	100.0	100.0	96.8	92.0
10th - <20th	924.6 – 929.5	100.0	100.0	98.7	93.5
20th - <30th	929.6 – 973.5	100.0	100.0	100.0	93.4
30th - <40th	973.6 – 995	100.0	100.0	100.0	94.3
40th - <50th	995.1 – 1034.5	100.0	100.0	97.0	97.0
50th - <60th	1034.6 – 1062.2	100.0	100.0	100.0	97.1
60th - <70th	1062.3 – 1111.7	100.0	100.0	98.6	97.9
70th - <80th	1111.8 – 1129.7	100.0	100.0	100.0	100.0
80th - <90th	1129.8 – 1164.9	100.0	100.0	100.0	98.2
>90th	>1165	100.0	100.0	99.4	98.9
	Mean	100.0%	100.0%	98.9%	95.9%

In bivariate analysis, NSES was positively related to school computer mean weekly hours (r_s = .086, p= .004), frequency (r_s = .148, p<.001) and longest durations (r_s = .088, p=.003), indicating that participants from an area of high advantage were more likely to use computers at school for more hours, more frequently and for longer durations. Conversely, home computer use was negatively related with NSES for home computer weekly hours (r_s = -.157, p<.001), usual duration (r_s = -.220, p<.001) and longest duration (r_s = -.138, p<.001), indicating that participants from an area of disadvantage were more likely to use computers at home for more hours and for longer durations.

Hierarchical multiple linear regression analyses were used to determine whether NSES could be used to predict the amount of school and home computer exposure in addition to individual and family correlates. Data were examined to ensure analysis assumptions were met.

Step 1 included individual user correlates of age, gender, BMI, computer anxiety, computer flow, frequency of computer choice and MVPA frequency. Step 2 included family correlates parental computer use, number of home computers, access to computer in own bedroom. Step 3 included NSES correlates of IRSAD index value based on home post code.

After inclusion of individual and family correlates, NSES accounted for a significant proportion of variance in hours spent using a computer at school and monthly frequency and longest duration of using a school computer. Similarly, NSES separately accounted for a significant proportion of usual and longest durations of home computer use. In additional post hoc analysis, the 55 participants without internet access were excluded and the pattern of results remained the same.

Table 6.3 demonstrates that the combination of individual, family and NSES correlates significantly predicted the amount of school and home computer use, although the R squared values show that the associations with home computer use were stronger than those with school.

Table 6.3 Influence of NSES on the amount of computer exposure: 3 step prediction model statistics for eight exposure measures

Outcome variables – computer exposure	Individual R squared change (Step 1)	Family R squared change (Step 2)	NSES R squared change (Step 3)	Overall model R squared	Overall model F and p
School					
weekly hours	.073**	.008*	.002	.083**	8.93, <.001
monthly frequency	.077**	.004	.018**	.100**	11.27, <.001
usual duration	.079**	.004	.001	.083**	9.07, <.001
longest duration	.049**	.002	.005*	.055**	5.84, <.001
Home					
weekly hours	.199**	.045**	.011**	.255**	33.09, <.001
monthly frequency	.268**	.011**	.000	.279**	39.07, <.001
usual duration	.198**	.027**	.029**	.254**	34.40, <.001
longest duration	.244**	.014**	.010**	.268**	36.89, <.001

Step 1 – individual correlates of age, gender, BMI, computer anxiety, home computer flow, frequency of computer choice, MVPA frequency
Step 2 – family correlates were parent computer use, number of home computers and home computer bedroom access
Step 3 - NSES IRSAD index values
* - significant R square, p<.05 ** - significant R square, p<.001

6.5.3 Relationships between the nature of computer exposure and NSES

The positive bivariate correlation between NSES and the frequency of school computer activities of playing games (r_s = .126, p<.001), learning programs (r_s = .094, p=.001) and emailing (r_s = .257, p<.001) indicates that participants from an area of high advantage were more likely to use these school computer activities. Table 6.3 shows these relationships.

In bivariate analysis the frequency of home computer activities of using multimedia (r_s = -.079, p=.005), surfing the internet (r_s = -.062, p=.028), emailing (r_s = -.056, p=.044) and chat room (r_s = -.117, <.001) were negatively correlated with NSES, indicating that participants from an area of disadvantage were more likely to use these home computer activities. Table 6.3 shows these relationships.

Table 6.4 Spearman's rho correlations of relationships between NSES and school and home computer activities

	NSES	
Computer activity	School	Home
Playing games	.126**	.020
Multimedia	-.010	-.079**
Write letters	.029	.009
Learning programs	.094**	.042
Surf net	.033	-.062*
Email	.257**	-.056*
Chat rooms	.017	-.117**
Other activity	.012	-.032

* = p<.05, ** = p<.001

6.6 SUMMARY OF RELATIONSHIPS BETWEEN COMPUTER EXPOSURE AND USER CORRELATES

Chapter 6 results show the relationships between school and home computer exposure and user correlates in the sample. Computer exposure correlates included the amount of exposure (access, frequency, usual duration, longest duration and mean weekly hours), and the nature of exposure (computer activities, choice of activity and who usually with). User correlates included age/ Year level, gender, somatic complaints, school and home computer flow, computer anxiety, NSES and other activities.

In general, school and home computer exposure was found to be more frequent and for longer durations with older participants and boys. All computer activities, except learning activities and game playing increased with Year level. Year 6 participants were found to have greater exposure to these computer activities.

Older participants were also likely to use a computer by themselves and reported more choice with computer activities. This included greater exposure to social computer activities such as multimedia, chat rooms and internet use. At home, boys were more likely to play computer games and girls were more likely to use social activities such as email.

Greater school and home computer exposure patterns were associated with an increase in some aspects of exposure of TV watching, mobile phones and electronic games. In contrast reading and MVPA frequency negatively correlated with home computer exposure.

Participants who were more anxious with computers, or were less likely to experience flow with school and home computer use, had reduced computer exposure. Participants reporting somatic complaints were more likely to have greater computer exposure.

Participants from areas of advantage were more likely to have greater school computer exposure and use school computers for learning program and games, whereas participants from areas of disadvantage were found to have greater exposure to home computers and computer activities that were social in nature, eg. email and chat room.

This chapter's results contribute to achieving study objectives 1, 3, 4, 5, and 6. These findings have further investigated children's computer exposure patterns, further explored the relationships between the computer environment and exposure patterns, and finally, explored the relationships between user correlates and children's computer exposure.

The following chapter continues to explore children's school and home computer exposure by investigating computer related musculoskeletal outcomes.

7.0 Results – Relationships between Computer Exposure and Musculoskeletal Outcomes

The results presented in this chapter help meet objectives 7, 8, and 9 of the study. These include identifying musculoskeletal outcomes associated with children's computer exposure, demonstrating how the use of different outcome measures better characterize computer related musculoskeletal outcomes, and assesses the relationships between user correlates and environment of use with computer related musculoskeletal outcomes.

This chapter is divided into 4 sections that include both descriptive and inferential statistics. Section 1 includes a general overview of the relationship between school and home computer exposure and the four computer related musculoskeletal outcomes used within the study. These include musculoskeletal symptom frequency, location and intensity of soreness, and the impact of this soreness. Additionally, musculoskeletal outcomes associated with other IT types are presented. Other IT types related musculoskeletal outcomes were also measured by frequency of musculoskeletal soreness and are referred to in this thesis as Other Activity Related MSS.

Sections 2 and 3 report results of analyses demonstrating the relationships between user correlates including age and gender, and computer related musculoskeletal outcomes.

Section 4 of this chapter shows further analyses including logistical and linear regression analysis used to investigate the relationships between children's computer exposure and computer related musculoskeletal outcomes.

7.1 GENERAL OVERVIEW - RELATIONSHIPS BETWEEN SCHOOL AND HOME COMPUTER EXPOSURE AND COMPUTER RELATED MUSCULOSKELETAL SORENESS (MSS)

The following section shows a general overview of results for the relationships between school and home computer exposure and the four computer related musculoskeletal outcomes of frequency of musculoskeletal soreness, location of musculoskeletal soreness, intensity of musculoskeletal soreness and impact of musculoskeletal soreness.

7.1.1 Frequency of School and Home Computer Related MSS

7.1.1.1 Overview - Frequency of School and Home Computer Related MSS

10.1% of participants reported experiencing MSS at least monthly with school computer use and 20.7% of participants at least monthly with home computer use. Table 7.1 shows the frequency of MSS with school and home computer exposure.

Table 7.1 Percentage (n) of participants reporting Musculoskeletal Soreness with school and home computer exposure

	Frequency of Musculoskeletal Soreness				
Activity type	Monthly	Weekly	2 – 3 x Week	Daily	TOTAL (>monthly)
School computer	5.6 (65)	3.2 (37)	0.5 (6)	0.8 (9)	10.1%
Home computer	9.9 (113)	6.1 (70)	3.2 (37)	1.5 (17)	20.7%

7.1.1.2 Relationships between frequency of Computer Related MSS and Other Activity Related MSS

The frequency of MSS related to school and home computer exposure were correlated with each other ($r_{s=}$.517 p<.001). School and home computer related frequency of MSS were also associated with electronic games frequency of MSS (school computer=$r_{s=}$.326 p<.001; home computer=$r_{s=}$.443 p<.001), other activities frequency of MSS (school computer=$r_{s=}$.300 p<.001; home computer=$r_{s=}$.343 p<.001) and MVPA frequency of MSS (school computer =$r_{s=}$.189 p<.001; home computer=$r_{s=}$.191 p<.001).

7.1.1.3 Relationships between frequency of School and Home Computer Related MSS and amount of computer and other activity exposure

The frequency of Computer Related MSS was found to be associated with frequency and duration of some school and home computer exposure measures, as well as other activities exposure. Table 7.2 shows results for the Spearman's rho correlation analysis. Specifically, School Computer Related MSS was associated with school computer and mobile phone frequency and mobile phone longest durations, indicating a greater frequency of MSS with greater exposure to these activities. A negative correlation for School Computer Related MSS and MVPA durations indicates reduced MVPA exposure with greater soreness.

Frequency of Home Computer Related MSS was positively associated with school computer frequency, all home computer exposure measures, TV/DVD frequency, and all mobile phone exposure measures, indicating a greater frequency of soreness with greater exposure to these IT types. The negative correlations between Home Computer Related MSS and electronic game frequency and all MVPA exposure measures indicate a reduced exposure to electronic games and MVPA with greater Home Computer Related MSS.

Table 7.2 Spearman's rho correlations of relationships between frequency of School and Home Computer Related Musculoskeletal Soreness and computer and other activity exposure
* = p<.05, ** = p<.001

	Activity								
Frequency of MSS	School computer	Home computer	Electronic games	TV / DVDs	Writing / drawing	Reading books	Mobile phones	Musical instrument	MVPA
	Frequency of exposure								
School	.110**	.045	-.036	.031	.017	.008	.069*	-.014	-.010
Home	.091**	.150**	-.066*	.069*	.049	.020	.126**	-.037	-.075*
	Usual duration of exposure								
School	.033	.038	-.003	.006	.007	.014	.046	-.012	-.079*
Home	.053	.110**	.044	.040	.041	.029	.143**	-.035	-.100**
	Longest duration of exposure								
School	.042	.011	-.032	.009	.013	.009	.064*	.012	-.091**
Home	.013	.129**	-.027	.032	.031	.045	.133**	-.017	-.071*

7.1.1.4 Relationships between frequency of School and Home Computer Related MSS and nature of school and home computer activities

The frequency of School and Home Computer Related MSS were associated with the frequency of some school and home computer activities. Specifically, School Computer Related MSS was positively associated with school computer activities of multimedia ($r_{s=}.098$ p=.001) and use of chat rooms ($r_{s=}.061$ p=.038). Within the home environment, Home Computer Related MSS was positively associated with home computer activities of multimedia ($r_{s=}.124$ p<.001), word documents ($r_{s=}.111$ p<.001), learning programs ($r_{s=}.096$ p=.001), surfing the internet ($r_{s=}.104$ p<.001), email ($r_{s=}.124$ p<.001), and use of chat rooms ($r_{s=}.081$ p=.006). Table 7.3 shows Spearman's rho correlations for the relationships between School and Home Computer Related MSS and frequency of different computer activities.

Table 7.3 Spearman's rho correlations of relationships between frequency of School and Home Computer Related Musculoskeletal Soreness and computer activities

	Computer activity							
Frequency of MSS	Playing games	Multimedia	Writing letters	Learning programs	Surf net	Email	Chat rooms	Other
School	.052	.098*	-.021	.039	.052	.016	.061*	.064*
Home	.012	.124**	.111**	.096**	.104*	.124**	.081**	.129**

* = p<.05, ** = p<.001

7.1.2 Anatomical body locations for School and Home Computer Related MSS

The most prevalent anatomical body locations for School and Home Computer Related MSS over the last month were the neck and low back for both school and home computer exposure. A greater proportion of participants reported Home Computer Related MSS in these locations. Table 7.4 shows the prevalence of Computer Related MSS in each of the 8 body locations.

Table 7.4 Percentage of participants (n) reporting School and Home Computer Related Musculoskeletal Soreness in the last month in each anatomical body location

	Anatomical body location							
Activity	Neck	Mid back	Low back	Left shoulder / arm	Left elbow / hand	Right shoulder / arm	Right elbow / hand	Lower limbs
School computer	4.4 (59)	2.1 (29)	3.0 (41)	0.8 (11)	0.9 (12)	1.2 (16)	1.2 (17)	1.4 (19)
Home computer	9.4 (128)	5.8 (79)	7.5 (101)	2.1 (28)	2.7 (37)	2.2 (29)	2.8 (39)	2.7 (37)

7.1.3 Intensity of School and Home Computer Related MSS

Intensity of musculoskeletal soreness for school and home computer exposure was recorded by participants using a numerical rating scale of 0 (no soreness) – 10 (extreme soreness). This numerical rating scale was used for each of the 8 body locations. The mean intensity scores for each of the 8 body locations are shown in Table 7.5. School and Home Computer Related MSS highest mean intensity of scores were for low back with scores of 5.1 and 4.9 respectively. Mean intensity of MSS scores ranged from 3.8 to 5.1 for all anatomical body locations indicating a moderate intensity at each location.

Table 7.5 Mean scores for intensity of Computer Related Musculoskeletal Soreness for each body location

	Anatomical body location							
MSS	Neck	Mid back	Low back	Left shoulder / arm	Left elbow / hand	Right shoulder / arm	Right elbow / hand	Lower limbs
School	4.6	5.1	5.1	3.9	3.7	4.2	4.5	4.5
Home	4.5	4.1	4.9	3.8	3.6	4.1	4.0	4.6

7.1.4 Impact of School and Home Computer Related MSS

Participants who experienced monthly Computer Related MSS indicated the impact of the MSS by reporting any or all of the following behaviours; limiting participation in their activity, taking medication and consulting a treating health professional. Table 7.6 shows the percentage of participants reporting different behaviours. Limiting participation was the most commonly reported impact for School and Home Computer Related MSS.

Table 7.6 Impact of Computer Related Musculoskeletal Soreness: Percentage of participants (n) reporting Computer Related MSS who undertook specific behaviours

	Impact		
MSS	Limit participation	Medication taken	Treating health practitioner consult
School	16.2 (19)	6.8 (8)	6.8 (8)
Home	29.8 (70)	9.7 (23)	6.4 (15)

Participants reported taking similar behaviours for both School and Home Computer Related MSS. For example, consulting a treating health practitioner for School and Home Computer Related MSS ($r_{s=}$ .689 p<.001) were related.

The impact of School Computer Related MSS was correlated to frequency of School Computer Related MSS and taking medication ($r_{s=}$-.256 p<.001) only. The impact of Home Computer Related MSS was correlated to frequency of Home Computer Related MSS limiting activity participation ($r_{s=}$-.186 p<.001) and taking medication ($r_{s=}$-.219 p<.001).

Correlations between the 3 behaviours measuring impact of MSS and most school and home exposure measures were not significant except for school computer frequency and taking medicine ($r_{s=}$-.221 p=.017). Table 7.7 shows these Spearman's rho correlations. Given that an impact of Computer Related MSS is for activity limitation this is therefore not surprising.

Table 7.7 Spearman's rho correlations of relationships between computer exposures and the 3 behaviours measuring impact of Computer Related Musculoskeletal Soreness

	Impact		
Computer exposure	Limit participation	Medication taken	Treating health practitioner consult
School			
Frequency	-.099	-.221*	-.123
Usual duration	.090	-.106	.101
Longest duration	.127	-.114	-.008
Home			
Frequency	-.012	-.009	.040
Usual duration	.079	-.075	-.057
Longest duration	.017	-.013	.009

* = p<.05, ** = p<.001

These results demonstrate the importance of using a range of outcome measures to better characterize and understanding of computer related outcomes on children. In summary, School and Home Computer Related MSS were experienced by up to 20% of participants. As expected, Computer Related MSS was associated with greater computer and other activity exposure. MSS were experienced by participants predominately in the body locations of neck, back and upper limbs. These results were also reflected with the intensity ratings participants reported for each of these body locations. On considering the body mechanics and mechanisms of seated postures for the frequent and sustained durations of children's computer use and IT interfaces requiring repetitive upper limb motions, reports of soreness in these body locations are as expected. The impact of the Computer Related MSS as reported by a small percentage of participants (see Table 7.6), showed that participants limited their computer activity and sought health professional treatment. These results indicate that Computer Related MSS in children are not trivial complaints and impact on their activities of daily living.

7.2 RELATIONSHIPS BETWEEN SCHOOL AND HOME COMPUTER RELATED MSS AND USER CORRELATES OF AGE, GENDER AND NSES

7.2.1 Relationship between frequency of School and Home Computer Related MSS and age

Frequency of Computer Related MSS was positively correlated with age for home computer use (r= .111 p<0.001), but not school computer use (r= .044 p=.140). When split for gender only girls had a positive correlation between age and frequency of School Computer Related MSS (r= .101 p=.028) and Home Computer Related MSS (r= .183 p<0.001).

7.2.2 Relationships between Frequency of School and Home Computer Related MSS and gender

A greater prevalence of School Computer Related MSS was associated with girls ($X_{(4)}$ = 9.4, p=.051). When split for Year level this was evident in Year 11 only ($X_{(4)}$ = 11.1, p=.025). A greater frequency of Home Computer Related MSS was also associated with girls ($X_{(4)}$ = 25.1, p <.001). When split for Year level this was evident in Year 9 ($X_{(4)}$ = 10.21, p=.037) and Year 11($X_{(4)}$ = 20.4, p<.001). Figures 7.1 and 7.2 show the relationships between Year level of participants and frequency of Activity Related MSS for boys and girls.

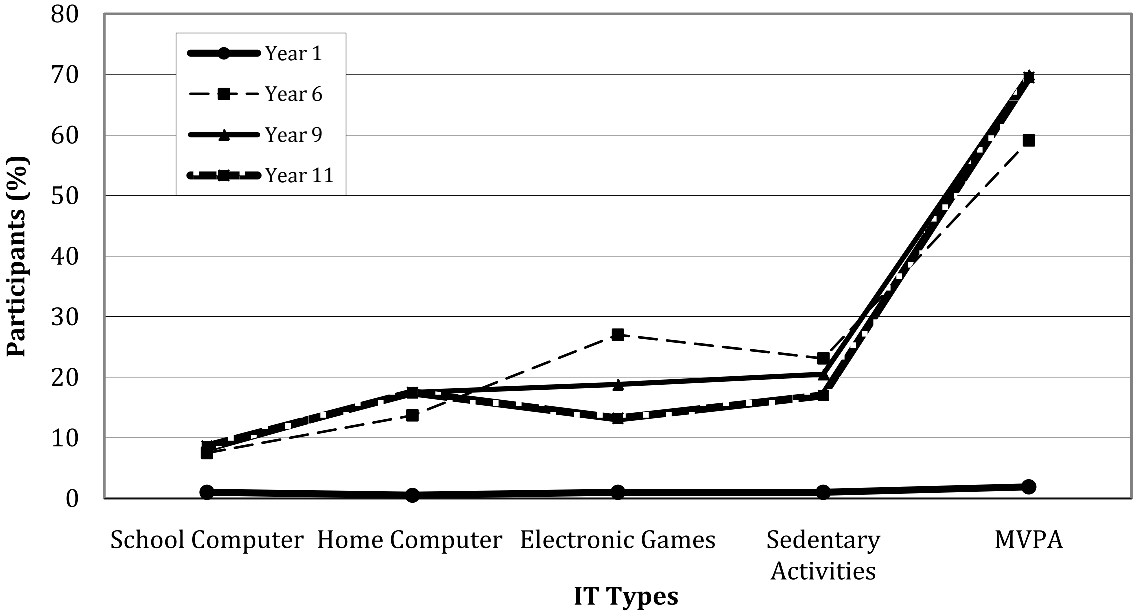


Figure 7.1 Relationship between Year level and Activity Related MSS for boys

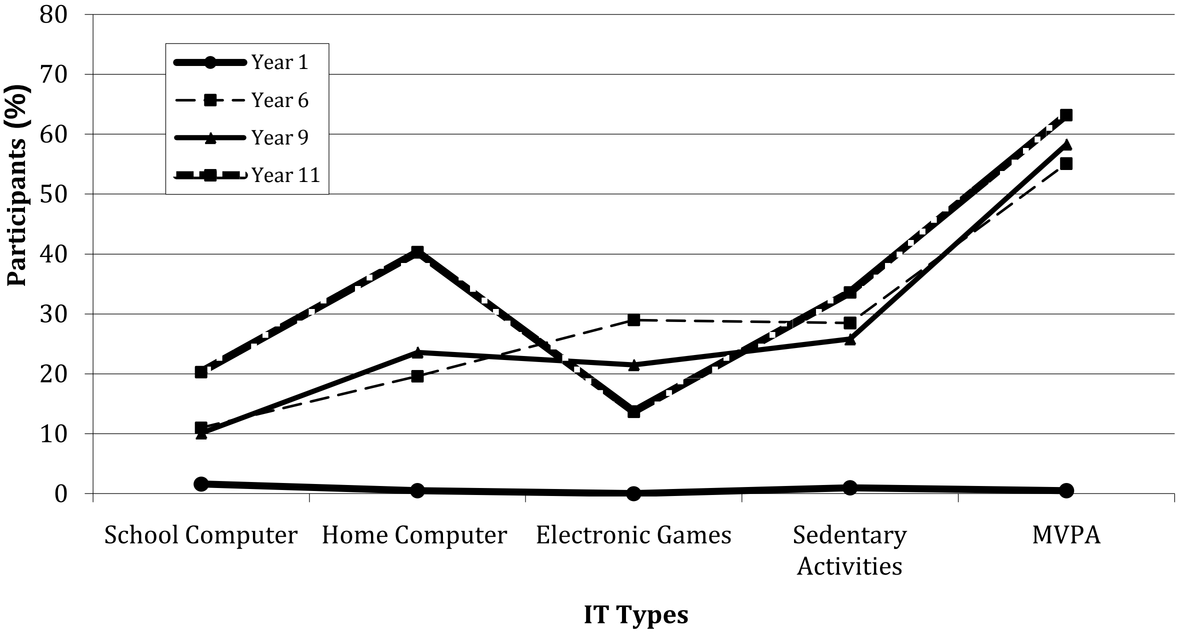


Figure 7.2 Relationship between Year level and Activity Related MSS for girls

7.2.3 Relationship between School and Home Computer Related MSS and NSES

Frequency of school (r=- .016 p=0.598) and home (r= -.013 p=0.668) Computer Related MSS was not associated with NSES.

These results demonstrated that individual factors were associated with Computer Related MSS. Computer exposure was greater in older participants, as were participants reports of Computer Related MSS. Gender was found to be related to Computer Related MSS, and as with reports of somatic complaints, girls were found to experience a greater prevalence of Computer Related MSS.

7.3 RELATIONSHIPS BETWEEN SCHOOL AND HOME COMPUTER RELATED MSS AND OTHER USER CORRELATES

User correlates discussed in this section include 'butterflies in your stomach', enjoyment of going to school, pre-existing MSD, somatic complaints of headache and stomach pain, and psychological correlates of flow and computer anxiety. Results are shown for the relationships between these user correlates and School and Home Computer Related MSS.

7.3.1 Relationships between School and Home Computer Related MSS and user correlates

Table 7.8 shows Spearman's rho correlations for relationships between School and Home Computer Related MSS and user correlates. In summary, 'butterflies in your stomach', headache and stomach pain were positively associated with frequency of School and Home Computer Related MSS, indicating greater frequency of Computer Related MSS was associated with greater frequency of other complaints.

A history of pre-existing MSDs was associated with greater frequency of School ($X_{(4)}$ = 24.7, p<.001) and Home Computer Related MSS ($X_{(4)}$ = 15.6, p=.004).

7.3.2 Relationships between user correlates

As shown in Table 7.8, most user correlates were associated with each other. Somatic complaints, including headache and stomach pain, 'butterflies in your stomach' and computer anxiety were all positively correlated with each other. This showed that a greater frequency of one complaint indicated greater frequency of another complaint.

Negative correlations were found for frequency of 'butterflies in your stomach', computer anxiety and enjoyment of school, indicating participants experienced greater butterflies in stomach and reduced computer anxiety with less school enjoyment.

Pre-existing MSDs were associated with a greater frequency of headaches ($X_{(4)}$ = 15.5, p=.004), and stomach pain ($X_{(4)}$ = 23.2, p <.001). Pre-existing MSDs were also associated with not enjoying school ($X_{(4)}$ = 29.3, p <.001) and 'butterflies in your stomach' ($X_{(4)}$ = 12.2, p =.016).

Table 7.8 Spearman's rho correlations of relationships between user correlates and School and Home Computer Related Musculoskeletal Soreness

	'Butterflies in your stomach'	Enjoy going to school	Headache	Stomach pain	School computer flow	Home computer flow	Computer anxiety
'Butterflies in your stomach'		-.074**	.179**	.202**	-.021	-.039	.117**
Enjoy going to school			-.050	-.040	-.114**	-.021	-.059*
Headache				.306**	.065*	.041	.063*
Stomach pain					-.004	-.026	.127**
Frequency of Computer Related Musculoskeletal Soreness							
School	.131**	-.025	.129**	.180**	-.018	.003	.052
Home	.158**	-.013	.182**	.207**	.004	-.016	.023

* = p<.05, ** = p<.001

7.4 RELATIONSHIPS BETWEEN SCHOOL AND HOME COMPUTER EXPOSURE AND SCHOOL AND HOME COMPUTER RELATED MSS

7.4.1 Relationships between computer exposure and *frequency* of Computer Related MSS

Hierarchical multiple linear regression analyses were used to determine whether computer exposure could be used to predict the *frequency* of Computer Related MSS in addition to individual and other user correlates. Data were examined to ensure analysis assumptions were met.

Step 1 included individual user correlates of age and gender. Step 2 included user correlates of pre-existing MSD, somatic complaints, computer anxiety and MVPA frequency. Step 3 included computer exposure measures of frequency, usual and longest duration of school and home computer use.

Across all participants, school and home computer exposure was found to significantly predict the frequency of School and Home Computer Related MSS, even after accounting for user correlates. Table 7.9 shows the results of the linear regression analysis for these relationships. The combination of all computer exposure measures (frequency, usual and longest duration) demonstrated a slightly stronger prediction of Computer Related MSS than using a single measure, with frequency of computer exposure usually the strongest single exposure measure.

Table 7.9 Relationships between user correlates, school and home computer exposure and School and Home Computer Related Musculoskeletal Soreness: Results of Linear Regression Analysis (3 step prediction model)

Exposure measures	Individual R square change (Step 1)	User correlates R square change (Step 2)	Exposure R square change (Step 3)	Overall R square	Model F and p
School Computer Related Musculoskeletal Soreness					
Frequency	.008*	.051**	.019**	.077**	10.18, <.001
Usual duration	.008*	.051**	.005*	.064**	8.22, <.001
Longest duration	.008*	.051**	.006*	.065**	8.35, <.001
Combined measures	.008*	.051**	.021**	.080**	8.54, <.001
Home Computer Related Musculoskeletal Soreness					
Frequency	.019**	.071**	.009*	.100**	13.24, <.001
Usual duration	.019**	.071**	.005*	.096**	12.65, <.001
Longest duration	.019**	.071**	.005*	.096**	12.66, <.001
Combined measures	.019**	.071**	.010*	.114**	11.77, <.001

Notes
Step 1 – individual correlates of age and gender
Step 2 – user correlates were pre-existing MSD, somatic complaints, computer anxiety, frequency of MVPA
Step 3 - exposure measures including frequency, usual and longest duration
* - significant R square, p<.05
** - significant R square, p<.001

7.4.2 Relationships between computer exposure and School and Home Computer Related MSS in specific *anatomical body locations*

Hierarchical multiple regression analyses were used to determine whether computer exposure could be used to predict Computer Related MSS in specific *anatomical body locations* in addition to individual and other user correlates. Data were examined to ensure analysis assumptions were met.

In hierarchal multiple regression analysis comparing participants experiencing Computer Related MSS in a specific *anatomical body location* to those participants without Computer Related MSS in the specific anatomical body location, school and home computer exposure were found to significantly predict Computer Related MSS in 3 step logistic regression models, even after accounting for general user and exposure correlates. Data were examined to ensure analysis assumptions were met.

Step 1 included individual user correlates of age and gender. Step 2 included reports of pre-existing MSD, somatic complaints (headache and stomach ache), computer anxiety and MVPA frequency. Step 3 included computer exposure measures of frequency, usual and longest duration of school and home computer use.

The correlates of age, gender, pre-existing MSDs, "butterflies in your stomach", and stomach pain were consistent predictors of MSS in nearly all anatomical body locations. Predictors were similar across the different anatomical body locations (neck, mid back, low back, left and right shoulder / arm, left and right elbow / hand) and when upper limb and lower limb locations were combined. Table 7.10 shows the odds ratios for age, gender, significant user correlates and exposure correlates for neck, low back, upper limbs and lower limbs. Usual and longest duration exposure measures were more discriminating in predicting anatomical body location of Computer Related MSS

Table 7.10 Relationships between user correlates, school and home computer frequency and School and Home Computer Related Musculoskeletal Soreness in specific anatomical body locations: Results of Logistic Regression Analysis (3 step prediction model)

Neck pain		
	OR	CI (95.0%)
School computer MSS (chi square 52.8, p<.001, Nagelkerke R square .141)		
Age	1.126	.964 – 1.317
Gender	2.425*	1.372 – 4.288
Pre-existing MSD	1.954*	1.067 – 3.579
Monthly "butterflies"	1.403*	1.088 – 1.810
Monthly Stomach pain	1.415*	1.082 – 1.850
Frequency of exposure	1.894**	1.338 – 2.682
Home Computer MSS (chi square 84.9, p<.001, Nagelkerke R square .147)		
Age	1.049	.937 – 1.175
Gender	2.432**	1.631 – 3.628
Monthly "butterflies"	1.311*	1.079 – 1.591
Monthly Stomach pain	1.506**	1.248 – 1.818
Frequency of exposure	1.823**	1.368 – 2.428
Low Back Pain		
	OR	CI (95.0%)
School Computer MSS (chi square 59.2, p<.001, Nagelkerke R square .195)		
Age	1.248*	1.026 – 1.518
Gender	2.709*	1.370 – 5.357
Pre-existing MSD	3.573*	1.580 – 8.077
Monthly Stomach pain	1.811**	1.355 – 2.419
Frequency of exposure	2.047**	1.350 – 3.104
Home Computer MSS (chi square 64.4, p<.001, Nagelkerke R square .126)		
Age	1.109	.976 – 1.261
Gender	1.460	.947 – 2.250
Monthly Stomach pain	1.735**	1.434 – 2.099
Frequency of exposure	1.901**	1.362 – 2.654
Upper limb Pain		
	OR	CI (95.0%)
School Computer MSS (chi square 43.4, p<.001, Nagelkerke R square .206)		
Age	.877	.699– 1.102
Gender	1.074	.439– 2.625
Monthly Stomach pain	1.995**	1.395 – 2.927
Frequency of exposure	2.499**	1.423 – 4.388
Home Computer MSS (chi square 37.8, p<.001, Nagelkerke R square .106)		
Age	.969	.828 – 1.135
Gender	1.207	.670 – 2.173
Monthly "butterflies"	1.458*	1.131 – 1.880
Monthly Stomach pain	1.495*	1.136 – 1.968
Frequency of exposure	1.522*	1.048 – 2.212
Lower Limb Pain		
	OR	CI (95.0%)
School Computer MSS (chi square 29.8, p<.001, Nagelkerke R square .183)		
Age	.920	.703 – 1.205
Gender	1.619	.572 – 4.584
Monthly Stomach Pain	1.702*	1.067 – 2.713
Frequency of exposure	2.789*	1.397 – 5.570
Home Computer MSS (chi square 31.0, p<.001, Nagelkerke R square .112)		
Age	.915	.756 – 1.109
Gender	.964	.471 – 1.974
Monthly Stomach pain	1.535*	1.110 – 2.122
Frequency of exposure	1.985*	1.149 – 3.431

Notes
Step 1 – individual correlates of age and gender
Step 2 – correlates were pre-existing MSD, somatic complaints (headache and stomach pain), 'stomach butterflies', computer anxiety, frequency of MVPA
Step 3 - exposure measures including frequency, usual and longest duration
* - significant R square, p<.05 ** - significant R square, p<.001

7.4.3 Relationships between computer exposure and the *intensity* of School and Home Computer Related MSS

Hierarchical multiple linear regression analyses were used to determine whether computer exposure could be used to predict the *intensity* of Computer Related MSS in addition to individual and other user correlates. Data were examined to ensure analysis assumptions were met.

Step 1 included individual user correlates of age and gender. Step 2 included user correlates of pre-existing MSD, somatic complaints, computer anxiety and MVPA frequency. Step 3 included computer exposure measures of frequency, usual and longest duration of school and home computer use. School and home computer frequency was used in this analysis as the exposure measure as this exposure measure was found to be the strongest predictor in this regression analysis.

In analysis of participants experiencing Computer Related MSS in a specific anatomical body location, as depicted by the 1 – 10 numerical rating scale for intensity of the MSS school and home computer exposures were found to *not* significantly predict the intensity of computer related MSS in 3 step linear regression models. Table 7.11 shows the results of analysis.

Table 7.11 Relationships between user correlates, school and home computer exposure and the intensity of School and Home Computer Related Musculoskeletal Soreness: Results of Linear Regression Analysis (3 step prediction model)

	Individual R square change (Step 1)	Correlates R square change (Step 2)	Exposure (frequency) R square change (Step 3)	Overall model R square	Overall Model F and p
School computer intensity of MSS					
Neck (n=59)	.109*	.283*	.003	.396*	3.42*
Low back (n=41)	.111	.459*	.001	.571*	4.44*
Mid back (n=29)	.065	.376	.027	.467	1.75
Lower limb (n=19)	.072	.522	.040	.634	1.54
Both upper limb (n=27)	.061	.337	.023	.420	1.29
Home computer intensity of MSS					
Neck (n=128)	.011	.061	.006	.077	1.07
Low back (n=101)	.058	.124*	.001	.182*	2.18*
Mid back (n=79)	.040	.147	.017	.204	1.91
Lower limb (n=37)	.026	.356*	.022	.405	1.96
Both upper limbs(n=60)	.009	.174	.038	.221	1.51

Notes
Step 1 – individual correlates of age and gender
Step 2 – correlates were pre-existing MSD, somatic complaints, anxiety, frequency of MVPA
Step 3 - exposure measures including frequency, usual and longest duration
* - significant R square, p<.05
** - significant R square, p<.001

7.4.4 Relationships between computer exposure and the *impact* of School and Home Computer Related MSS

Hierarchical multiple regression analyses were used to determine whether computer exposure could be used to predict the *impact* of Computer Related MSS in addition to individual and other user correlates. Data were examined to ensure analysis assumptions were met.

Step 1 included individual user correlates of age and gender. Step 2 included reports of pre-existing MSD, somatic complaints (headache and stomach ache), computer anxiety and MVPA frequency. Step 3 included computer exposure measures of frequency, usual and longest duration of school and home computer use.

In those participants reporting School and Home Computer Related MSS, the combination of user correlates and computer exposure correlates did *not* significantly predict MSS impact in 3 step logistic regression models for school or home computer exposure (school: chi square 4.0, p=.781, Nagelkerke R square .054; home chi square 17.7, p=.013, Nagelkerke R square .104).

Whilst the Nagelkerke R squared was larger in the final exposure step of each model, none of the computer exposure correlates significantly contributed to the prediction of Computer Related MSS impact after taking account of the user correlates. Due to smaller numbers of Computer Related MSS only the strongest two user correlates (other than age and gender), based on bivariate correlation, were included in each of the logistic regression models, see Table 7.12. Models using single computer exposure measures were weaker, and still not significant, for both school and home than models using all 3 computer exposure measures (frequency, usual and longest duration).

Table 7.12 Relationships between user correlates, school and home computer exposure and impact of School and Home Computer Related Musculoskeletal Soreness in specific anatomical body locations: Results of Logistic Regression Analysis (3 step prediction model)

	OR	CI (95.0%)
	School computer impact of MSS	
Age	0.940	0.739 – 1.195
Male gender	0.778	0.314 – 1.931
Pre-existing MSD	0.584	0.183 – 1.860
Monthly Stomach Pain	0.729	0.522 – 1.202
Frequency of exposure	1.383	0.788 – 2.427
Usual duration of exposure	0.945	0.486 – 1.839
Longest duration of exposure	0.729	0.347 – 1.532
	Home computer impact of MSS	
Age	0.919	0.772 – 1.093
Male gender	*0.528**	0.293 – 0.950
Pre-existing MSD	0.690	0.372 – 1.278
Monthly Stomach pain	*1.453**	1.102 – 1.917
Frequency of exposure	1.296	0.804 – 2.089
Usual duration	0.990	0.712 – 1.378
Longest duration	0.801	0.583 – 1.099

Notes
Step 1 – individual correlates of age and gender
Step 2 – correlates of pre-existing MSD, somatic complaints, computer anxiety, frequency of MVPA
Step 3 - exposure measures including frequency, usual and longest duration
* - significant R square, p<.05
** - significant R square, p<.001

7.5 SUMMARY OF RELATIONSHIPS BETWEEN SCHOOL AND HOME COMPUTER EXPOSURE AND COMPUTER RELATED MSS

10 - 20% of participants reported at least monthly Computer Related MSS with school and home computer exposure. Relationships were evident between all computer exposure measures and the frequency of School and Home Computer Related MSS, with further regression analysis showing all school and home computer exposure measures predicted frequency of School and Home Computer Related MSS.

Similarly, evidence for relationships between Computer Related MSS in specific anatomical body location and computer exposure was demonstrated. Regression analysis demonstrated computer exposure significantly predicted Computer Related MSS in body locations of neck, low back and upper limbs.

In regards to intensity and impact of Computer Related MSS, analysis did not show a significant predictive relationship with computer exposure. Descriptive statistics demonstrated that up to 30% of participants with Computer Related MSS reported limiting their activity, with nearly 10% taking medication and 7% seeking a health professional practitioner.

The following chapter further explores objective 8 of the study by reporting findings of MSS related to participant's exposure to other activities.

8.0 Results – Relationships between Other Activity Exposure and Musculoskeletal Outcomes

The aim of this chapter is to describe the analyses used to examine the relationships between other activity exposure and musculoskeletal outcomes. To further explore objective 8 of this study (characterization of musculoskeletal outcomes) the musculoskeletal outcomes measured in this chapter also included frequency of soreness, location of soreness, intensity of soreness and impact of soreness. Other activities included in this chapter include electronic games, sedentary activities (watching TV, reading, writing, using a mobile phone and playing musical instruments) and MVPA. The results included in this chapter are both descriptive statistics and inferential statistics.

This chapter is divided into 4 sections. Firstly an overview of the musculoskeletal outcomes associated with other activity exposure is presented including frequency of sedentary activity (watching TV, reading, writing, using mobile phones and playing musical instruments) musculoskeletal soreness, known as Other Sedentary Activity Related MSS, and frequency of MVPA musculoskeletal soreness, known as MVPA Related MSS. Sections 2 and 3 report results of analysis demonstrating the relationships between user correlates (including age and gender) and Other Activity Related Musculoskeletal Soreness (MSS). Finally, Section 4 shows further analysis of the frequency of musculoskeletal soreness associated with electronic game exposure, which is referred to as Electronic Games Related MSS within the thesis. Logistic and linear regression analyses to investigate the relationship between electronic games exposure and related musculoskeletal outcomes were undertaken as electronic games had been shown in the literature review (Chapter 2) to have similar patterns of exposure and relationships with MSS as computer use. It was also evident that previous studies have included electronic games in their IT exposure studies (Olds *et al.*, 2006, Ramos *et al.,* 2005, Rideout *et al.,* 2010).

This chapter informs an understanding of the relationships between children's exposure to other activities and other activity related musculoskeletal outcomes. The results shown in this chapter help identify potential risk factors for children's computer related musculoskeletal outcomes. These results assist in meeting objective 10 of the study by identifying correlates for the final models tested in Chapter 9 of the study.

8.1 GENERAL OVERVIEW - RELATIONSHIPS BETWEEN OTHER ACTIVITY EXPOSURE AND OTHER ACTIVITY RELATED MSS

The following section shows a general overview of results for the relationships between other activity exposure and related musculoskeletal outcomes of frequency of musculoskeletal soreness, location of musculoskeletal soreness, intensity of musculoskeletal soreness and impact of musculoskeletal soreness.

8.1.1 Frequency of Other Activity Related MSS

8.1.1.1 Overview - Frequency of Other Activity Related MSS

63. 4% of participants reported experiencing MSS at least monthly with moderate vigorous physical activity (MVPA), 21.1% of participants with electronic game use, and 21.8% with sedentary activities (including watching TV, reading, writing, using a mobile phone and playing musical instruments). Table 8.1 shows the frequency of MSS with other activity exposure.

Table 8.1 Percentage (n) of participants reporting musculoskeletal soreness with other activities exposure

	Frequency of musculoskeletal soreness			
Activity type	Monthly	Weekly	2 – 3 x Week	Daily
Electronic games	12.9 (107)	5.2 (43)	1.8 (15)	1.2 (10)
Sedentary Activities	10.2 (133)	5.6 (73)	3.6 (47)	2.5 (32)
MVPA	23.1 (257)	23.9 (266)	11.6 (129)	4.9 (54)

8.1.1.2 Relationships between the frequency's of Other Activity Related MSS

The frequency of Other Activity Related MSS was correlated with each other for all activities, as well as school and home computer exposure (as shown in Chapter 7). Table 8.2 shows Spearman's rho correlations for these relationships.

Table 8.2 Spearman's rho correlations of frequency of Other Activity Related MSS

	MSS frequency				
MSS frequency	School computer	Home computer	Electronic games	Sedentary Activities	MVPA
Electronic games	.326(**)	.443(**)		.314(**)	.217(**)
Sedentary Activities	.300(**)	.343(**)	.314(**)		.141(**)
MVPA	.189(**)	.191(**)	.217(**)	.141(**)	

* = p<.05, ** = p<.001

8.1.1.3 Relationships between frequency of Other Activity Related MSS and other activity exposure

Frequency of Other Activity Related MSS was associated with frequency and duration exposures of some other activities. Table 8.3 shows the Spearman's rho correlations for these results. Frequency of Electronic Games Related MSS was positively correlated with electronic games exposure (frequency, usual and longest durations) indicating greater soreness with greater exposure.

Frequency of Other Sedentary Activity Related MSS was positively correlated with mobile phones and musical instrument exposure (frequency, usual and longest durations) indicating greater soreness with greater exposure. Frequency of Other Sedentary Activity Related MSS was positively correlated with writing and drawing longest duration only, and was not associated with TV/DVD watching for any exposure.

Frequency of MVPA Related MSS was positively correlated with MVPA exposure (frequency, usual and longest durations) indicating greater soreness with greater exposure.

Table 8.3 Spearman's rho correlations of relationships between Other Activity Related Musculoskeletal Soreness and other activity exposure

	Activity						
Frequency of MSS	Electronic games	TV / DVDs	Writing / drawing	Reading books	Mobile phones	Musical instrument	MVPA
			Frequency of exposure				
Electronic games	.114**	.057	.054	.049	-.019	-.045	.073*
Other sedentary activities	.007	.049	.044	.009	.070*	.131**	-.088**
MVPA	.002	.037	-.006	.-.053	.098**	-.016	.216**
			Usual duration of exposure				
Electronic games	.121**	.073*	.010	.033	.005	-.051	.007
Other sedentary activities	.052	.025	.047	.040	.086**	.127**	-.022
MVPA	.078*	.034	.048	-.025	.095**	.008	.220**
			Longest duration of exposure				
Electronic games	.091**	.096**	.033	.054	.026	-.041	.003
Other sedentary activities	.044	.051	.089**	.057*	.079**	.125**	-.024
MVPA	.037	.070*	.036	.003	.053	.014	.187**

* = p<.05, ** = p<.001

8.1.2 Anatomical body locations for Other Activity Related MSS

The most prevalent body locations for Other Activity Related MSS over the last month were the neck and low back for both electronic games and sedentary activities. In contrast, lower limbs, low back and right arm locations were reported to be the most prevalent locations of MVPA Related MSS. Table 8.4 shows the prevalence of Other Activity Related MSS in each of the 8 body locations as shown by the percentage of participants (n) reporting soreness at these locations.

Table 8.4 Percentage of participants (n) reporting Other Activity Related Musculoskeletal Soreness in each anatomical body location

	Anatomical body locations							
Activity	Neck	Mid back	Low back	Left shoulder / arm	Left elbow / hand	Right shoulder / arm	Right elbow / hand	Lower limbs
Electronic games	6.9 (93)	4.1 (55)	5.4 (73)	2.5 (35)	3.1 (42)	2.4 (33)	3.7 (50)	2.6 (35)
Sedentary activities	10.9 (147)	8 (107)	8.7 (118)	4.8 (65)	5.3 (71)	5.6 (76)	6.5 (88)	5.9 (79)
MVPA	11.4 (154)	11.8 (159)	14.9 (202)	13.5 (182)	5.5 (75)	14.7 (199)	6.8 (91)	34.4 (465)

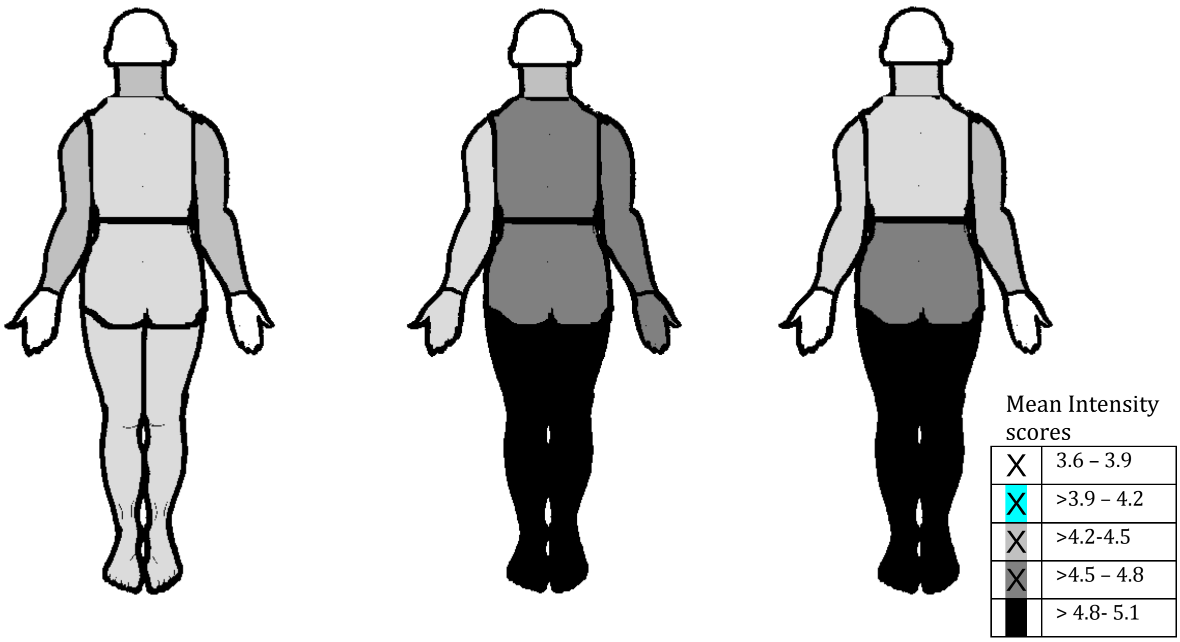
8.1.3 Intensity of Other Activity Related MSS

Intensity of musculoskeletal soreness for other activity exposure was recorded by participants using a numerical rating scale of 0 (no soreness) – 10 (extreme soreness). This numerical rating scale was used for each of the 8 body locations. The mean intensity score for each body location is shown in Table 8.5. Other Activity Related MSS mean intensity scores ranged from 3.8 to 5.0.

The highest mean score for Electronic Game Related MSS was 4.5 for right shoulder / arm. The highest mean scores for Sedentary Activity and MVPA were 4.9 and 5.0 for lower limb respectively. See Figure 8.1 for anatomical body map locations of intensity of MSS for each of the activities.

Table 8.5 Mean scores for intensity of Other Activity Related Musculoskeletal Soreness for each anatomical body location

	Anatomical body locations							
Activity	Neck	Mid back	Low back	Left shoulder / arm	Left elbow / hand	Right shoulder / arm	Right elbow / hand	Lower limbs
Electronic games	4.3	4.1	4.0	4.2	4.3	4.5	4.2	4.2
Sedentary activities	4.3	4.6	4.6	4.3	4.0	4.7	4.3	5.0
MVPA	4.2	4.1	4.6	4.2	3.9	4.4	3.8	4.9



Electronic Games | Sedentary Activities | MVPA

Figure 8.1 Anatomical body maps showing the prevalence of intensity of MSS for each activity

8.1.4 Impact of Other Activity Related MSS

Participants indicated the impact of Other Activity Related MSS by reporting any or all of the following behaviours; limiting participation in their activity, taking medication and consulting a treating practitioner. Participation limitation was reported more commonly for all activities than the other behaviours, see Table 8.6 for percentage of participants reporting different behaviours. Taking medication and consulting a treating health practitioner were reported more commonly by participants experiencing MVPA Related MSS.

Table 8.6 Percentage of participants (n) reporting impact of Other Activity Related MSS

MSS	Impact		
	Limit participation	Medication taken	Treating health practitioner consult
Electronic games	44.3 (78)	8.5 (15)	4.1 (7)
Sedentary activities	37.7 (103)	12.4 (34)	10.7 (29)
MVPA	25.6 (180)	15.1 (106)	18.3 (127)

The impact of Other Activity Related MSS was correlated with each other. See Table 8.7 for Spearmans rho correlations between the numbers of behaviours performed by participants for each activity.

Table 8.7 Spearman's rho correlations of relationships between the number of impact behaviours of Other Activity Related Musculoskeletal Soreness for electronic games, sedentary activities and MVPA

Impact of MSS	Electronic games	Sedentary activities	MVPA
Electronic games			
Sedentary activities	.485**		
MVPA	.245**	.354**	

* = p<.05, ** = p<.001

Impact of Other Activity Related MSS were correlated to frequency of Other Activity Related MSS ($r_{s=}$.249 p<.001), and frequency of MVPA Related MSS ($r_{s=}$.224 p<.001), but not correlated to frequency of Electronic Games Related MSS ($r_{s=}$.306 p=.107).

Correlations between the 3 behaviours measuring impact of MSS and electronic game and MVPA exposure measures were not significant except for electronic games impact and longest duration ($r_{s=}$-.155 p<.05), and MVPA impact and frequency ($r_{s=}$.102 p<.001), and usual duration ($r_{s=}$.092 p<.05). Table 8.8 shows these Spearman's rho correlations. Given that one of the 3 behaviours demonstrating the impact of MSS is activity limitation these results are therefore not surprising.

Table 8.8 Spearman's rho correlations of relationships between other activity exposures and the number of behaviours measuring impact of Other Activity Related Musculoskeletal Soreness

Activity exposure	Impact of MSS
Electronic games	
Frequency	-.131
Usual duration	-.118
Longest duration	-.155*
MVPA	
Frequency	.102**
Usual duration	.092*
Longest duration	.015

* = p<.05, ** = p<.001

In summary, Activity Related MSS were experienced by approximately 20% of participants for sedentary activity and electronic games and nearly two thirds of participants for MVPA. Similar to results for school and home computers, Activity Related MSS was usually associated with greater activity exposure, was experienced in body locations of neck, back and upper limbs, but also included lower limbs for MVPA. These results were also reflected with the intensity ratings participants reported for each of these body locations. The impact of the Activity Related MSS demonstrated that participants limited their activity and sought health professional treatment. These results once again demonstrate the importance of using a range of outcome measures to better characterize and understand the impact of Activity Related Outcomes in children.

8.2 RELATIONSHIPS BETWEEN OTHER ACTIVITY RELATED MSS AND USER CORRELATES OF AGE AND GENDER

8.2.1 Relationship between frequency of Other Activity Related MSS and age

Frequency of Other Activity Related MSS was positively correlated with age for sedentary activities (r= .069, p=.012) and MVPA (r=.075, p =.012). Frequency of Other Activity Related MSS was negatively correlated with age for electronic game use (r = -.130 p<0.001). This relationship could be associated with electronic game exposure peaking with younger participants.

When split for gender, girls had a positive correlation with age for frequency of MSS with sedentary activities (r= .140 p= .001) and a negative association with electronic games (r = -.133 p=.037). Boys were found to have a positive correlation with age and frequency of MSS with MVPA (r= .091, p=.020), and a negative association with electronic games (r = -.125 p<0.001).

8.2.2 Relationship between frequency of Other Activity Related MSS and gender

A greater frequency of Other Sedentary Related MSS was associated with girls ($X_{(4)}$ = 9.8, p=.041). When split for Year level this was evident in Year 6 ($X_{(4)}$ = 9.6, p=.047) and Year 11 ($X_{(4)}$ = 15.2, p=.004). Frequency of MVPA Related MSS was associated with gender ($X_{(4)}$ = 12.6, p=.013) with a greater frequency of soreness reported by boys. . When split for Year level this was evident in Year 9 ($X_{(4)}$ = 11.6, p=.020) and Year 11 ($X_{(4)}$ = 11.4, p=.022).

There was no association between gender and frequency of Electronic Game Related MSS.

8.3 RELATIONSHIPS BETWEEN OTHER ACTIVITY RELATED MSS AND OTHER USER CORRELATES

User correlates discussed in this section include 'butterflies in your stomach', enjoyment of going to school, pre-existing MSD, headache and stomach pain. Results are shown for the relationship between these user correlates and Other Activity Related MSS.

Table 8.9 shows Spearman's rho correlations for relationships between frequency of Electronic Games, Other Sedentary Activity and MVPA Related MSS and user correlates. In summary, Electronic Games, Other Sedentary Activity and MVPA Related MSS were positively correlated with 'butterflies in your stomach', headache and stomach pain indicating a greater frequency of Other Activity Related MSS was associated with greater frequency of other complaints ($.080<r_s<.234$ $p<0.001$). A negative correlation was evident for frequency of MVPA Related MSS and enjoyment going to school, indicating a greater frequency of MSS with less enjoyment with school.

A history of pre-existing MSDs was associated with increased frequency of Activity Related MSS for Electronic Games Related MSS ($X_{(4)}$ = 16.9, p=.002), Other Sedentary Activity Related MSS ($X_{(4)}$ = 33.3, p<.001) and MVPA Related MSS ($X_{(4)}$ = 106.9, p<.001), indicating a history of MSD's was associated with greater frequency of Other Activity Related MSS.

Table 8.9 Spearman's rho correlations of relationships between user correlates and Other Activity Related Musculoskeletal Soreness

	User Correlates			
Frequency of Other Activity Related MSS	"Butterflies in your stomach"	Enjoy going to school	Headache	Stomach pain
Electronic games	.106(**)	.033	.139(**)	.234(**)
Sedentary activities	.125(**)	-.031	.182(**)	.162(**)
MVPA	.080(**)	-.064(*)	.144(**)	.188(**)

* = p<.05, ** = p<.001

8.4 RELATIONSHIPS BETWEEN ELECTRONIC GAMES EXPOSURE AND ELECTRONIC GAMES RELATED MSS

8.4.1 Relationships between electronic games exposure and Electronic Games Related MSS

Hierarchical multiple linear regression analyses were used to determine whether electronic games exposure could be used to predict the *frequency* of Electronic Games Related MSS in addition to individual and other user correlates. Data were examined to ensure analysis assumptions were met.

Step 1 included individual user correlates of age and gender. Step 2 included user correlates of pre-existing MSD, somatic complaints, computer anxiety and MVPA frequency. Step 3 included electronic games exposure measures of frequency, usual and longest duration.

Electronic games exposure was found to significantly predict the frequency of Electronic Games Related MSS, even after accounting for user correlates, see Table 8.10 for these results. The combination of all exposure measures (frequency, usual and longest duration) demonstrated a stronger prediction of Electronic Games Related MSS, with usual duration being the slightly stronger single exposure measure.

Table 8.10 Relationships between user correlates, electronic games exposure and Electronic Games Related Musculoskeletal Soreness: Results of Linear Regression Analysis (3 step prediction model)

Exposure measure	Individual R square change (Step 1)	Health R square change (Step 2)	Exposure R square change (Step 3)	Overall R square	Model F, p
Electronic Games Related Musculoskeletal Soreness					
Combined measures	.012*	.108**	.028**	.147**	12.17, <.001
Frequency	.012*	.108**	.019**	.139**	14.02, <.001
Usual duration	.012*	.108**	.020**	.140**	14.03, <.001
Longest duration	.012*	.108**	.015**	.134**	13.45, <.001

Notes
Step 1 – individual correlates of age and gender
Step 2 – user correlates were pre-existing MSD, somatic complaints, computer anxiety, frequency of MVPA
Step 3 - exposure measures including frequency, usual and longest duration
* - significant R square, p<.05
** - significant R square, p<.001

8.4.2 Relationships between electronic game exposure and Electronic Game Related MSS in specific *anatomical body locations*

Hierarchical multiple regression analyses were used to determine whether electronic games exposure could be used to predict the Electronic Games Related MSS in specific *anatomical body locations* in addition to individual and other user correlates. Data were examined to ensure analysis assumptions were met.

Predictors were consistent across the different locations (neck, mid back, low back, left and right shoulder / arm, left and right elbow / hand) and when upper limb and lower limb locations were combined.

Step 1 of the analyses included individual user correlates of age and gender. Step 2 included reports of pre-existing MSD, somatic complaints (headache and stomach ache), computer anxiety and MVPA frequency. Step 3 included the computer exposure measure of frequency of electronic game use. Table 8.11 shows the odds ratios for age, gender, user correlates and exposure correlates for neck, low back, upper limbs and lower limbs.

Table 8.11 Relationships between user correlates, electronic games frequency and Electronic Games Related Musculoskeletal Soreness in specific anatomical body locations: Results of Logistic Regression Analysis (3 step prediction model)

Neck pain		
	OR	CI (95.0%)
Electronic Games Related MSS (chi square 93.5, p<.001, Nagelkerke R square .192)		
Age	.878*	.775 - .996
Gender	1.430	.826 – 2.477
Pre-existing MSD	1.996*	1.195 – 3.334
Monthly Stomach pain	1.776**	1.438 – 2.192
Frequency of exposure	1.787**	1.458 – 2.191
Low Back Pain		
	OR	CI (95.0%)
Electronic Games Related MSS (chi square 64.9, p<.001, Nagelkerke R square .156)		
Age	.944	.821 – 1.084
Gender	1.299	.705 – 2.395
Pre-existing MSD	1.864*	1.055 – 3.293
Monthly Stomach pain	1.716**	1.368 – 2.153
Frequency of exposure	1.740**	1.392 – 2.175
Upper limb Pain		
	OR	CI (95.0%)
Electronic Games Related MSS (chi square 86.5, p<.001, Nagelkerke R square .218)		
Age	.764*	.656 - .891
Gender	1.201	.617 – 2.341
Pre-existing MSD	2.563*	.1.328 – 4.948
Monthly Stomach pain	1.655**	1.281 – 2.138
Lower Limb Pain		
	OR	CI (95.0%)
Electronic Games Related MSS (chi square 40.9, p<.001, Nagelkerke R square .160)		
Age	.852	.696 – 1.042
Gender	1.655	.694 – 3.944
Monthly Stomach pain	1.888**	1.372 – 2.596
Frequency of exposure	1.552*	1.134 – 2.123

Notes
Step 1 – individual correlates of age and gender
Step 2 – correlates were pre-existing MSD, somatic complaints, computer anxiety, frequency of MVPA
Step 3 - exposure measures including frequency
* - significant R square, p<.05
** - significant R square, p<.001

8.4.3 Relationships between electronic games exposure and the *intensity* of Electronic Games Related MSS

Hierarchical multiple linear regression analyses were used to determine whether electronic games exposure could be used to predict the *intensity* of Electronic Games Related MSS in addition to individual and other user correlates. Data were examined to ensure analysis assumptions were met.

Step 1 included individual user correlates of age and gender. Step 2 included user correlates of pre-existing MSD, somatic complaints, computer anxiety and MVPA frequency. Step 3 included electronic games exposure measures of frequency.

In analysis of participants experiencing Electronic Games Related MSS in a specific anatomical body location, as depicted by the 1 -10 numerical rating scale for the intensity of MSS, electronic game exposure was found to *not* significantly predict the intensity of Electronic Games Related MSS in 3 step linear regression models. Table 8.12 shows the results of these analyses.

Table 8.12 Relationships between user correlates, electronic game exposure and the intensity of Electronic Games Related Musculoskeletal Soreness: Results of Linear Regression Analysis (3 step prediction model)

	Individual R square change (Step 1)	Covariates R square change (Step 2)	Exposure (frequency) R square change (Step 3)	Overall model R square	Overall Model F and p
Electronic games intensity of MSS					
Neck (n=93)	.024	.153*	.000	.177	1.89, =.006
Low back (n=73)	.019	.205*	.031	.254*	2.28, =.029
Mid back (n=55)	.112*	.300*	.005	.417*	3.42, =.003
Lower limb (n=35)	.038	.173	.011	.221	.726, =.081
Both upper limbs(n=69)	.140*	.096	.026	.262*	2.21, =.034

Notes
Step 1 – individual correlates of age and gender
Step 2 – correlates were pre-existing MSD, somatic complaints, anxiety, frequency of MVPA
Step 3 - exposure measures including frequency, usual and longest duration
* - significant R square, p<.05
** - significant R square, p<.001

8.4.4 Relationships between electronic games exposure and the *impact* of Electronic Games Related MSS

Hierarchical multiple regression analyses were used to determine whether electronic games exposure could be used to predict the *impact* of Electronic Games Computer Related MSS in addition to individual and other user correlates. Data were examined to ensure analysis assumptions were met.

Step 1 of the analyses included individual user correlates of age and gender. Step 2 included reports of pre-existing MSD, somatic complaints (headache and stomach ache), computer anxiety and MVPA frequency. Step 3 included the computer exposure measure of frequency, usual and longest duration of electronic game use.

In those participants reporting Electronic Game Related MSS the combination of user correlates and exposure correlates did *not* significantly predict MSS impact in 3 step logistic regression models for electronic game exposure (chi square 11.8, p=.108, Nagelkerke R square .099). Whilst the Nagelkerke R squared was larger in the final exposure step of each model, none of the electronic game exposure correlates significantly contributed to the prediction of Electronic Games Related MSS impact after taking account of user correlates. Due to smaller numbers of Electronic Games Related MSS in each location, only the strongest two user correlates, based on bivariate correlation, were included in each of the logistic regression models, as shown in Table 8.13. Models using single electronic games exposure measures were weaker for all activities than models using all 3 electronic games exposure measures (frequency, usual and longest duration).

Table 8.13 Relationships between user correlates, electronic games frequency and the impact of Electronic Games Related Musculoskeletal Soreness in specific anatomical body locations: Results of Logistic Regression Analysis (3 step prediction model)

Electronic games impact of MSS	OR	CI (95.0%)
Age	0.955	0.789 – 1.157
Male gender	***2.244****	1.003 – 5.020
Pre-existing MSD	1.153	0.548 – 2.426
Monthly Stomach pain	1.079	0.776 – 1.500
Frequency of exposure	0.983	0.650 – 1.487
Usual duration of exposure	1.169	0.757 – 1.804
Longest duration of exposure	0.706	0.473 – 1.053

Notes
Step 1 – individual correlates of age and gender
Step 2 – correlates of pre-existing MSD, somatic complaints, computer anxiety, frequency of MVPA
Step 3 - exposure measures including frequency, usual and longest duration
* - significant R square, p<.05
** - significant R square, p<.001

8.5 SUMMARY OF RELATIONSHIPS BETWEEN OTHER ACTIVITY EXPOSURE AND OTHER ACTIVITY RELATED MSS

The results from this chapter demonstrated that the majority of participants had experienced Other Activity Related MSS, with nearly two thirds of participants having reported MVPA Related MSS. Additionally, approximately 20% of participants reported MSS with electronic games and other sedentary activities exposure. These findings are similar to Home Computer Related MSS findings.

Relationships were evident between all electronic games exposure measures and the frequency of Electronic Game Related MSS, with further regression analysis showing all exposure measures predicted frequency of Electronic Games Related MSS. Similarly, evidence for a relationship between Electronic Games Related MSS in specific anatomical body locations and electronic games exposure was demonstrated. Regression analysis demonstrated exposure significantly predicted Electronic Games Related MSS in body locations of neck, low back and upper and lower limbs.

Similarly to computer exposure, further analysis did not show a predictive relationship with exposure and the intensity and impact of Electronic Games Related MSS. Descriptive statistics did however demonstrate that up to 45% of participants reported limiting their electronic game activity due to Electronic Games Related MSS, with nearly 10% taking medication and 4% seeking a health professional practitioner.

The next chapter reports results related to the main aim of the study by testing the proposed children's model of potential risk factors associated with Computer Related MSS.

9.0 Results – Pathway model of relationships between user correlates, computer exposure and musculoskeletal outcomes

This chapter discusses the results related to the main aim of this study by testing models to investigate the relationships between correlates associated with computer related musculoskeletal soreness in children. The final models tested in this chapter have been modified from the proposed model shown in the literature review (Section 2.4.6, page 46). The proposed model was initially modified on the basis of this study's preliminary findings (results as discussed in the preceding Chapters 4 – 8), and limitations with two measures. Furthermore, given the significant findings of different relationships between children's computer exposure patterns at school and home (see Chapter 4), two models were developed and tested, with one model for school computer exposure and the other model for home computer exposure. These two modified models were then further refined using path analysis to develop two final models.

Chapter 9 is divided into 3 sections. Firstly, the modified school and home computer exposure models are discussed, covering selection and use of model correlates including user and other activities, and the outcome variables of computer exposure and Computer Related MSS. Section two shows results for the initial path analysis of the modified school and home computer exposure models. Given results from this initial testing the final refined models were developed for school and home computer exposure these results are shown in Section three. Data preparation was performed using StataIC Version 10.1 for Windows (Statacorp LP, College Station TX) with subsequent path analysis performed with MPlus Version 5.21 (Muthén & Muthén, 2007).

9.1 MODIFIED MODELS OVERVIEW

The modified models discussed in this section were developed from the proposed model as shown in Section 2.4.6, page 46, this study's preliminary findings (results as discussed in the preceding Chapters 4 – 8), and due to limitations with two correlate measures.

Given the preliminary results, two modified models were developed and tested in the study, one model for school computer exposure, and the other for home computer exposure. As shown in Chapter 4, computer exposure patterns differed in school and home environments. These differences included the amount and nature of the computer exposure and the activity and social aspects of school and home computer environments.

This section discusses the selection and use of the modified model variables including user correlates and computer exposure and musculoskeletal outcome variables.

9.1.1. User and other activity correlates

User and other activity correlates used within the school and home computer exposure models are discussed within this section. Correlates have been included in the modified models due to evidence from the literature and / or preliminary analysis demonstrating a relationship between these correlates and the outcome variables of computer exposure and / or Computer Related Musculoskeletal Soreness (MSS).

In summary, literature discussed in Chapter 2 of this thesis has demonstrated that the correlates of gender, age, BMI, MVPA, other sedentary activities (electronic games and TV watching), psychological correlates (flow and computer anxiety), somatic complaints (headache and stomach pain), NSES, and children's computer environments (physical, social and location) were associated with children's computer exposure and / or computer related MSS in children. Additionally, preliminary statistical analysis, as discussed in Chapters 4 to 8, has provided further evidence for specific relationships.

1. *Age* and *gender* within this study, and as supported by recent literature, have been found to be related to the amount and nature of computer exposure, with an increase in exposure with age (Kent & Facer, 2004; Ramos *et al*., 2005; Roberts *et al*., 2005; Wake *et al*., 2005; Hardy *et al*., 2006; Marshall *et al*., 2006; Olds *et al*., 2006; Olds *et al*., 2008; Sommerich *et al*., 2007; Rideout, 2010) and different exposure patterns depending on gender (Kent and Facer 2004; Ramos *et al*., 2005; Wake *et al*., 2005; Willoughby, 2005; Burke *et al*., 2006; Olds *et al*.,

2006; Chou and Tsai, 2007; Mathers *et al*., 2009). Age *an*d gender were also found to interact in their association with reports of computer related musculoskeletal outcomes, with older females more likely to report outcomes. Age and gender were thus included in the modified models.

2. Within the analysis of this study *BMI* was *not* found to have a statistically significant relationship with computer exposure or musculoskeletal outcomes. However recent literature indicates that increased BMI and obesity in children may be linked to sedentary behaviors such as computer exposure (Wake *et al*., 2005; Olds *et al.,* 2006) and so BMI was included in both modified models.

3. Recent literature has shown the continued prevalence of *TV watching* in children's lives (Rideout *et al.*, 2010). Additionally, heavy users of one type of IT have been found to be heavy users of other IT (Roberts *et al.*, 2005). TV watching was found within this study to have moderate correlations with the frequency of school computer use and the frequency and duration of home computer use, and similar exposure patterns to home computer exposure. TV frequency and duration were therefore included in the modified models.

4. Previous literature has reported concerns with computer exposure displacing *MVPA* (Marshall *et al*., 2004; Biddle *et al*., 2009). Preliminary analysis within this study demonstrated mixed findings, with negative and positive correlations existing depending on the measures of frequency or duration of exposure used. Given this, MVPA was included in the modified models.

5. Somatic complaints *(headache and stomach pain*) within recent literature have been used as measures of children's psychological health (Hamer *et al*., 2009). Additionally, their role in influencing musculoskeletal symptoms reports have been shown in recent literature (Crombez *et al.,* 2000). Somatic complaints within this study have been shown to be related to increased computer exposure and computer related musculoskeletal outcomes and were therefore included in the modified models.

6. *Computer anxiety* has been reported to be associated with computer exposure (Rozell *et al.,* 1999; Arrowsmith, 2002) and this study has demonstrated similar findings with participants demonstrating reduced exposure with more anxiety. Computer anxiety was thus included in the modified models.

7. Children's sustained attention (*flow*) has been reported to be positively associated with computer exposure (Webster *et al.,* 1993; Arrowsmith, 2002). Within this study flow was associated with both school and home computer exposure measures of frequency and duration. Flow was therefore included in the modified models.

8. Literature has presented issues of a digital divide with access to computers for children (Lowe, 2003; Calvert *et al.*, 2005; Roberts et al., 2005). Within this study, *NSES* was associated with the amount and nature of school and home computer exposure. NSES was thus included in the modified models.

The literature review presented in Chapter 2 also showed relationships between computer exposure and social correlates, such as who is with the child when using computers, and influence of parental support, involvement and regulation (Orleans and Lacey, 2000; Kent and Facer, 2004; Olson *et al*., 2007; Vekiri, 2010). Additionally the physical computer environment, in terms of equipment and physical work station set up, was shown to influence children's exposure and musculoskeletal outcomes (Oates *et al*., 1998; Gillespie, 2002; Straker *et al.,* 2002). These correlates however, were not tested within the model, as the survey measures used in the study were not able to adequately characterize these correlates.

9.1.2 Computer exposure variables

Literature reported in Chapter 2 demonstrated that measures of frequency, usual duration and longest duration have previously been used to define computer exposure. Preliminary analysis in Chapter 4 showed relationships between the four exposure measures (mean weekly hours, frequency, usual and longest durations) and the reported correlates. Additionally, frequency was shown to have consistent significant relationships with correlates and usual and longest duration measures were often shown to represent similar exposure patterns when related to children's computer use.

As discussed in the literature review, musculoskeletal outcomes have been reported in children when using computers more frequently and for longer durations (Harris, 2000; Jacobs and Baker, 2002; Coleman, 2009). Frequency and duration measures for computer use are thus both thought to be important for characterizing risk associated with the computer exposure (Gillespie, 2002). A task performed frequently or a task performed for a long duration, are independently potential risk factors. However if the exposure to the risk factor is combined, (eg a frequent task for longer durations) then the risk is thought to be significantly greater than that due to a single independent variable exposure (IAPA, 2007). As exposure literature has recommended the use of more than one estimate for an exposure profile (Hagberg, 1991) and as frequency and duration were found to both be clearly important to describe computer exposure patterns in the current study, a parsimonious solution for modeling was to construct an outcome exposure correlate using both measures.

The computer exposure measure used for both school and home models was derived from the measures of monthly frequency and usual duration. Four categories were developed and included low risk (LOW), moderately low risk (MODLOW), moderate risk (MOD) and high risk (HIGH). Table 9.1 shows how these risk categories were defined.

Table 9.1 Computer exposure risk categories

	Monthly usual duration				
Monthly frequency	< 30 minutes	30-60 minutes	1-2 hours	2-5 hours	>5 hours
Not at all	LOW	LOW	LOW	LOW	LOW
1 x month	LOW	LOW	MODLOW	HIGH	HIGH
1 x week	LOW	LOW	MODLOW	HIGH	HIGH
2 –3 x week	MODLOW	MOD	MOD	HIGH	HIGH
Daily	MODLOW	MOD	MOD	HIGH	HIGH

The number of study participants allocated to each computer exposure risk category (based on their frequency and duration of school and home computer exposure) is shown in Table 9.2.

Table 9.2 Percentage (n) of participants within school and home computer exposure risk categories

Computer exposure categories	School computer exposure %(n) of participants	Home computer exposure %(n) of participants
Low risk	41.1 (433)	13.5 (141)
Moderately low risk	15.5 (163)	10.7 (112)
Moderate risk	41.6 (438)	52.7 (549)
High risk	1.8 (19)	23.0 (240)
Total	100.0(1053)	100.0(1042)

9.1.3 Relationships between user correlates and computer exposure

As discussed in section 9.1.1, and preliminary analysis (Chapter 6), user correlates of gender, age, BMI, TV exposure, MVPA exposure, somatic complaints, computer anxiety, flow and NSES have evidence of a relationship to school and home computer exposure. As these correlates were deemed to be measured adequately with this study's large scale survey, these correlates were further tested via regression analysis for modeling purposes. Table 9.3 shows the relationships between the correlates and the constructed outcome variable of computer exposure, for school and home computer. Coefficients are reported as unadjusted, and adjusted for all other correlates except BMI, as BMI was found to have no relationships with the dependent variables in preliminary analysis. Models for computer exposure were developed using linear regression for the ordinal outcome (dependent) variable of computer exposure.

Table 9.3 The relationships between user correlates and school and home computer exposure: Unstandardised (linear regression) unadjusted and adjusted for other listed correlate coefficients

	School Computer Exposure (n= 1053)			Home Computer Exposure (n=1042)		
	Co-efficient	t-score	p-value	Co-efficient	t-score	p-value
Female gender	-0.042	-1.37	0.169	-0.071*	-2.31	0.021
Adjusted	-0.020	-0.35	0.727	-0.023	-0.43	0.666
Age	0.081**	5.23	<0.001	0.142**	9.54	<0.001
Adjusted	0.094**	6.10	<0.001	0.142**	9.79	<0.001
BMI	0.006	0.20	0.841	0.010	0.29	0.770
TV frequency	0.134*	3.42	0.001	0.198**	5.22	<0.001
Adjusted	0.082*	2.03	0.043	0.089*	2.41	0.016
TV usual duration	0.087*	3.46	0.001	0.206**	8.48	<0.001
Adjusted	0.058*	2.19	0.029	0.131**	5.31	<0.001
Flow	-0.015**	-4.87	<0.001	-0.017**	-5.71	<0.001
Adjusted	-0.016**	-5.28	<0.001	-0.017**	-5.91	<0.001
Computer anxiety	-0.004	-1.35	0.176	-0.014**	-4.97	<0.001
Adjusted	-0.001	-0.41	0.682	-0.012**	-4.51	<0.001
NSES[1]	0.148**	4.24	<0.001	-0.127**	-4.05	<0.001
Adjusted	0.162**	4.69	<0.001	-0.087*	-3.02	0.003

** < .001, * < .05

[1] NSES scores used are /100, due to large scale of original index values.

Adjusted correlates showed significant relationships between age, TV exposure, flow, NSES and computer exposure for both school and home computers, and computer anxiety for home computer exposure. Co-efficients were generally greater for home computer exposure. For all correlates other than NSES the direction of the relationship for both school and home computer exposure was the same. As previously shown in the results section (Chapter 6), NSES had a positive relationship with school computer exposure and negative relationship with home computer exposure, indicating children from higher NSES have greater exposure to school computers and children from lower NSES have greater exposure to home computers.

9.1.4 Computer Related MSS outcome variable

The results from the preliminary analysis in Chapter 7, demonstrated that the measures of frequency location, and impact of musculoskeletal soreness were related to children's school and home computer exposure. Additionally, even though multiple measures better characterized the outcome profile, the preliminary analysis showed that frequency of musculoskeletal soreness was the most consistent measure of the four in the relationships between musculoskeletal outcomes and computer exposure. Therefore, frequency of soreness was used as the outcome measure in path analysis for parsimony reasons. This variable was represented as a binary variable where 'yes' equated to frequency of at least monthly musculoskeletal soreness. Table 9.4 demonstrates the percentage of participants experiencing at least a monthly frequency of soreness at each level of computer exposure. School ($x^2_{(12)}$=36.1, p<.001) and home ($x^2_{(12)}$=20.8, p=.053) computer exposure, as defined by the constructed exposure variable (low to high exposure risk), were found to be associated with Computer Related MSS.

Table 9.4 Percentage (n) of participants reporting at least monthly soreness related to computer exposure risk categories

	Computer exposure			
Monthly Soreness	Low	Moderately low	Moderate	High
	School computer			
No	93.5 (405)	86.5 (141)	88.1 (386)	68.5 (13)
Yes	6.5 (28)	13.5 (22)	11.9 (52)	31.5 (6)
	Home computer			
No	86.5(122)	83.9 (94)	78.3 (430)	72.5 (174)
Yes	13.5 (19)	16.1 (18)	21.7 (119)	27.5 (66)

9.1.5 Relationships between user correlates, computer exposure and Computer Related MSS

Given the results from preliminary analysis (Chapters 4 – 8 of the thesis) and discussion from 9.1.1 computer exposure and user correlates of gender, age, BMI, TV exposure, MVPA exposure, somatic complaints, computer anxiety, flow and NSES were shown to be related to school and home computer related MSS. As these correlates were deemed to be captured well by the use of the study's large scale survey, further regression analysis to test the relationships between these correlates and related MSS was undertaken for modeling purposes.

Table 9.5 shows the relationships between the user correlates and computer exposure measures used in the modified models and the outcome variable of musculoskeletal soreness, for school and home. Coefficients are reported both as unadjusted and adjusted for all correlates except BMI (due to BMI being unrelated to dependent variables). Probit regression for the binary variable of musculoskeletal soreness was used. Only those cases with a full set of outcome and correlates were included for analysis (home=1042, school=1053).

Table 9.5 Probit regression coefficients for user correlates on School and Home Computer Related MSS (binary)

	School Computer Related MSS (n= 1053)			Home Computer Related MSS (n=1042)		
	β	t-score	p-value	β	t-score	p-value
Computer exposure	0.190*	3.35	0.001	0.175	3.55	<0.001
Adjusted	0.182*	2.79	0.005	0.111	1.88	0.060
Female gender	0.331*	3.14	0.002	0.410	4.65	<0.001
Adjusted	0.291*	2.34	0.019	0.406	4.33	<0.001
Age	0.030	1.14	0.256	0.084	3.52	<0.001
Adjusted	0.015	0.45	0.654	0.071*	2.61	0.009
BMI	-0.020	-0.32	0.75	-0.014	-0.27	0.785
TV frequency	0.004	0.06	0.955	0.122*	2.06	0.039
Adjusted	0.034	0.41	0.683	0.155*	2.12	0.034
TV usual duration	-0.022	-0.49	0.621	0.034	0.86	0.388
Adjusted	-0.048	-0.86	0.390	-0.038	-0.83	0.404
Headache	0.212**	4.34	<0.001	0.244**	5.46	<0.001
Adjusted	0.085	1.41	0.158	0.136*	2.72	0.007
Stomach pain	0.315**	6.02	<0.001	0.279**	6.10	<0.001
Adjusted	0.278**	4.76	<0.001	0.227**	4.55	<0.001
Flow	-0.003	-0.59	0.557	-0.001	-0.26	0.793
Adjusted	-0.006	-0.88	0.411	-0.007	-1.20	0.229
Computer anxiety	0.010*	2.09	0.037	0.003	0.66	0.512
Adjusted	0.005	0.86	0.391	-0.001	-0.23	0.819
NSES[1]	-0.018	-0.34	0.737	<0.001	-0.01	0.993
Adjusted	-0.034	-0.56	0.573	0.050	0.98	0.327

** < .001, * < .05

[1] NSES scores used are /100, due to large scale of original Index Values

Different relationships between School and Home Computer Related MSS and correlates were evident. Adjusted correlates showed significant relationships between computer exposure, gender, stomach pain and School Computer Related MSS outcomes. Adjusted correlates showed significant relationships between computer exposure, gender, age, TV frequency, headache, stomach pain and Home Computer Related MSS outcomes.

9.2 MODIFIED MODEL RESULTS OF DIRECT AND INDIRECT RELATIONSHIPS BETWEEN USER CORRELATES, COMPUTER EXPOSURE AND COMPUTER RELATED MSS

To obtain a better understanding of the pathways through which user correlates relate to School and Home Computer Related MSS, path analysis was conducted specifying sequential relationships between user correlates, school or home computer exposure and musculoskeletal soreness. This allowed both the direct and indirect (via computer exposure) effects of user correlates on musculoskeletal soreness to be examined simultaneously (Smith, 2008). Path analysis was firstly performed with the modified computer exposure models. These models were modified from the proposed model presented in Chapter Section 2.4.6, page 51, based on the evidence for relationships as presented in Chapters 4 - 8 and also in sections 9.1.1 – 9.1.5 of this chapter. Models were further refined to a reduced final school and home computer exposure models (section 9.3 of this chapter).

9.2.1. Modified school computer exposure model

A modified path model for School Computer Related MSS was initially tested with both direct and indirect pathways. Based on the earlier analysis gender, age, BMI, somatic complaints, flow, computer anxiety, other activities of TV and MVPA, and NSES were modeled as having an indirect association with musculoskeletal soreness through association with school computer exposure. Similarly, gender, age, somatic complaints, flow, computer anxiety, other activities of TV and MVPA and school computer exposure were modeled as having a direct association with musculoskeletal soreness. As previously discussed the direct and indirect pathways were initially modeled in these modified models based on evidence for relationships from available literature and this study's preliminary analysis. Relationships that were not evident, and therefore not included in the modified model, were a direct relationship between BMI and musculoskeletal soreness (Refer to sections 2.3.3 and 9.1.1- 9.1.5) and NSES and musculoskeletal soreness (Refer to Results section 7.2.3, 9.1.1 – 9.1.5). Refer to Figure 9.1 for the modified school computer exposure model. Pathways indicated by a dashed arrow show correlates hypothesized to have had a direct effect on school computer exposure and therefore an indirect effect on School Computer Related MSS. Pathways indicated by a solid arrow show correlates hypothesized to have had a direct effect on School Computer Related MSS.

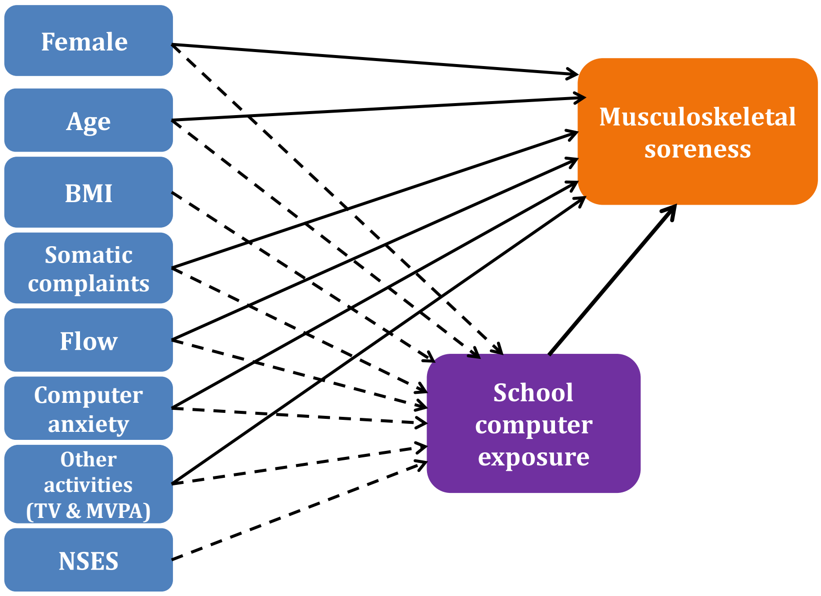


Figure 9.1 Modified pathway model of the direct and indirect relationships between user correlates, school computer exposure and related musculoskeletal soreness

9.2.2. Modified home computer exposure model

A modified path model was also for Home Computer Related MSS was also initially tested with both direct and indirect pathways. Again, based on the earlier analysis gender, age, BMI, somatic complaints, flow, computer anxiety, other activities of TV and MVPA, and NSES were modeled as having an indirect association with musculoskeletal soreness through association with home computer exposure. Similarly, gender, age, somatic complaints, flow, computer anxiety, other activities of TV and MVPA and home computer exposure were modeled as having a direct association with musculoskeletal soreness. Again, relationships that were not evident, and therefore not included in the modified model, were a direct relationship between BMI and musculoskeletal soreness (Refer to sections 2.3.3 and 9.1.1- 9.1.5) and NSES and musculoskeletal soreness (Refer to Results section 7.2.3, 9.1.1 – 9.1.5). Refer to Figure 9.2 for the modified home computer exposure model. Pathways again that are indicated by a dashed arrow show correlates hypothesized to have had a direct effect on home computer exposure and therefore an indirect effect on Home Computer Related MSS. Pathways indicated by a solid arrow show correlates hypothesized to have had a direct effect on Home Computer Related MSS.

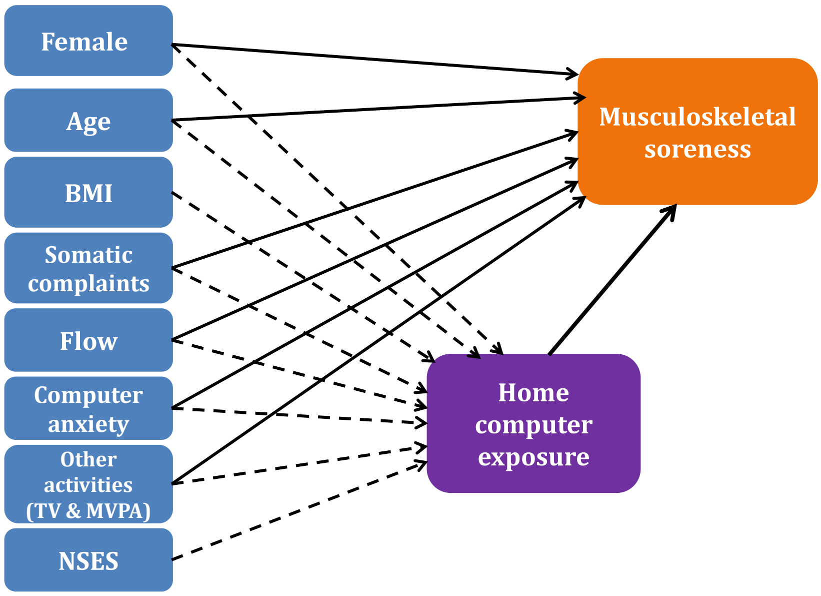


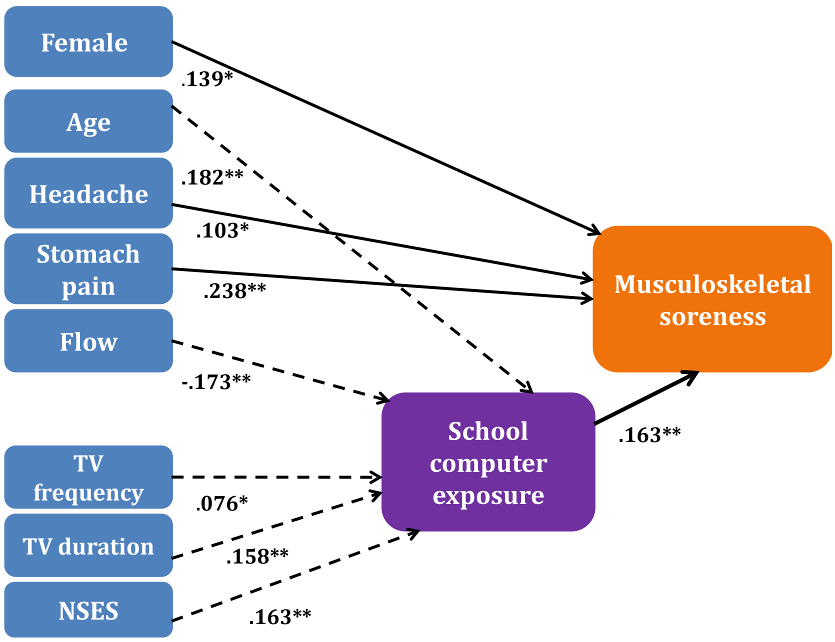
Figure 9.2 Modified pathway model of the direct and indirect relationships between user correlates, home computer exposure and related musculoskeletal soreness

9.3 FINAL MODEL RESULTS OF DIRECT AND INDIRECT RELATIONSHIPS BETWEEN USER CORRELATES, COMPUTER EXPOSURE AND COMPUTER RELATED MSS

The final school and home computer exposure models were refined from the modified school and home computer exposure models, primarily by examination of the size and significance of path coefficients and secondarily by changes in global fit measures. The final refined models are presented in Figures 9.3 and 9.4. Pathways indicated by a dashed arrow show correlates that had a significant direct effect on school computer exposure and therefore an indirect effect on School and Home Computer Related MSS. Pathways indicated by a solid arrow show correlates that had a direct effect on School and Home Computer Related MSS. Standardized estimates were used on all path models to demonstrate the strength of the relationships between correlates and allow direct comparison of the linear regression paths (to computer exposure) and the probit regression paths (to musculoskeletal outcomes).

9.3.1 Final school computer exposure model

Figure 9.3 shows the final school computer exposure model as determined by path analysis.



** p<.001
*p<.05

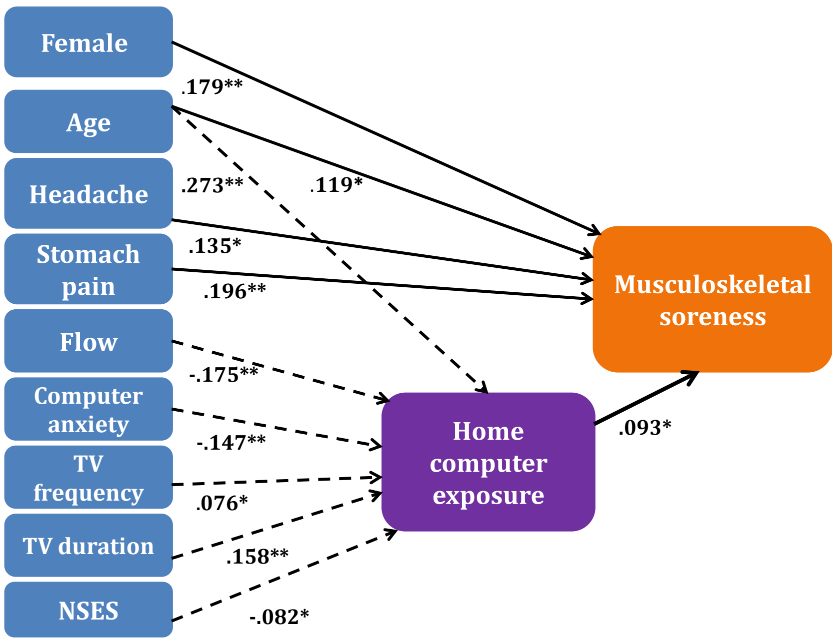
Figure 9.3 Final refined pathway model, including standardized regression coefficients (b), of the relationships between user correlates, school computer exposure and School Computer Related MSS

The standardized *indirect* paths between correlates and School Computer Related MSS via school computer exposure were; age b=0.017(t = 2.95, p=.003); TV frequency b=0.011 (t = 1.79, p=.074); TV usual duration b=0.010(t = 1.74, p=.081); Flow b= -0.028 (t = -2.94, p=.003); NSES b=0.027(t = 2.84, p=.005).

The refined pathway analysis model resulted in an overall R^2 estimate for school computer exposure of 0.093 and School Computer Related MSS of 0.136. This weak model fit was largely reflected in other model fit indices, with only the Root Mean Square Error of Approximation consistently showing acceptable fit across models (School Final Model = 0.042). As no index has been shown to perform well in all situations (Chandola, 2006) model choice was based primarily on retaining those paths statistically different from zero.

9.3.2 Final home computer exposure model

Figure 9.4 shows the final home computer exposure model as determined by path analysis.



** p<.001
*p<.05

Figure 9.4 Final refined pathway model, including standardized regression coefficients (b), of the relationships between user correlates, home computer exposure and Home Computer Related MSS

The standardized *indirect* paths between covariates related to Home Computer Related MSS via home computer use were as follows; age b=0.026(t =-2.052, p=.040); TV frequency b= 0.007(t =-1.64, p=.100); TV usual duration b=0.015(t =-1.94, p=.052); flow b= -0.016(t =-1.95, p=.051); computer anxiety b=-0.001(t =-1.95, p=.051); NSES b=-0.008(t =-1.68, p=.093).

The refined pathway analysis model resulted in an overall R^2 estimate for home computer exposure of 0.192 and Home Computer Related MSS of 0.165. Similar to the school computer exposure model, this weak model fit was largely reflected in other model fit indices, with only the Root Mean Square Error of Approximation consistently showing acceptable fit across models (Home Final Model =0.036). Once again, as no index has been shown to perform well in all situations (Chandola, 2006) model choice was based primarily on retaining those paths statistically significantly different from zero.

As the literature demonstrated important links between computer exposure and MVPA, MVPA was also tested in both modified models. During the refinement of the model no significant paths were however evident, even though MVPA univariate analysis demonstrated relationships between duration of MVPA and School and Home Computer Related MSS (Chapter 8). This analysis did however have a large number of missing values (MVPA n= 962 (school model); MVPA n= 950 (home model)), and so while there may have been an influence of MVPA, this was not evident in the current path analysis. This relationship will need to be explored in future research with larger sample numbers. MVPA was therefore not included in the refined path analysis modeling.

9.4 MODEL RESULTS SUMMARY

This chapter has shown the relationships between user correlates, computer exposure and musculoskeletal soreness related to children's school and home computer exposure. Results from testing the final two refined models (school and home computer exposure) have shown significant direct and indirect (via computer exposure) relationships between gender, age, other sedentary activities, psychological correlates (somatic complaints, flow and computer anxiety), NSES, and computer exposure and children's musculoskeletal soreness.

The tested models provide a framework of the potential risk factors and issues associated with children's computer exposure and musculoskeletal soreness. This framework can be used as a guide for encouraging safe and productive use of computers by children.

The following Discussion chapter will further outline the importance of the study's results and tested models and how these findings could encourage effective and wise use of computers for optimum health and development in children.

10.0 Discussion

The study investigated factors relating to musculoskeletal outcomes associated with children's use of computers. Through path analysis modeling, these relationships were tested to identify significant direct and indirect effects through computer exposure. The aim of this chapter is to provide a discussion on these relationships and other issues arising from the study.

This chapter is divided into six sections. Firstly, a summary of the study results is presented, highlighting key findings. Secondly the interpretation of the main findings of the study are discussed including a discussion on child versus adult models, the relationships computer exposure and musculoskeletal outcomes, the relationships between user correlates and computer exposure, and finally, the relationships between user correlates and computer related musculoskeletal outcomes. Section 3 discusses the outcome measures used in the study including computer exposure and computer related musculoskeletal outcomes. Section 4 discusses the limitations of the methods used in the study, together with the strengths of the study. Section 5 outlines future directions and Section 6 discusses the implications of the study.

10.1 SUMMARY OF RESULTS

This section reports the major findings of this study, which are summarised under each of the study's ten objectives.

10.1.1 Objective 1: To investigate children's computer exposure patterns

-Nearly all children had access to computers at school and home, and home internet access.

-Mean weekly use of home computers (7.2 (sd =9.6) hours) was three times more than use of school computers (2.4(sd=3.3) hours).

-Nearly all children had used school and home computers in the last month and durations were most commonly 30 – 60 minutes at school and 60 - 120 minutes at home

-Computer activities performed more frequently at school were surfing the internet, learning programs and multimedia. At home the most frequent computer activities were surfing the internet and email.

-Bedroom computer access was associated with greater exposure, including nearly 50% greater mean weekly hours.

10.1.2 Objective 2: To further evaluate, and better characterize, different aspects of children's computer exposure patterns by comparing different exposure measures

-School and home computer exposure patterns were identified by the use of a range of exposure measures including access, frequency, usual and longest duration and mean weekly hours. The use of a range of exposure measures provided better characterization of exposure as different exposure patterns were demonstrated with individual measures.

- The importance of using a combination of exposure measures (frequency, usual and longest duration) was demonstrated in linear regression analysis with a slightly stronger prediction of computer related musculoskeletal outcomes occurring with the combination of exposure measures.

-Although all 3 exposure measures were significantly related, in regression analysis *frequency* of exposure was the strongest single exposure measure for prediction of frequency of musculoskeletal soreness, when compared to duration measures.

10.1.3 Objective 3: To investigate the relationships between the children's computer exposure and the computer environment, including school and home

- Different exposure patterns were evident at school and home in terms of the amount and nature of exposure. Home computer use was found to be more frequent and for longer durations with greater mean weekly hours. School computer activities included more learning based activities, with more social activities at home.

10.1.4 Objective 4: To investigate the relationships between children's computer exposure and user correlates of age, gender, BMI, pre-existing MSD, somatic complaints, psychological factors and other activity exposure

-School and home computer use *frequency* and *duration* were greater with age for both boys and girls. Boys had greater computer exposure than girls at ages 6, 11, 14 and 16 years for all school and home measures, except school usual duration.

-The *nature* of computer activities was associated with *both* age and gender. Frequency of all school and home computer activities was greater with age, except for learning programs and home computer games use which peaked at Year 6 level. Girls were found to have greater use of social activities such as home computer email. Boys had greater use of playing games and surfing the internet at both school and home.

-Body mass index (BMI) was not associated with computer exposure

-Children with more flow had greater exposure to computers and participated more frequently in a range of computer activities. Children with greater computer anxiety had less exposure. Children experiencing somatic complaints showed patterns of greater exposure and a wide range of computer activities.

10.1.5 Objective 5: To investigate the relationships between children's computer exposure and their other activities

-A complex interplay of associations was shown between school and home computer exposure and other activities. These associations were also dependent on exposure measures.

-Greater school computer use was associated with greater durations of most other IT types (eg. TV watching and mobile phone use) and frequency of TV watching and MVPA. School computer use was not associated with writing, reading and electronic game frequency.

-Greater home computer use was associated with greater frequency and durations of most other IT types (eg. TV watching, writing, mobile phone, and electronic games).

-Greater home computer use was associated with greater MVPA durations, was negatively associated with reading frequency and MVPA frequency, and was not associated with writing frequency.

10.1.6 Objective 6: To investigate the relationships between children's computer exposure and neighbourhood socioeconomic status (NSES)

-NSES was found to account for a small but significant proportion of school and home computer exposure (amount and nature).

-A positive relationship was found between NSES and the amount of school computer exposure, indicating that children from an area of high advantage were more likely to use computers at school. Children from areas of high advantage were also found to have greater frequencies of school related computer activities, such as learning programs, playing games and email.

-At home, computer use was negatively related with NSES, indicating children from an area of disadvantage were more likely to use computers at home. Children from areas of disadvantage were also found to have greater frequencies of social computer activities, such as chat room and email.

10.1.7 Objective 7: To identify musculoskeletal outcomes associated with children's school and home computer exposure

-10% of children experienced musculoskeletal outcomes with use of school computers and 20% with home computers, which was similar to the frequency of outcomes experienced by children when using other electronic and paper based IT. Children experiencing computer related outcomes were more likely to report experiencing outcomes with other IT and MVPA activities.

-Computer exposure (frequency and duration) was found to significantly predict frequency of musculoskeletal soreness, with greater computer exposure associated with greater frequency of musculoskeletal soreness.

-Neck and low back locations were the most prevalent anatomical body locations for musculoskeletal soreness for both school and home computer exposure. Computer exposure was associated with Computer Related MSS in specific anatomical body locations.

-Moderate musculoskeletal soreness intensity scores across all 8 body locations were reported for school and home computer exposure.

-Up to 30% of children who have reported musculoskeletal soreness, limited their computer exposure, with up to 10% taking medication and 7% consulting a treating practitioner.

10.1.8 Objective 8: To compare different musculoskeletal outcome measures to evaluate, and better characterise, computer related musculoskeletal outcomes

-Children's computer related outcomes were shown by the use of the four outcome measures: frequency, location, intensity and impact of musculoskeletal soreness.
-Computer exposure was shown to result in frequent soreness, of moderate intensity, in a range of locations (typically neck and low back), impacting on activity participation and at times requiring health professional attention. Each measure characterized different aspects of musculoskeletal soreness, demonstrating the importance of using a combination of measures.

10.1.9 Objective 9: To understand the relationships between children's computer related musculoskeletal outcomes and user correlates of age, gender, BMI, pre-existing MSD, somatic complaints, psychological factors and other activity exposure.

-Associations between frequency of School and Home Computer Related MSS and age and gender were evident. Female and older children were more likely to experience outcomess.
-Associations between frequency of School and Home Computer Related MSS and user correlates (headache, stomach pain, pre-existing MSD) and psychological factors ("butterflies in your stomach", enjoyment going to school, computer flow and computer anxiety) showed mixed results.
-Somatic complaints were positively correlated with School and Home Computer Related MSS.
-No association was evident between School and Home Computer Related MSS and enjoying going to school, computer flow or computer anxiety.

10.1.10 Objective 10: To test a model of direct and indirect effects of potential risk factors, (including user correlates and computer exposure), for musculoskeletal soreness in children using computers

-Through path analysis both direct and indirect (via computer exposure) effects of user correlates, and school and home computer exposure and musculoskeletal soreness were tested.

-The final school computer exposure model showed direct relationships between gender, somatic complaints, computer exposure and musculoskeletal soreness; and indirect relationships, via computer exposure, between age, computer flow, TV exposure, SES and musculoskeletal soreness
- The final home computer exposure model showed direct relationships between gender, age, somatic complaints, computer exposure and musculoskeletal soreness; and indirect relationships, via computer exposure, between age, computer flow, computer anxiety, TV exposure, SES and musculoskeletal soreness.

10. 2 MODELS OF THE RELATIONSHIPS BETWEEN USER CORRELATES, COMPUTER EXPOSURE AND MUSCULOSKELETAL SORENESS

The high prevalence of musculoskeletal outcomes in children as reported in past literature (Kristjánsdóttir, 1997; Mikkelsson, 1997; Balague *et al.,* 1999; Gillespie, 2002; Diepenmaat *et al.*, 2006) was also evident in this study, with monthly frequency of outcomes reported by 1/5th of children for computer and other sedentary activities, and 2/3rd of children for moderate vigorous physical activities.

As musculoskeletal outcomes are a common complaint for many children, understanding factors influencing these outcomes is imperative. Results from this study have uniquely demonstrated that individual user factors, computer exposure and the exposure environment are related to children's musculoskeletal outcomes. Additionally this study's findings have demonstrated that these outcomes impact on children as shown by their reports of limitations with activity participation, taking medication and seeking health professional treatment.

This is the first study to show significant relationships between children's user correlates, computer exposure and musculoskeletal outcomes by testing a model incorporating all these factors. Results have clearly shown specific correlates have direct and indirect relationships with computer related musculoskeletal outcomes via children's school and home computer exposure.

This section presents a discussion on the study's child specific model as compared with the adult models, and then discusses the model relationships as defined by the path analysis. The first relationship discussed within this section is between computer exposure and musculoskeletal outcomes, followed by the relationships between user correlates and computer exposure, and finally the relationships between user correlates and computer related musculoskeletal outcomes.

10.2.1 Child versus adult models

As presented in the Introduction of this thesis, general models and theories relating to the causality of musculoskeletal outcomes in adult workers demonstrated relationships between workplace factors and musculoskeletal outcomes. The adult related literature has identified specific workplace risk factors (eg. prolonged durations, high physical load, and static loading) and has presented models representing the interactive process of exposure to these risk factors with physical, psychological, social, and environmental factors, leading to the precipitation of musculoskeletal outcomes (Mathiassen, 1993; Moon and Sauter, 1996; Kumar, 2001; Cole and Rivilis, 2004; Karsh, 2006). Additionally, mechanisms demonstrating that the link between exposure to these risk factors and precipitating musculoskeletal outcomes can follow a dose-response relationship have been proposed (Armstrong *et al.*, 1993).

Similarities in child and adult models include the underlying multivariable consideration to risk factors associated with work / computer related musculoskeletal outcomes. As seen in The Multivariate Interaction Theory of Musculoskeletal Injury Precipitation by Kumar (2001) this model includes the inherent characteristics of the individual's musculoskeletal system; how it interacts with hazards and stresses of biomechanical factors; and the individuals' biological response mechanism, including pain behaviour. This model demonstrates the multivariable nature of exposure to risk factors and takes into consideration individual's physical and psychosocial factors (inputs). Additionally, this model specifically depicts the injury mechanisms and responses. Mechanisms are detailed and included structural (strain, shear, tension), biochemical and physiological reactions. Injury responses (outputs) are also detailed including inflammation, pain and pain behavior. While the current study's models have also demonstrated a multivariable approach, the correlates shown to be related to injury precipitation have involved broader factors (inputs) relating to not only the individual (eg psychosocial and physical correlates), but have included children's environment and activity participation. Additionally as the current study's focus was specifically computer exposure, exposure and musculoskeletal outcomes (outputs) were also specifically computer related. The mechanisms and outputs used in the current study's models were also limited to what could be measured given the design of the study. To capture data for a large scale study measures that could be used within a survey questionnaire were therefore used.

The Exposure-effect Model by Mathiassen (1993) demonstrates the interaction of external and internal exposure variables (inputs) and associated responses (outputs). This model demonstrates the importance of time and depicts the time associated with injury precipitation. This model shows that initially injury responses are acute but with continued exposures can lead to chronic effects. While the current study's child related models demonstrated relationships between correlates both external (eg. SES, computer environment, other activities participation, computer exposure) and internal (eg. Age, gender, computer anxiety, somatic complaints, flow) to the user, the potential acute and chronic effects were not modeled. The current study's child specific models do however show the potential effects of children's computer exposure to follow a dose-response relationship (Armstrong *et al.*, 1993).

The Ecological model of MSDs in Visual Display Terminal Work proposed by Sauter and Swanson (1996) again demonstrates the multivariable nature of potential risk factors for computer related musculoskeletal outcomes. Unlike the previous adult models, this model shows the relationships between external environment factors, including psychosocial and biomechanical factors (inputs) based on work related computer exposure, and musculoskeletal outcomes (outputs). This adult model is similar to the current study's child specific models as the work tasks both involve computer exposure, and have also both included similar user correlates (inputs), including psychological, individual factors, work organization and somatic complaints. The cognitive component of this adult model referring to the detection and attribution of symptoms, has also been shown to be important in this study's child specific model. As demonstrated by the final school and home computer exposure models in Figures 9.3 and 9.4, somatic complaints were found to have the strongest relationships with outcomes. Differences between the models however are related to the types of computer environment and physical biomechanical factors included within the model. Due to children's significant school and home computer exposures family and computer environments were represented in the current study's models by including locations of school and home (as depicted by two models were being developed and tested, one for each environment), and the child's SES background. Additionally, this adult model shows the potential injury mechanisms as demonstrated by biomechanical components of physical demands and biomechanical strains. The current child related study was not able to measure these physical and biomechanical aspects of exposure again due to the study design and constraints of a large scale survey.

The three adult models discussed above and in the Introduction of this thesis are based on *theories* of relationships between risk factors and precipitation of musculoskeletal injuries (Kumar, 2001). These models propose pathways between associated risk factors and musculoskeletal outcomes. The illustrated pathways have demonstrated directions for the relationships between variables, and imply both direct and indirect effects of risk factors on musculoskeletal outcomes. What however is not clear from these theories and adult models are which variables have direct and/or indirect effects on exposure and musculoskeletal outcomes.

The child specific models in this study were initially developed based on these adult models, current adult and child specific literature, and then tested via path analysis modeling with children's computer exposure data. These child specific models based on this evidence have therefore provided more specific information on the relationships between the potential risk factors for children's computer related musculoskeletal outcomes, including the direct and indirect effects of potential risk factors for outcomes (exposure and musculoskeletal outcomes). These results have shown the unique characteristics of children are important, as user correlates such as age, psychological factors (flow, computer anxiety) and TV exposure have indirect effects via computer exposure on computer related outcomes; and age, gender, somatic complaints, and computer exposure were found to have direct effects on computer related outcomes. These multivariable child specific models therefore provide valuable information to guide parents, teachers, and researchers to ensure this technology is safe and productive for children's use.

10.2.2 Relationships between computer exposure and musculoskeletal outcomes

The study's findings showed evidence for a relationship between children's school and home computer exposure and musculoskeletal outcomes. This is consistent with recent research findings of a relationship between both adult's and children's computer exposure and musculoskeletal outcomes.

Within this study, the amount (frequency and duration) and nature of the exposure have been shown to be related to musculoskeletal outcomes. Musculoskeletal outcomes were defined in the current study by the frequency, location, intensity and impact of musculoskeletal soreness.

Although children had greater exposure within the home environment, both school and home computer exposure were related to musculoskeletal soreness. This major finding shows the importance of considering both school and home environments in recommendations for children's wise use of computers.

This section will discuss the relationships between computer exposure and musculoskeletal outcomes including the amount of exposure, the nature of the exposure and finally the amount and nature of the musculoskeletal outcomes.

10.2.2.1 Relationships between the amount of computer exposure and musculoskeletal outcomes

In adult literature, the intensity of computer exposure (duration x frequency of computer use) is more consistently associated with musculoskeletal outcomes than any other risk factor (Gerr *et al*., 2004). Within the current study frequency and duration of computer exposure were found to be related to school and home computer related musculoskeletal outcomes :1) independently; 2) as measures combined in regression analysis accounting for individual and health correlates; and 3) as a constructed combination exposure measure for modeling purposes. Additionally, a linear pattern of relationships between computer exposure over the four risk categories (low, moderately low, moderate and high) and frequency of musculoskeletal soreness was evident. The use of frequency, usual and longest duration measures together, when compared with single measures, were found to be a slightly stronger predictor of musculoskeletal outcomes. Although in the current study frequency of computer exposure was the strongest correlate, an additive effect was also evident with duration measures. Within the regression analysis as there was a suggestion of an interaction effect between frequency and duration measures, including both measures, as seen in adult literature, when assessing exposure is important.

As previously discussed, *frequency* of computer exposure, as a single measure, was associated with musculoskeletal outcomes in both computer environments. Frequency was particularly important when investigating computer exposure within the school environment. School timetables with set class times were likely to have constrained children's usual and longest duration computer exposure. It was therefore not surprising that only school computer frequency was associated with musculoskeletal soreness. Other child related computer exposure studies have not however found associations with school computer exposure and musculoskeletal outcomes. These findings were most likely due to the school environmental constraints of computer duration not being taken into consideration. Kelly *et al.* (2009) used only duration measures, and Sommerich (2007) used a combined (frequency and duration) measure.

Relationships between *duration* of children's computer exposure (as a single measure) and musculoskeletal outcomes have been shown in recent literature (Harris and Straker, 2000; Jacob and Baker, 2002; Jacobs *et al.*, 2009; Kelly *et al.,* 2009). These studies have included time in one sitting or mean daily and/or weekly hours as exposure measures. Additionally, computer duration thresholds, the time periods which have been associated with the report of musculoskeletal outcomes, have been reported. Thresholds have varied in children's literature, for example: 80 minutes in one sitting (Kelly *et al*., 2009); 2 hours / day for neck and shoulder pain and 5 hours / day for low back pain (Hakala *et al.,* 2006); and >15hours per week for low back pain in adolescents (Sjolie, 2004). Although the current study did not identify thresholds for the duration of school and home computer exposure, analyses demonstrated a dose-response relationship between exposure and outcomes.

This study's use of a range of duration exposure measures (usual and longest duration and mean weekly hours) provided more comprehensive exposure information. In a previous laptop computer study by Harris and Straker (2000), different findings between usual and longest duration and musculoskeletal outcomes were found using preliminary analysis. The differences in Harris and Straker's (2000) study were likely due to the sample mix, 87% of participants were girls, mean age 13 years. Within the current study both duration measures were found to act similarly in correlation and regression analysis, demonstrating relationships between school and home computer exposure and musculoskeletal outcomes. Duration measures can indicate the potential risk factor of sustained postures. As previous literature has demonstrated the relationship between sustained postures and musculoskeletal outcomes in adult and children IT users (Harris and Straker, 2000; Wahlström, 2005; Chang *et al*., 2007), including duration measures in exposure analysis is important.

10.2.2.2 Relationships between the nature of computer exposure and musculoskeletal outcomes

Most studies investigating children's computer related musculoskeletal outcomes have not investigated the relationship between the *nature* of the computer exposure and related musculoskeletal outcomes. Some studies have inferred the nature of the computer exposure by investigating computer use in a specific environment. For example, school computer use only (Breen *et al.,* 2007; Kelly *et al.,* 2009); home computer use only (Jacobs and Baker, 2002); or both school and home computer environments (Gillespie, 2006); and / or the types of computer activities used in each environment (Ramos *et al.,* 2005). However as specific computer activities in these environments have not always been assessed the nature of the children's computer use is not always clear. As the nature of children's computer use in these studies has not been clear, not surprisingly, these studies have reported mixed results. Ramos *et al.* (2005) found neck and back discomfort related to the nature of computer exposure in both locations. Whereas Gillespie, (2006) reported outcomes related to home rather than school computer exposure.

Within the current study, the nature of children's computer exposure was clearly identified by identifying the types of computer activities used by children in each environment. Social activities (chat rooms) on school computers and both learning orientated activities (word documents and learning programs) and social activities (email, surfing the internet and multimedia) on home computers were associated with an increased frequency of musculoskeletal outcomes. Understanding the types of computer activities, and thus the nature of the computer exposure, identifies potential risk factors for associated musculoskeletal outcomes. As both school and home social computer activities were linked with computer related musculoskeletal outcomes, providing guidelines for the safe performance of these school and home computer activities could be beneficial for the children's health and development.

Interestingly, computer games exposure was not associated with musculoskeletal outcomes in either environment. This finding could be a function of age and gender, as these activities are usually associated with younger boys, and musculoskeletal outcomes were found in this study to be associated with older females. This finding highlights the importance of understanding the nature of children's exposure, in addition to the user correlates such as age and gender, when considering risk factors for musculoskeletal outcomes.

10.2.2.3 Relationships between computer exposure and amount and nature of musculoskeletal outcomes

As previously discussed, computer exposure has been linked to computer related musculoskeletal outcomes in adults and children. Reported outcomes have included the amount, eg. frequency of soreness, and the nature, eg. anatomical body location, intensity and impact of the outcome. Within the current study greater school and home computer exposure were associated with greater frequency of soreness, and soreness in specific anatomical body locations. This study identified musculoskeletal outcomes in terms of soreness of moderate intensity which in some cases impacted on children's activity participation and health professional service use.

Computer exposure has been shown to be related to *frequency* of computer related musculoskeletal outcomes in previous child related studies (Burke and Peper, 2002; Hakala *et al*., 2005; Sommerich, 2007; Coleman *et al*., 2009). Findings from the current study have also demonstrated the link between computer exposure (amount and nature) and frequency of musculoskeletal outcomes with both school and home computer use. Given children's greater computer exposure within the home environment it is not surprising that the frequency of home computer related outcomes was double that of school computer related outcomes. These positive relationships between computer exposure and frequency of computer related outcomes indicate that greater computer exposure is linked to greater frequency of soreness. This mechanism supports current dose – response relationship theories as previously discussed in adult literature (Armstrong *et al*., 1993). These findings emphasize the importance of identifying safe exposure guidelines for children's school and home computer exposure.

Recent literature has also shown computer exposure associated with musculoskeletal outcomes in specific anatomical *body locations*. Typically, adult studies on office based computers and child studies on a range of computer types and activities have identified specific anatomical body locations. Most commonly these are the neck and low back (Harris and Straker, 2000; Jensen *et al.*, 2002; Hakala *et al*., 2005; Ramos, 2005). Upper limbs symptoms have also been reported (Blatter and Bonger, 2002; Jensen *et al.*, 2002), including studies with an emphasis on children's gaming activities (Burke and Peper, 2002). Results from the current study are consistent with these findings. For example, neck and low back locations were found to be the most prevalent body locations for musculoskeletal outcomes with school and home computer exposure. Musculoskeletal outcomes in these anatomical body locations are understandable when considering most children in this study used sustained seated postures for school and home computer use. Additionally, as children involved in one IT type were more likely to have increased exposure to another IT type, sustained postures were likely to be used for both school and home computers as well as other IT types such as electronic games, writing and watching TV.

The frequency of upper limb musculoskeletal outcomes was also associated with computer exposure in the study. Upper limb symptoms were however greater for other sedentary activities (including musical instrument playing, writing and reading) and electronic game playing. When considering the upper limb body mechanics required for these activities, and given the frequency and duration of the children's exposure to these activities, these upper limb musculoskeletal outcomes are not surprising.

There was no significant association between the intensity of musculoskeletal outcomes and school and home computer exposure in this study. This finding is likely due to the small variance for the moderate intensity scores across all anatomical body locations. The combination of outcomes measures in the current study assists in understanding the relationship between exposure and musculoskeletal outcomes, and supports the significant findings with other outcome measures.

10.2.3 Relationships between user correlates and computer exposure

This study's findings of relationships between user correlates and children's computer exposure are consistent with recent literature. However, this study's findings extends these recent findings by demonstrating relationships between user correlates of age, gender, other activity exposure (eg TV), somatic and psychological factors, NSES and the interplay of some of these correlates, with *both* the amount and nature of school and home computer exposure. The following section discusses the relationships between these user correlates and computer exposure.

10.2.3.1 Relationships between age and gender and computer exposure

Children's age and gender are reportedly associated with the amount and nature of their computer exposure (Kent and Facer, 2004; Ramos *et al.,* 2005; Roberts *et al.,* 2005; Wake *et al*., 2005; Burke *et al*., 2006; Hardy *et al.*, 2006; Marshall *et al.*, 2006;

Olds *et al.*, 2006; Chou and Tsai, 2007; Punamaki *et al.*, 2007; Sommerich *et al.,* 2007; Mathers *et al.*, 2009). Within this study, relationships between age, gender and computer exposure were consistent with this literature. Additionally this current study further explored the *interplay* of age and gender to further elucidate these associations.

Previous research on the relationships between the amount of computer exposure and gender has shown that boys use computers at home more than girls. This study confirmed this in terms of the amount of overall computer exposure, and found this across all Year levels, as both genders increased their use with age. However, in terms of frequency of use this study showed that older (Yr 9 &11) girls and boys had similar home computer frequency. Furthermore, while older students *may not* have the highest frequency of computer exposure, when they do participate they perform for longer durations.

The nature of computer use has previously been shown to be related to age and gender, in particular younger boys having greater gaming exposure. This study found similar patterns, for example boys performing more gaming and surfing the net, and girls more email. Additionally, greater social computer activities such as chat rooms and email were found to be performed in both environments as children aged. The change in the nature of children's computer activities, and therefore their exposure, perhaps reflects developmental stages in children's lives. IT has previously been shown to be an integrated function of children's everyday life. Older children who developmentally are more likely to be engaged in social networking, and who generally have greater choice in how they spend their computer time, are therefore more likely to be engaged in more social computer activities. The opportunity for socialization via computer exposure has been seen in recent literature to be positive for those children that may otherwise lack social skills or opportunity (Orlean and Lacey, 2000; Straker and Pollock, 2005). Furthermore, older children's requirements for school related computer activities are shown through greater durations of writing, and internet activities.

Understanding the relationship of age and gender, and the interplay of these factors is important. When targeting intervention recommendations for wise computer use, strategies that are aimed at the appropriate age, gender and the types of activities each specific gender / age group are engaged in, will help ensure the interventions are meaningful to that audience.

10.2.3.2 Relationships between other activity exposure (TV) and computer exposure

Recent literature has discussed two key findings in relation to children's exposure to computers and other IT types. Children's IT exposure is increased via their ability to multi-task, and heavy users of one IT type are often heavy users of other IT types (Borzekowski and Robinson 2005; Roberts, 2005; Olds *et al.*, 2006; Rideout *et al.*, 2010). While this current study did not measure exposure to multi-tasking, children with greater school and home computer exposure were more likely to have greater exposure (frequency and duration) of other IT activities. As children with greater computer exposure were also found to have less computer anxiety and to experience flow with these activities, the positive psychological experience associated with their computer exposure may also occur with other IT activities.

The importance of TV exposure in children's lives has been shown in recent literature (Rideout *et al.,* 2010) as it is often the most common children's IT activity. Furthermore, the current study showed through path analysis that both TV frequency and duration were associated with school and home computer exposure. Given that TV watching has similar potential risk factors as computer use with sustained postures, then given the dose response relationship of children's IT exposure, potentially children are exposed to greater risk with the combination of these activities. When researchers are investigating children's IT exposure patterns and potential risk factors for children's computer exposure, investigating both frequency and duration of TV and other IT type exposure is recommended.

10.2.3.3 Relationships between psychological correlates and computer exposure

Psychological correlates of flow and computer anxiety have been shown to be related to both adult's (Webster *et al.,* 1993) and children's (Arrowsmith, 2002; King *et al*., 2002) computer exposure. This study's findings are consistent with previous literature with final path analysis demonstrating a direct relationship between flow and school and home computer exposure and computer anxiety and home computer exposure.

Flow was found to have a positive relationship with both school and home computer exposure, indicating greater computer engagement resulted in greater exposure. Final path analysis showed *computer anxiety* to have a negative relationship with home computer exposure only. In regards to school computer exposure, as duration exposure measures are constrained in the school environment, a relationship between only frequency of school computer use and computer anxiety was found. These findings show that greater computer anxiety can result in reduced school and home computer exposure. These findings are not surprising as children reporting computer anxiety are likely to be having a negative psychological computer experience, they would therefore be more likely to *not* engage in computer use. Within the school environment these relationships were less clear than in the home environment. The curriculum demands and potentially more compulsory expectations in the school environment would encourage children to participate in computer activities at school irrespective of their negative experience. Additionally, in the school environment given the potential classroom structure and instruction associated with computer exposure, this guidance could assist in reducing related anxiety as success with the computer interaction would be facilitated by the teacher or peers. As these correlates have been shown to be associated with computer exposure patterns, and indirectly related to musculoskeletal outcomes, they are important factors to consider in understanding children's computer related musculoskeletal outcomes.

10.2.3.4 Relationships between NSES and computer exposure

Findings from the current study demonstrated that children's access to computers at home and school was high across all neighbourhoods. Despite almost universal computer access, this study demonstrated that children's neighbourhood continues to be associated with their computer use. The impact was shown to be in relation to the amount and nature of children's computer exposure, therefore indicating that a 'digital divide' is still evident even when access to computers is provided for all.

10.2.3.4.1 Relationships of children's computer exposure and high NSES

Children from advantaged neighbourhoods (high NSES) were found to use school computers more frequently, for longer durations and for different activities. It is interesting that a difference in exposure patterns within the school environment of this study sample existed at all, given current political agendas and resources to provide equal school computer access, along with State curriculum guidelines which cover all Western Australian schools. Previous studies have found that school computer use is linked to improved educational attainment (Fuchs and Wößmann, 2005; Li *et al.*, 2006). The greater use of school computers reported by children from high SES neighbourhoods is therefore likely to provide an opportunity for extended educational attainment and improved academic skills. Similarly, the students from high SES neighbourhoods were found to have higher frequencies of using computer learning programs and other academic related computer activities at school. This further promotes the development of academic skills. Additionally these students were found to be more likely to read books and play musical instruments. As current literature shows the potential for increased academic skills with playing music (Diamantes, 2002; Schellenberg, 2005), and reading (Senechal and LeFevre, 2002), the overall activity patterns of these students are likely to support enhanced academic skills.

Moderate to vigorous physical activity for at least 60 minutes per day for children is recommended as part of government guidelines to promote optimum health for children (CDC, 2009). As students from high SES neighbourhoods were found to participate in more vigorous physical activity, their lifestyles have the potential for increased health and physical development in addition to enhanced academic attainment.

Children from high SES neighbourhoods had more opportunity for developing their academic skills given the greater use of school computers, the type of computer activities performed, and the variety of other activities they participated in. It is therefore evident that the digital divide issue is not only to do with access to computers but also the nature of their use. For all children to participate in activities that promote academic attainment and good health, the nature of computer activities and the variety of other activities they participate in needs to be addressed.

10.2.3.4.2 Relationships of children's computer exposure and low NSES

This study showed that children from disadvantaged neighbourhoods (low NSES) used home computers for greater durations and for different activities. While greater use of home computers could be viewed as compensatory for reduced school computer use, a closer examination of the nature of their home computer use indicated different issues. Children from low NSES, were found to *not* be using home computers for learning programs /academic related activities, but rather for multimedia and chat room activities. Whilst multimedia may include the development of school based project work and presentations, it could also include such activities as down loading video and music media. Coupled with the use of chat rooms there appears to be a trend for more social based home computer activities, rather than educationally focused activities, being used by children from low SES neighbourhoods. Greater social use of computers by children from low SES neighbourhoods was also reflected in the different types of IT used. These children were found to have greater use of non educational IT including TV

/ DVDs, mobile phones and electronic games. TV watching and computer gaming, which have been linked to decreased academic performance in areas including reading, written expression and mathematics (Comstock, 1995; Hedley *et al.,* 1995; Cooper *et al.*, 1999; Moseley *et al.*, 2001; Hancox *et al*., 2005). Therefore children from low SES / disadvantaged areas have a pattern of IT use which may not be conducive to academic enhancement.

Greater home computer use by children from neighbourhoods of low NSES was significant for all three duration measures used within this study, indicating that these students had greater mean weekly hours of use, usual duration and longest durations. Given that these children are using other recreational screen based IT for long durations (eg. mode daily use for lowest 10% NSES were: TV usual duration 2-5 hours, home electronic game usual duration 1 – 2hours, mobile phone usual duration 30 – 60 minutes), they are potentially accumulating significant exposure to sustained postures while using these various forms of IT. Sustained postures have been shown to relate to musculoskeletal discomfort with children's IT use including home computers (Jacobs and Baker 2002), electronic games, and laptop/tablet computers (Harris and Straker, 2000; Sommerich *et al.,* 2007).

Additionally, it has been suggested that children's screen time activities may reduce vigorous physical activity participation and contribute to increased childhood obesity rates (Wake *et al*., 2003; Olds *et al*., 2006). As this study found children from low SES neighbourhoods participated in less vigorous physical activity and used computers for longer durations they may be at greater risk of poor health and physical development outcomes.

Hancox *et al*. (2005) found that mean TV viewing time in adolescence was a strong predictor of leaving school without qualifications and increased childhood TV viewing was a strong predictor of non-attainment of a university degree. When viewing IT patterns of children from low NSES in this study (reduced school computer use, longer durations of TV use and socially orientated home computer use), it appears that these children are more likely to be compromised in fully developing their academic skills.. These findings demonstrated that the nature of IT use by children in low NSES areas may have long lasting adverse consequences for economic, academic and health outcomes. Unfortunately, the evidence suggests a viscous cycle of self- perpetuating SES disadvantage.

10.2.3.5 Relationships between school and home environments and computer exposure

The near universal access to computers at school and home for children in this study demonstrated the importance of computers in children's daily life. This section discusses the relationship between the school and home environment, and computer exposure including the amount and nature of use. The interplay of other user correlates, for example age, gender and social environment, are also discussed.

Previous children's studies comparing school and home computer exposure have shown mixed results. Some studies have indicated that children are typically exposed to computers more in the school environment (Moseley *et al.*, 2001; Kerawalla and Crook 2002; Kent and Facer 2004; Olds *et al.,* 2006). However, the current study's findings found that while the proportion of children with access is similar at school and home, total exposure is greater at home. This is shown by greater frequency, duration and mean weekly hours of home computer use. When educators, parents and health professionals are assisting children with health and development issues associated with computer use, it is now clear that the home environment must also be considered in assessment and intervention.

Despite children's greater exposure at home, the importance of both environments on children's computer exposure was demonstrated in this study. School and home computer exposure were independently found to have associations with user correlates and computer related musculoskeletal outcomes. Additionally, school and home exposure were positively associated with each other, indicating that children with greater exposure in one environment were more likely to have greater exposure in the other. The findings from testing the final path analysis models did however demonstrate the constraints of the school environment. This was shown by the overall weaker school model, with some user correlates not being associated with exposure, and/or computer related musculoskeletal outcomes in the school environment despite being related in the home environment. Additionally, findings show that school computer exposure durations may not be associated with computer related musculoskeletal outcomes further demonstrate the school classroom environment constraints.

School computer exposure environment constraints are reportedly due to set curriculum, availability of resources, timetables and teacher direction. Although these constraints would impact on children's computer use, detailed school computer exposure patterns have to date not been clear Kerawalla and Crook, 2002; Kent and Facer, 2004). This current study's findings showed all students were exposed to computers at school, and that school computer use had an educational focus, with an increased frequency of learning programs and writing activities. School computer time constraints were reflected in reduced computer exposure durations (<11.3% one hour in a usual sitting at school compared with <47. 7% one hour at home) and frequencies (55% 2-3 x week at school compared with 77% 2-3 week at home). The constraints were likely due to set class time periods, availability of computers in classrooms or computer lab environments and involvement of computers in the curriculum. As this study's findings showed that the majority of school computers were used in computer laboratories, children would need to change classes to move to the computer laboratory. These constraints would likely impact on the frequency and duration of school computer exposure.

This study did however demonstrate that despite the constraints of the school environment individual correlates, as depicted by the interaction of their Year level and gender, were associated with the amount of school computer use for some activities. For example, Year 9 and 11 boys had found to have greater exposure to school computer gaming activities.

Given this study's findings of the exposure patterns of children's school computer use, understanding exposure patterns in this environment is important for understanding potential risk factors for children's health and development.

Home computer use has previously been reported to involve the use of educational and recreational activities, and involve parents, siblings, friends or students on their own (Orleans and Lacey, 2000; Olson *et al*., 2007). This study's findings confirmed a range of activities were used at home, particularly social activities. It also confirmed that the nature of computer use was influenced by age and gender. Exposure to computer activities increased with age, except gaming and learning programs which peaked around 10 years of age. Given the nature of younger children's computer exposure (increased frequency of games and learning programs) it is not surprising that this study found that younger children were more likely to involve others, including parents, in their computer use. These types of computer activities can be social and performed with others and potentially parents would assist with learning programs if assistance was required to understand or complete activities. This study's findings of older students being more likely to use computers on their own is likely to also be due to the nature of their computer exposure, for example multimedia, surfing the internet and social activities. Orleans and Lacey (2000) reported that adolescents whose parents were less involved in their children's computing were more likely to socialize using the computer. The use of email, more often by girls, and surfing the internet, more often by boys, were found to be the most frequently used home computer activities that increased with age. Kent and Facer (2004) also found more frequent use of social IT activities at home with older children, suggesting this occurs to allow students to continue their social networks.

Some aspects of computer exposure were found in this study to be similar at school and home. These similarities included increased amount of exposure with age, and similar nature of computer activities with each age group at school and home. These similarities demonstrate the importance of the relationship between the computer *user* and exposure. Even though the environment has been shown to be related to the amount and nature of the computer exposure, the individual user's own characteristics are also important. This finding supports the importance of multivariable modeling as discussed in the Introduction of this thesis, and provides support for user correlates to be included in models. For example, within adult work environments with set work tasks the individual correlates relating to personality, demographics, lifestyle, experience, health, psychosocial and physical factors, have been shown to be associated with exposure to tasks and related musculoskeletal outcomes (Armstrong *et al.,* 1993; Cole and Rivilis, 2004; Karsh, 2006).

Children with greater *personal* access to IT have been found to have greater TV and electronic game exposure, thus potentially effecting young people's health and development (Borzekowski and Robinson, 2005; Roberts *et al.*, 2005; Marshall *et al.*,2006; Olson *et al.*, 2007). Current study findings show that greater access to computers, in this case a bedroom computer, was associated with greater home computer use. This was evident in terms of the amount and nature of the computer exposure. Greater exposure, in addition to risks associated with less supervision and potentially more sustained and awkward postures, mean special attention should be given to bedroom computer use within the home environment.

10.2.4 Relationships between user correlates and computer related musculoskeletal outcomes

User correlates have been shown to be related to musculoskeletal outcomes in both adult (Armstrong *et al.*, 1993; Mathiassen, 1993; Kuorinka and Forcier, 1995; Moon and Sauter, 1996; Kumar, 2001) and children's computer literature (Li and Buckle, 1999; Burke *et al*., 2002; David, 2005; Reneman *et al.,* 2006). This section discusses child related user correlates used within this study (age, gender, other activity exposure, somatic complaints, psychological and NSES) and their association with computer related musculoskeletal outcomes.

10.2.4.1 Relationships between age/ Year level and gender, and computer related musculoskeletal outcomes

Within child related literature, computer exposure and musculoskeletal outcomes are associated and reportedly increase with age (Ramos *et al.*, 2005). Findings within the current study were consistent with this literature. Age was positively related to computer exposure in both school and home computer environments. Path analysis showed a direct relationship between age and Home computer related musculoskeletal outcomes, and an indirect relationship between *age* and School computer related musculoskeletal outcomes via computer exposure.

These findings were not surprising given the results of the study demonstrating an increase in the frequency and durations of school and home computer exposure. With increased exposure with older children the potential risks of sustained postures, static loading and repetition are more likely to occur.

Female gender has usually been associated with increased computer related musculoskeletal outcomes (Wahlström, 2005). Females are reported to experience a greater incidence of musculoskeletal outcomes in general (Diepenmaat *et al*., 2006), and related to computer exposure (Blatters and Bongers, 2002; Sjolie, 2004; Hakala *et al.*, 2006).

Results from the current study are consistent with recent literature, that being a girl was associated with greater musculoskeletal soreness. Final path analysis also demonstrated that female gender was related with both School and Home Computer Related MSS. Within this study girls also reported experiencing more somatic complaints, moderate computer anxiety and more 'butterflies in the stomach'. They were however found to have less exposure to computers, and other activities such as MVPA and electronic games. Girls may be likely to be more at risk of computer related outcomes due to their general predisposition to musculoskeletal outcomes, however as this finding was associated with Year 9 and 11 girls only it may also be related to the adolescents physically developing at this age. This finding demonstrates the interplay of age and gender and therefore the importance of this analysis. Additionally, as girls were found to have less exposure to activities such as MVPA, they may not be gaining the protective mechanism that these types of activities can afford.

10.2.4.2 Relationships between other activity exposure and computer related musculoskeletal outcomes

Children's exposure to other IT activities, such as TV watching, mobile phones, and electronic games, has been shown to be positively related to computer exposure (Rideout *et al.,* 2010). Within the current study, exposures to school computer, home computer, electronic games, mobile phones and TV watching were also positively correlated with each other. Furthermore these IT activities were found to be positively correlated to the frequency of computer related musculoskeletal outcomes. TV watching frequency and duration were also shown to be positively and indirectly related to school and home computer related MSS via computer exposure in the final path analyses.

Given the sedentary nature of many of the associated IT activities in the current study, the potential for children to spend greater amounts of time in sedentary activities is demonstrated. Recent literature shows mixed findings between children's IT related sedentary lifestyles and health and development. The current study's findings of these sedentary IT activities being positively associated with each other, demonstrated potential risks with greater IT exposure. Given the significant findings of the relationship between the amount of TV watching exposure and school and home computer exposure in both preliminary and final path analysis, the importance of investigating other IT activity exposure is demonstrated. Additionally, as other IT activity exposure is related to greater computer exposure, recommendations for wise use of IT should not be limited to computers in school and home environments, but should also include these other IT activities.

10.2.4.3 Relationships between psychological factors and computer related musculoskeletal outcomes

Psychological factors found to be associated with adult work related musculoskeletal outcomes are reflective of adult work environments and have included work demands (pace, work load, time pressure, deadlines, overtime), sensory demands (precision, visual demands, attention), cognitive demands (job control, decision making, memory, responsibilities), social support and quality of work (Moon and Sauter, 1996; Jensen, 2002). As children's computer exposure is different, different aspects of psychological factors including flow and computer anxiety were measured in the current study. Previous child related studies have demonstrated psychological factors, such as depression and personality traits of aggression and withdrawal, are predictive of computer related musculoskeletal outcomes (Burke and Peper, 2002; Diepenmaat *et al.*, 2006). These psychological traits were not included in this current study as these constructs were difficult to capture given the large scale study and questionnaire survey used.

Within the current study path analysis demonstrated that psychological measures of flow and computer anxiety were associated with musculoskeletal outcomes indirectly via computer exposure. The use of path analysis modeling within the current study was useful to shows these relationships as findings from only preliminary correlations showed no significant relationships between psychological measures and musculoskeletal outcomes. These findings are consistent with other child related literature, as previous studies have also used psychological measures, and their results haves shown an association between psychological factors (Burke and Peper, 2002; Diepenmaat *et al.*, 2006) and computer related musculoskeletal outcomes (Burke and Peper, 2002; Diepenmaat *et al.*, 2006). To ensure safe and wise use of computers for children from a psychological perspective, recommendations for appropriate school and home computer *exposure* therefore need to be considered.

10.2.4.4 Relationships between somatic complaints and computer related musculoskeletal outcomes

Somatic factors have been shown to be related to musculoskeletal outcomes in adult computer users (Blatter and Bongers, 2002). Limited child related literature has shown some evidence for a positive relationship between somatic complaints and IT use (Hamer's *et al.,* 2009). Somatic complaints (headaches, stomach pain) within the current study were a common complaint with ½ - ¾ of children reporting these outcomes. Final path analysis demonstrated the importance of considering these factors when investigating children's computer related outcomes. Somatic complaints (including headache and stomach pain) were directly related with musculoskeletal outcomes, with stomach pain shown to be the strongest predictive factor in analysis, greater than school and home computer exposure.

The current study's finding of a positive association between somatic complaints and Computer Related MSS indicated that children with greater reports of somatic symptoms experienced greater frequency of Computer Related MSS. Given this association, children's symptoms are potentially from shared etiology. Recent adult studies have demonstrated common neurobiology with underlying patho-physiology of chronic pain and somatic complaints, leading to evidence for shared mechanisms of symptom manifestation (McFarlane, 2007). Furthermore, this relationship is shown in Sauter and Swanson's Ecological model of musculoskeletal disorder in VDT work with the model depicting the influence of the cognitive interpretation of somatic symptoms reliant on the detection and attribution of sensations. Somatic complaints are therefore important to consider when investigating musculoskeletal risk factors associated with computer exposure.

10.2.4.5 Relationships between NSES and computer related musculoskeletal outcomes

Recent research demonstrates a link between young people's prevalence of musculoskeletal outcomes and family member's experience of musculoskeletal outcomes (Hakala *et al.,* 2006; Reneman *et al.,* 2006; Murphy, 2007; El – Metwally *et al.*, 2007). However, further evidence for associations between aspects of neighbourhood socioeconomic status (NSES) and children's musculoskeletal outcomes is limited, with no significant associations with children's computer related outcomes in the two available studies (Sjolie, 2004; Hakala, *et al*., 2006).

Within the current study, preliminary analysis found that NSES was also not associated with children's musculoskeletal outcomes. However in path analysis when other factors were controlled, NSES was found to be predictive of musculoskeletal soreness indirectly through school and home computer exposure. The weak positive relationship between NSES and school computer exposure demonstrated that children from high NSES backgrounds were more likely to have greater school computer exposure, which in turn was shown to be related to greater frequency of computer related musculoskeletal outcomes. The weak negative relationship between NSES and home computer exposure demonstrated that children from low NSES backgrounds were more likely to have greater home computer exposure, which was also shown to be related to greater frequency of computer related musculoskeletal outcomes.

These results demonstrate the importance of NSES in further analysis when investigating children's computer related musculoskeletal outcomes. It also shows the importance of multivariable analyses to investigate potential risk factors for children's computer related musculoskeletal outcomes. NSES has been shown to be associated with children's computer exposure, with the influence of NSES differing depending on the school or home computer environment. Given these results, recommendations for wise IT use should be appropriate in both school and home environments with children from all NSES backgrounds.

10.3 OUTCOME MEASURES

10.3.1 Computer exposure

10.3.1.1 Amount of computer exposure

Previous literature has demonstrated the use of different measures to determine children's computer exposure patterns, with the importance of using more than one aspect of exposure demonstrated (Harris and Straker 2000; Jacobs and Baker, 2002; Fuchs and Wößmann, 2005). This study's use of multiple exposure measures was effective in demonstrating different patterns of school and home computer exposure.

Frequency of computer exposure was important, showing consistent and significant relationships with user correlates and musculoskeletal outcomes, with frequency of exposure being usually the strongest single exposure measure. This finding is different to recent literature relating to children's computer exposure musculoskeletal outcomes. Both Harris and Straker (2000) and Jacobs and Baker (2002) found associations between duration, rather than frequency, of computer exposure and musculoskeletal outcomes. These studies however used preliminary analysis for these results. Additionally, limitations in these studies of predominately a female sample and narrower exposure focus with laptop computer use (Harris and Straker, 2000) and home computer use (Jacobs and Baker, 2002) may explain their different results.

However, duration of exposure in this study was also important. Duration of IT activities, including school and home computer, TV, writing, reading, mobile phone and electronic games, were positively correlated with each other. Greater exposure of one type of activity was therefore associated with greater exposure to other activities. However frequency measures did not necessarily demonstrate the same relationship as some IT types were not always positively correlated, for example electronic games and home computer were associated with *decreased frequency* of reading.

Additionally, the use of usual and longest *duration* and mean weekly hours demonstrated the significant differences between school and home computer use. While frequency of school and home computer use was similar, the results of duration measures demonstrated that home computer exposure was for longer durations at each sitting and overall accumulated exposure. Previous studies linking computer exposure thresholds and prevalence of musculoskeletal outcomes (Sjolie, 2004; Hakala *et al.,* 2006; Kelly *et al*., 2009) show that durations of computer exposure are important to measure as they indicate potential risk from sustained postures. As the potential for sustained postures, which have been linked to musculoskeletal outcomes in adult and children IT users (Harris and Straker, 2000; Ramos *et al.*, 2005), is greater in the home environment parental guidance to control this potential risk factor is required.

Combining exposure measures (frequency and duration) to construct an overall computer exposure variable for modeling has previously been used, for example," no use", "moderate use" and "high use" (Burke and Peper, 2002). The use of the constructed variable (frequency and duration) allowed for both computer exposure measures to be used simultaneously in the path analysis, thus providing different aspects of exposure, to be included. Results from this study's path analysis demonstrated the direct relationships between computer exposure and computer related musculoskeletal outcomes, thus demonstrating the impact of both exposures of frequency and duration. This includes computer activities that can therefore be frequent with short durations, or a long duration activity that is less frequent.

10.3.1.2 Nature of computer exposure

The nature of children's computer exposure has previously been investigated to understand children's exposure patterns (Rideout *et al.,* 2010). As the amount of children's computer exposure has increased, the nature of the computer exposure has also changed. As computer technology is changing, computer activities are evolving and replacing each other. This was demonstrated in Rideout *et al.*'s, 2009 study. Computer activities that were not included in their research 5 years ago were found to be two of the most popular computer activities used in the 2009 study.

Given the pace with which the nature of children's computer exposure is changing, current research quickly becomes out of date. As seen in this study, understanding the nature of children's computer exposure is important to understand the potential musculoskeletal risk. Researchers therefore need to keep pace with the changes in IT to ensure adequate characterization of the amount and nature of the computer exposure, and therefore to understand the risk factors for children's health and development.

Another challenge for future research on children's IT exposure is to capture the concurrent and multi-tasking nature of children's use of a variety of IT, including repetitive IT tasks such as mobile phone texting. To date exposure measures often target the primary IT type being used, and if various IT types are investigated simultaneous exposure is not necessarily measured (Olds et al, 2009). However given recent findings from Rideout *et al*. (2010), of children multi-tasking for 29% of the 7.38 hours of daily IT use (creating a total IT exposure on average 10.45 hours per day), consideration of suitable measures is required. As technology continues to develop in terms of activities and connectivity, small devices that could be worn or attached to computers interfaces to capture children's amount and nature of exposure are likely to be available.

10.3.2 Computer related musculoskeletal outcomes

Previous child computer research have used different outcome measures to investigate computer related musculoskeletal outcomes. These have included a narrow characterization by investigating only one or two aspects of the outcome, eg. lifetime prevalence of symptoms (Jacobs *et al.,* 2009) or duration and location of symptoms (Diepenmat, 2006). Terminology for symptoms has also been varied including terms such as "pain," "discomfort" and "disorder". The use of these terms does not appear to be consistent, and different studies have interpreted the meaning of these terms differently. Few studies have attempted to characterize computer related musculoskeletal outcomes by evaluating the impact of the outcome. Two studies that have included the impact of the musculoskeletal outcomes are Ramos *et al.* (2005) and Coleman *et al.* (2009). These studys' findings showed the impact of Computer Related

MSS included limitations in activity, loss of function, and increased treatment in terms of access and cost.

Within the current study, the use of range of outcome measures (frequency, intensity, location and impact) did contribute to a greater understanding of the issues associated with children's IT exposure. For example, when reviewing electronic games and locations of soreness, neck and low back were most prevalent. Further information on the intensity of soreness showed that the right upper limb body location had the strongest intensity scores for this activity.

Home computer related outcomes within the current study were also well characterized with the use of multiple measures. Frequency of soreness was found to be positively associated with exposure, indicating greater soreness with more exposure. Neck and low back locations were most prevalent for home computer exposure, and these locations had the highest mean intensity scores. The use of these measures together build a profile for home computer outcomes, showing frequent and long durations of exposure were associated with increased likelihood of moderate intensity neck and low back soreness. This characterization of outcomes provides evidence for the validity of the children's responses across the 4 outcome measures, as the results from these 4 outcome measures are what would be expected given the body mechanics and biological responses required for these activities. For example, as children is this study reported predominately sustained seated postures for home computer use, as expected the body locations of neck and back were affected. Additionally, given evidence for a dose-response relationship with computer exposure and related outcomes, moderate intensity of soreness is therefore likely in these anatomical body locations.

Anatomical body location as an outcome measure for computer related musculoskeletal outcomes showed within the current study that soreness was experienced in different anatomical body locations depending on the IT type used. The most common anatomical body locations (neck, low back, upper limbs, and lower limbs) of outcomes within this study were consistent with findings from other studies (Ramos *et al.*, 2005; Hakala *et al.*, 2006; Breen *et al.*, 2007). The current study's findings of most common anatomical body locations are biologically sensible when considering the body mechanics required for use of the IT type. These findings are also consistent with adult and college student study's demonstrating relationship with body locations and risk factors for work related discomfort (Punnett and Wegman, 2004; Chang *et al.,* 2007). Examples within the current study related to both computers and other children's activities including neck and low back soreness with computer use and lower limb soreness with MVPA.

Intensity of musculoskeletal outcomes within the current study was not associated with computer exposure. Two possible reasons include (a) children not being able to accurately report soreness using the numerical rating scale, or (b) as the study is cross sectional, with increased intensity of soreness children may have modified their behaviour thus limiting their activity exposure. Additionally if health professional attention was sought (as indicated by children within the current study) and children were treated for their soreness, it would be expected that intensity of their soreness would be reduced.

The impact of computer related musculoskeletal outcomes in this study was measured by 3 behaviours. These included reports of activity limitations, medication uptake and health practitioner consultations. Findings within the current study on those 20% of children reporting computer related musculoskeletal outcomes included 30% of children limiting their activity, 10% taking medication and 7% visiting treating practitioner. These findings are consistent with other studies researching the associations between children's activities and outcomes. Sjolie (2004) when investigating low back pain and adolescents activities (including physical activity, computer, TV and reading) reported of those with low back pain, 24% change of activity, 10% taking medication and 12% undergoing treatment.

However *impact* within the current study was not found to be significantly related to computer exposure. This could be explained by this study's cross sectional design as increased soreness may have modified their behavior, therefore limiting their activity. Additionally, as any of these behaviours are dependent on familial (parental assistance and resources) and personal (coping mechanisms) factors the three behaviours used to define impact in this study may not be adequate to measure these factors.

Children within the current study reported frequent computer related musculoskeletal outcomes with moderate intensity in a range of locations. Furthermore, findings of activity limitation and seeking medical and treating practitioner support, indicate that children's musculoskeletal outcomes are not a trivial complaint. Additionally, as recent literature (Murphy *et al*., 2004; Jefferies 2007) indicates that children's experience of musculoskeletal outcomes in childhood can track into adulthood, the potential for a predisposition to further musculoskeletal outcomes is of concern.

10.4 LIMITATIONS AND STRENGTHS

Limitations of this study included; 1) the use of a cross sectional study design; 2) self-report for exposure and outcome estimates; 3) with limited evidence of psychometric properties; 4) lack of family based SES measures; 5) limited exposure measures for school and home computer activities and 6) the sample not representative of the general population for BMI.

A cross-sectional study design was used in this study to gain an understanding of the relationships between user correlates, computer exposure and musculoskeletal outcomes across a range of ages and both genders at a point in time. While this does not demonstrate longitudinal patterns of IT use, or allow for causal relationships to be interpreted, it is an essential first step (Gillespie, 2002). This study design did allow a large sample of data to be collected at one time and capture a 'snap shot' of technology related activities and outcomes. This information can then be compared to later data as technology and usage patterns change (Roberts *et al.,* 2005).

Children's computer exposure data collected in 2009 (Rideout *et al.,* 2010) has shown that children's computer use has continued to increase, with children now being able to generally interact with IT for 10.75 hours per day taking into consideration multi-tasking of different IT types. Computer use is reportedly performed daily for 46 minutes (8 – 10 year olds); 106 minutes (11 – 14 year olds); and 99 minutes (15 – 18 year olds) (Rideout *et al.,* 2009), and reportedly facilitated by the availability of internet access, mobile and online IT. These results are different from this study's data which was collected in 2006. These differences demonstrate that computer technology and patterns have changed over this short time and may have become greater based on studies from different countries.

Use of a self report measure to collect exposure data was another limitation to this study. Data collection was based on different reporting methods for each of the 2 survey questionnaires, self report for Years 6, 9, and 11, and parents and child reports for Year 1 children. Previous research has shown self report measures can increase error (Schmitz *et al*., 2004; Marshall *et al*., 2006) when compared with observation/direct measurement. This has been demonstrated by over- (Hussey *et al.*, 2007, Mikkelson, 2007) or under-estimating frequency, durations and the nature of IT use (Schmitiz *et al.,* 2004).

In support of self report measures, children's end of day self- reports of time spent in different occupations, including IT related activities, were found to be valid when compared with observations (Ciccarelli, 2008). Furthermore, within the adult literature, self reported ergonomic exposures have been reported to be adequate for many epidemiological purposes. Moderate correlations between physical exposure and outcomes have previously been derived from questionnaire data (Punnett and Wegman, 2004). For large sample exposure information self report questionnaires are still reportedly the method of choice (Craig *et al*., 2003; Hussey *et al*., 2007). Furthermore, self report methods are most commonly accepted to assess psychological user correlates in relation to exposure related outcomes (Wahlström, 2005).

Additionally, the use of self report measures via questionnaire format to assess computer related musculoskeletal outcomes such as 'soreness' are a limited measure when compared with measures used in some adult based studies. Marcus *et al.* (2002) in their prospective study of 632 office based used questionnaires to identify prevalence, location (neck/shoulder and hand /arm) intensity and impact of discomfort. However, to further support these findings clinical interviews and/ or physical assessments were used to determine if the workers met criteria for specific disorders. Limitations however with this study showed poor agreement for clinical diagnoses and as the sample size was smaller less power.

Although the YAQ survey tool has previously been used with children in computer exposure studies (Harris and Straker, 2000), there is limited evidence of its psychometric properties in regards to validity and reliability. As outlined in the Methods section of this thesis, prior studies have shown evidence for measures used within the tool. Exposure measures (Harris and Straker, 2000; Jacobs and Baker, 2002), psychological measures (Arrowsmith, 2002), somatic measures (Murphy *et al.,* 2007) and musculoskeletal outcome measures (Taimela *et al.,* 1996; Murphy *et al.,* 2004; Ramos *et al.,* 2005; Breen *et al.*, 2007; Sommerich *et al.*, 2007) used within the YAQ have been demonstrated in previous child related computer exposure studies. Where possible recognized scales were used, eg Flow Measure by Webster, Trevino and Ryan (1993), and the Computer Anxiety Scale from Lloyd and Gressard (1984). Additionally, height and weight measures used standard protocols.

Child reports of family based SES measures such as parental education level and/or parental income and perceived socio-economic level were not used in this research, nor were government estimates of median income for the postcode of each participating school. Errors can occur with these methods as children of different SES backgrounds as defined for example by income or parent education levels, attend schools that have been allocated a different SES category based on the majority of their students SES background. Additionally, children may not fully understand their parents' occupations, or know details of family income or the educational levels attained by their parents. This study used reports of children's primary resident postcode as it is expected that the children were able to recall and report on the name of their own suburb. Additionally, Turrell *et al*. (2007) found that the use of local area postcode was adequate in measuring the nature and extent of mortality rates. Similarly, Olds *et al.* (2006) found a relationship between NSES and screen time, however this was mainly due to TV viewing, not computer use or video game playing. An examination of the sample Index of Relative Socioeconomic Advantage Disadvantage (IRSAD) (ABS, 2006) showed a good range of SES in the sample.

Within this study's sample the majority of participants were within a healthy weight range with approximately 17% of children being either overweight or obese. Given figures in 2008 (Dowling, 2008) showed that 25% of Australian children were overweight or obese, this sample may be over representative of children of a healthy weight range when compared with the general Australian population.

Strengths of the study included a large, representative sample of children across a range of ages, including both genders and across a range of SES. Separate data on school and home computer exposure (amount and nature) and a range of other activity exposures, using a range of exposure measures was essential to understand computer exposure patterns. Additionally a combination of musculoskeletal outcome measures relating to children's activity exposures were collected. The large sample size allowed for path analysis and multivariable modeling to be performed in order to meet the overall aims of the study.

10.5 FUTURE DIRECTIONS

Given the limitations of this study, future study directions are suggested that involve the use of different research designs and methods, and further outcome measure development.

Although there is no study to date that has demonstrated a clear and indisputable casual relationship between any of the risk factors and precipitation of work related musculoskeletal outcomes (Kumar, 2001) there are many studies with moderate to strong evidence demonstrating an association between multidimensional risk factors and musculoskeletal disorders (Lanfranchi and Duveau, 2008). These studies have involved prospective longitudinal designs and used internal physical exposure measures such as muscle activity and posture. Further research with children that involves the use of physical observation and clinical assessment for musculoskeletal outcome measures is recommended. These research methods will allow data to be collected on potential physical and individual risk factors to further understand the relationships between these factors, computer exposure and musculoskeletal outcomes.

While parent / child reports of IT exposure were suitable for this study to gain the required sample size, data collected was based predominately on self reports. In future research to assist with the validity of using a large survey, the use of other data collection methods such as electronic computer activity monitoring would be useful.

As discussed the YAQ-II and YOAQ questionnaires have been used in previous studies, however limited psychometric testing has been performed on this tool. Future research to ensure the validity and reliability of these measures is recommended.

Results from this study demonstrated that both the amount *and* nature of IT exposures were important in understanding children's exposure patterns. Additionally, the use of multiple exposure measures (frequency and duration) was also important. However, as only the frequency of different school and home computer activities (eg. surfing the internet and email) were investigated, further research needs to include duration measures of usual, longest and mean weekly hours to assist in a greater understanding of the nature of school and home computer use.

A combination of exposure measures in the current study allowed for better characterization of exposure. However to further understand computer exposure patterns, exposure measures that provide information on the pattern of use over time (day and week) is required. The use of measures such as the Multimedia activity recall for children and adolescents (MARCA) (Ridley *et al.*, 2006), with tested psychometric properties, would be beneficial. Given evidence for the high day–to -day variability in children's activities during a week and over a weekend, any tool would need to be used over a range of days to ensure habitual activity exposure was captured adequately, while minimizing respondent burden (Baranowski and de Moor, 2000).

Given this study's sampling frame, the pattern of computer exposure reported here is likely to be representative of children in an Australian metropolitan context. Further research should explore these patterns in samples from other cultures and rural and remote locations. Given that technology continues to change and new technologies are being further integrated into children's school and home activities, exposure patterns are constantly changing. Future research methods and measures need to reflect these changing IT environments and have suitable and contemporary clinical utility. Additionally, all computer activities and types should be assessed using a combination of exposure measures, such as frequency and duration measures as used in this study, to ensure a good understanding of exposure patterns.

Exposure measures used within the adult literature to assess work related musculoskeletal discomfort often involve the assessment of factors such as physical (force, posture), dose (frequency and duration) and user correlates (eg. stress / anxiety / social) (Bridger, 2009). This study used exposure measures that were conducive to a survey design, however this did not provide the opportunity to capture adequate data relating to physical factors associated with children's computer exposure. Physical measures to assess children's computer postures and their school and home computer work stations are recommended. Given that recent literature pertaining to computer related musculoskeletal outcomes show evidence for relationships with physical factors (Breen *et al.,* 2007, Jacobs *et al.,* 2009; Kelly *et al.,* 2009) this physical environment information would be useful for future path analysis and modeling of these relationships.

Outcome variables investigated within the constraints of this study were related to computer exposure and musculoskeletal outcomes only. Recent literature has however shown that children's computer exposure is also associated with educational, cognitive and psychosocial outcomes. Further research and modeling involving these outcome variables is recommended to understand the overall impact of IT on children's health and development.

10.6 IMPLICATIONS

Results from this study provide a unique contribution to the body of knowledge pertaining to children's exposure to computers and associated risk factors. Findings show that children's computer exposure is an important part of daily life. However, findings also demonstrate that musculoskeletal outcomes are associated with children's computer exposure. These outcomes are common, typically involving the neck, back and arms, of moderate intensity, and in a proportion of cases impact on children's activity participation and require treatment. Computer related musculoskeletal outcomes in children are therefore not trivial, and recommendations are required to assist in managing the associated risk factors.

Children's computer exposure is expected to continue to increase with the introduction of new engaging technologies, and the further integration of IT into children's everyday activities. It is therefore anticipated with this increased computer exposure there will be further associated musculoskeletal outcomes. Additionally, as findings from this study indicate predominately the short term effects of children's computer exposure, longer term effects still remain unknown. Recent literature has indicated that musculoskeletal outcomes occurring in adolescence track into adulthood, and therefore are viewed as predictors of future musculoskeletal outcomes. The potential for an increase in the amount and nature of musculoskeletal outcomes in adulthood is of concern.

Computer related musculoskeletal outcomes in children have been shown to be a complex issue, with associated potential risk factors identified including a range of user characteristics and school and home computer exposure. As outcomes were found to be associated with both school and home environments, recommendations for safe and wise use of computers needs to be implemented in both locations. Additionally, as different aged boys and girls use computers in different ways, targeting interventions to take these user correlates into consideration are required.

Parents, educators, schools and governments have a responsibility to ensure that the use of computers in their respective environments is performed in a safe and productive manner. Furthermore, as governments report the roll out of improved IT connectivity and additional hardware for all students, they need to provide adequate resourcing. This should include teacher training for the implementation of computers into the curriculum. Parents also have a responsibility that the home environment is set up for safe and productive use. This should include modifications for physical risk factors, and take into consideration the nature of children's computer use given their NSES background, age, gender and social environment. Within the community, health practitioners treating children with musculoskeletal outcomes have a responsibility to also assist in education and prevention. Researchers and academics need to continue to provide guidance on ergonomic recommendations and guidelines for wise use of IT, eg. Straker *et al.* (2010b). Additionally, all of these interventions need to be specific to the child computer user using computers for their normal daily occupations, including school and home.

11.0 Conclusion

Computer use is an important activity in children's lives, with children as young as 5 years, through to 18 years, having substantial exposure in a range of computer environments. Children's computer activities are reported to include school and leisure activities such as playing games, communication and social networking, watching video websites, surfing the internet, reading and writing documents, downloading music, graphics and photos.

Recent literature demonstrates an increase in children's reports of computer related musculoskeletal outcomes. Risk factors and models explaining the causation of computer related outcomes have previously been defined by studies of adults in their work environments. However, as children's computers use appears to be different to adult's work related computer use, risk factors and models of causal relationships between computer use and musculoskeletal outcomes may vary for children.

The main aims of this study were: (1) to investigate children's computer exposure in their usual occupational environments of school and home; and (2) to develop and test a model that would assist in understanding relationships between child user correlates, computer exposure and computer related musculoskeletal outcomes.

1351 students (792 boys and 559 girls) from eight primary and five secondary schools in Perth, Australia, participated in the study. Convenience sampling was undertaken to ensure the sample had the required range of participants from different socioeconomic status (SES) backgrounds, both genders and school Years 1, 6 9 and 11(approximately ages 6, 9, 14 and 16 years).The study design was cross sectional involving the completion of a questionnaire survey by participants, and for younger participants their parents. Questionnaires contained items relating to the participant and their activity exposure as an individual, within a family context, and within their neighbourhood. Physical measures of height and weight were also collected.

The results showed that 100% of children had access to computers at school, and at home 98.9% of children had access to computers, with 95.9% reporting home internet. The use of different exposure measures demonstrated that at school 97.8% of children had used a computer in the last month, for an average of 2.4 hours per week, commonly for 30-60 minutes in one sitting. At home 95.7% of children had used a computer in the last month, for an average of 7.2 hours per week, commonly for 60 - 120 minutes in one sitting. Computer activities performed more frequently at school were surfing the internet, learning programs and multimedia. At home the most frequent computer activities were surfing the internet and email. Children with bedroom computer access were found to have nearly 50% greater mean weekly hours of use. The use of a range of computer exposure measures (frequency, usual and longest duration, mean weekly hours and frequency of computer activities) provided better characterization of the amount *and* nature of children's school and home computer exposure. This information on children's school and home computer exposure patterns provides valuable information to assist further research on children's computer exposure and associated outcomes.

Age and gender were associated with children's school and home computer use. Computer use was greater with age for both boys and girls, and boys had greater use than girls across all Year levels for all exposure measures except school usual duration. Children with greater computer exposure were shown to experience less computer anxiety; reported more somatic complaints; had used a broader range of computer activities; had greater exposure to other IT activities (electronic games, TV, mobile phone) and moderate vigorous physical activity. SES was associated with computer exposure, with children from low SES backgrounds having greater home computer exposure, and children from high SES backgrounds having greater school computer exposure.

Computer related musculoskeletal outcomes were reported by 10% of children for school computer use and 20% for home computers. The most commonly affected body locations were the neck and back, and 30% of those children reporting outcomes limited their activity participation, 10% took medication and 7% consulted a treating health professional. The use of a range of outcome measures allowed for a better understanding of the impact of children's computer related musculoskeletal outcomes.

Given the significant findings of different relationships between children's computer exposure patterns at school and home, two models were developed and tested, with one model for school computer exposure and one model for home computer exposure. Path analysis modeling, accounting for user correlates, demonstrated that school and home computer exposure were associated with children's musculoskeletal soreness.

The final school computer exposure model showed direct relationships between gender, somatic complaints, computer exposure and musculoskeletal soreness; and indirect relationships, via computer exposure, between age, computer flow, TV exposure, SES and musculoskeletal soreness. The final home computer exposure model showed direct relationships between gender, age, somatic complaints, computer exposure and musculoskeletal soreness; and indirect relationships, via computer exposure, between age, computer flow, computer anxiety, TV exposure, SES and musculoskeletal soreness.

Limitations of the study were primarily related to the cross sectional study design, self report for exposure and outcome estimates with limited evidence of psychometric properties. Strengths of the study included a large representative sample of children from across a range of ages, including both genders and a range of SES backgrounds. The large sample allowed for multivariable path analysis and modeling to be performed in order to meet the overall aims of the study of developing a model as a conceptual framework for understanding children's computer related outcomes.

In conclusion, the child specific models tested within this study demonstrated direct relationships between children's computer exposure and musculoskeletal outcomes. Additionally, direct and indirect relationships (via computer exposure) were also shown between a range of user correlates and musculoskeletal outcomes. These models demonstrated that child computer users are different from adult computer users in work environments, and thus reflect the unique characteristics of children, their computer environments and musculoskeletal outcomes. These findings will assist researchers, teachers and parents to understand the range of potential risk factors for children's computer related musculoskeletal outcomes. This will also allow researchers to target interventions to child users and their computer environments to ensure children's computer use is performed in a safe and productive manner.

12.0 References

Every reasonable effort has been made to acknowledge the owners of copyright material. I would be pleased to hear from any copyright who has been omitted or incorrectly acknowledged.

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Appendices

APPENDIX A – Initial Ethics Application

APPENDIX B – Ethics Application – Form B Changes, Parent and Guardian Information Forms – Short Form

APPENDIX C – Ethics Application – Form B Changes, Parent and Guardian Information Forms – Long Form

APPENDIX D – YAQ II – Young People's Activity Questionnaire

APPENDIX E – YOAQ – Year One's Activity Questionnaire

APPENDIX F – Harris, C., Straker, L., Pollock, C. & Trinidad, S. (2005). Musculo-skeletal outcomes in children using information technology–the need for a specific etiological *International Journal of Industrial Ergonomics, 35*, 131-138.

APPENDIX G- Harris, C., Straker, L. & Pollock, C. (2007). Children's Exposure and Use of Information Technology, *Proceedings from The 43rd Annual Conference of the Human Factors and Ergonomics Society*, Perth, Western Australia, November, 2007.

APPENDIX H- Harris, C., Straker, L. & Pollock, C. (2009). Young people's home, school and neighbourhood can influence their computer use. *Proceedings from the International Ergonomics Association Conference*, Beijing, China, August, 2009.

APPENDIX I - Harris, C., Straker, L., Pollock, C. (2010). Musculoskeletal outcomes in children using home computers – A proposed model. *Proceedings of the International Conference on Prevention of Work-Related Musculoskeletal Disorders (PREMUS)*, Angers, France, August 2010.

APPENDIX J- Harris, C., Straker, L., Smith, A. & Pollock, C. (Accepted subject to minor review 6 November 2010). The influence of age, gender and other information technology use on young people's computer use at school and home. *Work*.

Appendix A

Initial Ethics Application

Human Research Ethics Committee FORM A
APPLICATION FOR ETHICS APPROVAL OF RESEARCH INVOLVING HUMANS – New Application

Office use only HR ________

Curtin
UNIVERSITY OF TECHNOLOGY

All investigators applying for first-time ethics approval of the project in question should complete this Form (Form A). Applications for an extension of ethics approval can be made using a Form B.

INSTRUCTIONS FOR APPLICANTS

(a) Prospective applicants should refer to the *Application Procedures and Guidelines*, and the attached *Checklist* (appended to this application) to determine if an application is required. An application must be submitted if any of the *Checklist* questions are answered 'yes'.

(b) Applications should be word processed/completed electronically. This application form can be downloaded from the Research & Development website:
http://www.curtin.edu.au/corporate/research/ethics/ethics.html#HREC

(c) Applicants MUST refer to the NHMRC *National Statement on Ethical Conduct in Research Involving Humans* before submitting an application. This document can be accessed from the following website:
http://www.health.gov.au/nhmrc/publications/synopses/e35syn.htm

(d) Applicants are also advised to consult the *Joint NHMRC/AVCC Statement and Guidelines on Research Practice*, Section 2 "Data Storage and Retention"
http://www.health.gov.au/nhmrc/research/general/nhmrcavc.htm
and the NHMRC *Guidelines under Section 95 of the Privacy Act 1988*, Section 2 "Procedures to be followed by researchers"
http://www.health.gov.au/nhmrc/publications/synopses/e26syn.htm

(e) Applications MUST include all relevant attachments eg *Participant Information Form* and *Consent Form*; advertisements; letters of invitation; survey instruments (or if not yet developed, the proposed content of the instrument), list of questions for interviews; details of ethical approval from other Institutional Ethics Committees as applicable; and description of project as requested in Q7. These items are ESSENTIAL and must be submitted for consideration before approval will be granted.

(f) Completed applications, including **one original and two (2) copies** should be submitted to:
The Secretary, Human Research Ethics Committee, C/- Office of Research & Development, Curtin University of Technology, GPO Box U1987, PERTH WA 6845*

* Applications for undergraduate projects may be submitted direct to the Committee Member or Ethics Coordinator in the relevant School/Division for Fast-track approval – see *Application Procedures and Guidelines*

Project title	Development of a Model of Musculoskeletal Problems Associated with Children's Use of Information Technology
Principal investigator	Courtenay Harris — Student ID *(if applicable)*: 9862183E
School/area/organisation	School of Physiotherapy
Contact phone number(s)	9266 3634 — EMAIL: charris@cwim.com.au
Co-investigator(s)	
Project supervisor	Associate Professor Dr Leon Straker

Project or application Type

1. X **STUDENT please specify**
   - (i) Doctoral (eg, PhD) X
   - (ii) Masters by Research ☐
   - (iii) Masters by Coursework ☐
   - (iv) Honours or undergraduate ☐

   If (i) or (ii) above,
   Have you submitted an application for Candidacy? YES X NO ☐
2. **STAFF**
3. **EXTERNAL**

(i) If project type is staff or external please provide details

(ii) What is the estimated completion date of the project? December 2005

(iii) Has an application been made for a research grant for this project? If YES, please state the name of the granting body and the status of the application. **NO**

(iv) Has this project been approved by the Curtin Human Research Ethics Committee previously? If YES, please quote the approval number. **NO** X HR _____

(v) Is this project part of a larger study? If YES, please provide details. **NO** X

(vi) Is this project part of a multi-centre research project? If YES, please provide details of the other centres and the approval status of the study at each centre. **NO** X

(vii) Has this project been submitted or is it likely to be submitted to any other ethics committee? If YES, please supply details including approval dates and approval number. *Attach a copy of all relevant approvals.* **NO** X

(viii) Does this proposal involve:

(Research involving any of the categories listed below is subject to compliance with the provisions of the NH&MRC National Statement on Ethical Conduct in Research Involving Humans. *Please refer to the relevant chapters for details.)*

Please answer ALL questions with a tick

	YES	NO
Minors ie, under the age of 18 (chapter 4)	X	
persons with an intellectual or mental impairment (chapter 5)		X
persons highly dependent on medical care (chapter 6)		X
persons in dependent or unequal relationships (chapter 7)		X
collectivities (such as other specified racial groups) (chapter 8)		X
Aboriginal and Torres Strait Islander peoples (chapter 9)	X	
ionising radiation (X-rays, fluroscopy or radioisotopes) (chapter 10)*		X
assisted reproduction technology (chapter 11)		X
clinical trials (chapter 12)		X
innovative therapy or intervention (chapter 13)		X
epidemiological research (chapter 14)		X
use of human tissue samples (chapter 15)		X
human genetic research (chapter 16)		X

**For research involving ionising radiation, microwaves, lasers or ultraviolet light, researchers must submit a separate application to the Radiation Safety Officer, for consideration of approval by the Radiation Safety Committee. Research cannot commence without such approval.*

(ix) Please indicate the chapters you have consulted. Chapters 4 and 9

(x) Does your research comply with the provisions therein? **YES** X

(xi) Provide a brief description of the participants/collectivities involved.

Students from Years 1, 6 and 10, ages 5 – 17 years enrolled at different schools in metropolitan and regional WA. Approximately 500 students in each year will be recruited, with a gender balance if possible. An even number of schools have been selected based on low, medium and high socio-economic status as indicated by ABS 1996 Census Data and WA Education Department funding principles.

(xii) Will personal data be obtained from ~~a Government database or archive~~ a Commonwealth Agency? If YES, please specify. Eg. CHIC, CURFS (see Section 1.1 of the *Guidelines under Section 95 of the Privacy Act 1988*, "The use of the Guidelines")? **NO** X

PROTOCOL DETAILS

The main concern of the Human Research Ethics Committee in evaluating proposals is to establish conformity with the NHMRC *National Statement on Ethical Conduct in Research Involving Humans.* Researchers must comply with the provisions of the National Statement. Chapters 1 *Principles of Ethical Conduct* and 18 *Privacy of Information* are essential reading for all applicants prior to completion of the following questions.

All questions must be answered. Applicants are required to provide a brief summary **in the spaces provided.** This will assist in expediting the review process. Non-compliance with this request will result in the application being returned to the applicant.

1. **Provide sufficient procedural/experimental detail to enable the Committee to judge whether any risks to which the participants may be exposed are warranted by the possible benefits/outcomes of the study.** Your answer must demonstrate that the welfare, rights, beliefs, perceptions, customs and cultural heritage of the participants are observed; the risks of harm or discomfort to participants is minimised; and that respect for the dignity and well being of the participants takes precedence over the expected benefits.

There are no risks to the participants' safety, health and well being by participating in this research project. Participants aged 10 or more will be required to complete a questionnaire during class time, given the school's permission. A parent of students aged below 10 years will be required to complete the questionnaire at school with their child participating also. All participants will be supervised by the principal investigator and relevant school teacher when completing this questionnaire. The principle investigator will be available for any questions during the course of questionnaire completion.

The questionnaire will require approximately 30 –40 minutes to complete. Questions to answer are about the participants themselves; their participation in a range of activities at home and school and how they feel about participating in these activities. The students will complete the questionnaires by themselves at their desks. They will be required to measure their height and weight using a scale and rule during the course of the questionnaire. The researcher will be available to assist in this task. The students are expected to do this fully clothed with shoes off. The teacher will also complete 2 questions on the questionnaire regarding literacy and numeracy levels.

Selection of students will be from low, medium and high socioeconomic areas to reflect the population of computer users as fairly as possible. Private schools will be used to source the sample as public school systems are not available for this research at this stage. The catholic school system will be predominately utilized as it traditionally covers the range of socioeconomic levels required.

All students in selected classes will be able to participate should they choose and parental consent is given.

Students / and or parents who do not consent to participate in the study will be provided with other suitable school activities to complete during completion of the questionnaire in class.

2. **Provide detail that demonstrates the research is being conducted or supervised only by persons or teams with experience, qualifications and technical competence appropriate to the research.**

The principal investigator involved in this research project is currently undertaking a PhD program. This research is under the supervision of Associate Professor Dr Leon Straker who has been reviewing and monitoring the research to date. Candidacy was obtained in December 2001 for this current project.

The principal investigator has previously completed her Masters degree in researching information technology issues with school children using questionnaire data collection tools. Dr Leon Straker was also be the supervisor of this project.

3. **Describe how participants will <u>consent</u> to participate in the study, and how they are informed of their rights.** Please attach copies of the Participant Information Sheet and Consent Form intended for use. Approval cannot be granted until these documents have been submitted. *Your answer should demonstrate that the provisions of Section 1.7-1.12 of the National Statement have been satisfied.*

Prior to commencement of the questionnaires the students will be given information regarding the research including the purpose, methods, requirements, and possible outcomes, including the publication of results.
Students will then have the opportunity to voluntarily participate in the study. Additionally during the course of completing the questionnaires the students will be able to withdraw from participating at any time.

Parental permission will be gained for participation. For the year one students this will occur when the researcher meets with the parents, by obtaining the signed consent form. For the 10 and 15 year old students a letter to the parents will be given to the students to take to their parents. The letter will explain the purpose and procedures of undertaking the research and allow the parents to omit their child from participating in the research by returning the withdrawal to participate form. If a letter is not received by the class teacher from the parent then it will be assumed that the student is able to participate on the research. This method of consent will only occur if the school principal has agreed to and signed consent for this approach. Should the principal and school community wish for consent to be obtained via a written form prior to commencement in the research then this will occur. Please see the attached consent forms, subject information and withdrawal to participate forms.

It will be made clear to the participants that their consent/non-consent to participate in this research project will in no way effect them. Participants will be encouraged to discuss questions/concerns with the investigator and if/ when necessary Associate Professor Dr Leon Straker

4. **(i) Describe the extent to which issues of privacy are to be addressed in relation to the collection of data from individuals or groups, and the extent to which the collection intrudes upon the personal affairs of the individual or group.** *Refer to Appendix 2 <u>Information Privacy Principles</u>.* Your response should specifically address:-

(a) Justification if identified or potentially identifiable information is to be used rather than de-identified information
(b) Justification if consent is not being sought to use personal information.
(c) The specific uses to which the personal information used during the study will be applied.
(d) The proposed method of publication of results of the research

(a) Participants will be assigned a numeric code that will be written on the front cover of the questionnaire. This will be used to match consent forms / class lists and classes for data collection purposes. With regards to personal information participants will be required to include their age, gender, suburb they live in, initials, height, weight, school they attend, teacher's name; number of computers in the home, presence of any symptoms with their muscles / bones or joints, feelings they have towards different activities. A students name will not be written on the questionnaire at any time.
(b) Consent is being sought to gain and to use information from the questionnaire from the participant's and their parents.
(c) The investigator will use the findings of this research project to complete the written requirements of her PhD. Results gained will also be used at conference(s) and/or as a submission for publication to professional journals. Any data presented in written or verbal formats will comprise group data only, and not identify any participants.

4 **(ii) Provide details of the storage and security arrangements for personal information that will be collected within the study.** *Refer to the* *<u>Joint NHMRC/AVCC Statement and Guidelines on Research Practice,</u>* *Section 2 'Data Storage and Retention'* Your response should address

(a) The estimated time of retention of the personal information
(b) The identity of the custodian(s) of the personal information used during the research
(c) Security standards to be applied to the personal information
(d) List of personnel with access to the personal information
(e) Standards that will be applied to protect personal information disclosed by a Commonwealth agency (if applicable)

(a) The questionnaires will be held for a period of 5 years in a secure location at Curtin University, School of Physiotherapy.
(b) The principal researcher and Dr Leon Straker will be the only custodians of the information gained from the questionnaires.
(c) A list with participant's names, consent forms and their respective numeric codes will be stored in a secure location separate to where the numeric codes, raw data questionnaires and data analysis will be securely stored. Once again all information will be stored securely by the principal investigator at the School of Physiotherapy.
(d) The principal investigator, Courtenay Harris, will be responsible for securely storing the data collected during this research project. Dr Leon Straker as supervisor of this project will also have access to the data.

5. **State the proposed precautions to ensure confidentiality of results.** *Where personal information about research participants or a collectivity is collected, stored, accessed, used, or disposed of, a researcher must strive to ensure that the privacy, confidentiality and cultural sensitivities of the participants and/or the collectivity are to be fulfilled.*

Participants will be assigned a numeric code to ensure anonymity in the results. The participant list information with their name and code will be stored securely in the School of Physiotherapy, along with consent forms. The questionnaires will be stored in a separate locked location within the School of Physiotherapy.

6. **Provide a description of any survey instruments/questionnaires intended for use in the study, including questions/material intended for interviews/workshops and semi-structured interviews.** All such material must be submitted for approval. If the instrument has not been designed at the time of application, then a brief description of the anticipated nature of the questions must be provided. Instruments that are widely recognised as being standard in the field should be identified as such, or be available for viewing upon request. **Final approval will be dependent on the satisfactory submission of all instruments.**

- A questionnaire regarding the participant's involvement in a range of activities at school and home will be used. The questionnaire requires the participant to report on their participation (frequency and duration) in various activities during the previous month; and the nature and intensity of any discomfort experienced. Other questions relating to personal characteristics, and how they feel about school and activities will also be answered. The questionnaire will take approximately 30 –40 minutes to complete. Please refer to the sample questionnaire attached.
- The questionnaire has been designed by the principal investigator under supervision of Dr Leon Straker. Some questions used are from the School of Psychology honors students projects, with agreement from this student and his supervisor Dr Clare Pollock, who is an associate supervisor for the principal researcher.

7. **Attach a detailed description of the project using the headings below.**

- Aims/objectives of the study
- Background
- Significance/Justification of the study
- Methods (including - data to be collected and source of data; target population; study period; participant recruitment procedures, instruments)
- References

Do not attach copies of grant applications

Recommended length = 5-6 pages, excluding references. Research students may alternatively attach a copy of their research proposal. Pages should be numbered. Applicants are reminded to use non-specialist language.

SIGNATURES

Principal Investigator	Courtenay Harris	Date	September 17, 2002
Project Supervisor		Date	
Head of School *(only where investigator is a student)*		Date	

Checklist For Research Involving Humans Or Information About Humans APPENDIX

Does this research involve any of the following (please circle): *If you answer YES to any of the questions, you will be required to submit an application.*

1.	Any novel procedure in the therapy or management of patients in a clinical setting?	NO
2.	Any form of physically invasive procedure on patients such as blood collection, exercise regimes or physical examination, and which is not part of their clinical management?	NO
3.	Any form of physically invasive procedure on volunteer subjects such as blood collection, exercise regimes or physical examination?	NO
4.	The administration of any form of drug, medicine (other than in the course of standard medical procedure) or placebo?	NO
5.	Physical pain, beyond mild discomfort?	NO
6.	Obtaining and storage of blood, body fluid or tissue samples from the subjects?	NO
7.	The participation of minors (under 18 years), other than in the observation of normal classroom activity?	YES
8.	Participants who are in a dependent situation, such as students or residents of an institution (such as a hospital, nursing home or prison or patients highly dependant on medical care), other than those who are being observed in their normal environment where such observation is considered innocuous?	NO
9.	Subjects who are unable to give informed consent?	NO
10.	The intentional recruitment of Aboriginal or Torres Strait Islanders, or any other identifiable cultural or minority group or collectivity?	NO
11.	Acquisition of data about organisations or individuals through any form of database and in which those organisations or individuals are directly or indirectly identifiable?	NO
12.	Use of questionnaire or interviews through which personal data will be obtained and which may be linked either directly (through recording of names) or indirectly (through a cross-linked code) to the individual?	YES
13.	Use of questionnaire or interview, irrespective of the recording of the individual's identity, which might be reasonably expected to cause discomfort, embarrassment, or psychological or spiritual harm to the subjects?	NO
14.	Processes that are potentially disadvantageous to a person or group, such as the collection of information which may expose the person/group to discrimination?	NO
15.	Collection or disclosure of personal information by a Commonwealth agency that might involve a breach of an Information Privacy Principle (as defined by the Commonwealth Privacy Act 1988 and the Australian Standard)?	NO
16.	Payments or other financial inducements (other than reasonable reimbursement of expenses) to subjects for their participation?	NO
17.	Deception of the subjects including concealment and covert observation?	NO
18.	Disclosure of the response outside the research which could place the participants at risk of criminal or civil liability or be damaging to their financial standing, employability, professional or personal relationships?	NO

Parent Information Sheet

Title of Study: Survey to Identify Risk Factors Associated with School Children's Use of Information Technology (IT).

Chief Researcher: Ms Courtenay Harris, PhD student
School of Physiotherapy Curtin University of Technology.
0417993269

Purpose of the Study:
Children are participating in a range of activities everyday at school and home. Many of these activities involve the use of new technology such as desk top / laptop / palm computers, video games, electronic hand held games. These activities are engaging and research indicates that children are continuing to participate in these activities for longer durations and more frequently. Research to date on the effects of children participating in these types of activities indicate that some children experience discomfort as a result of their interaction.

This study will help us to better understand how children spend their time, the activities they participate in, and what activities and personal characteristics may contribute to children experiencing discomfort. In particular this study will help to identify factors effecting children with their use of both old and new Information Technology, eg. Reading and writing, computers, electronic games, watching television and playing video games. This will therefore enable and encourage children to use IT resources in educational, recreational and communication environments in a safe and productive manner.

Participants
This study involves surveying 1500 West Australian children from years one, six, nine and eleven during term 3 and 4 of 2006. Surveying of Mandurah Catholic College Students will be occurring at the College during the last two weeks of August 2006. Students from years one, six and nine will be participating in the research.

Procedures:
If you agree for your child to be in this study, you and / or your child will be asked to complete a questionnaire during school time. The questionnaire is approximately 16 pages and should take about 30 –40 minutes to complete. For students aged 5 or 6 years then you as the parent with your child will need to complete the questionnaire. If your child is aged 10 or more then it is expected that your child will complete the questionnaire themselves at school with their teacher and the chief researcher present.

Your child's teacher will also answer two questions on the questionnaire regarding your child's numeracy and literacy skill level. When the questionnaires are completed they will be taken by the chief researcher to collate the data.

Risks, discomfort and benefits
Your child's participation in the study will only occur if you and your child voluntarily consent to participate. As your School Principal has given his consent for this study to

take place during class time, the study will occur at school. If you DO NOT wish for your child to participate you MUST return the enclosed withdrawal form prior to completion of the questionnaires.

The costs to you and your child will be the time taken to complete the questionnaire, which we anticipate will be 30 – 40 minutes. There are no risks associated with participation in this research.

Your child will be expected to answer some personal questions however these are related to their date of birth, suburb they live in, class teacher's name, initials, school they attend, and any history of health problems with their muscles, bones or joints. Questions will also be asked on what type of activities they participate in, eg. Writing, reading, drawing, playing on computers or electronic games, watching television, exercise and playing musical instruments. Your child's height and weight will also be measured and recorded, whilst they are fully dressed in the classroom, on completion of their questionnaire.

The benefits of participating in this study is that you and your child will assist in the researcher understanding the effects of a range of activities on children at school and home. Information about the findings of this study and recommendations for safe use of IT by children will be made available to participants via the school they attend.

Approval has been gained from Curtin University of Technology Human Research Ethics Committee prior to commencement of this study.

Will my child's personal information be kept confidential?
Your child will be allocated an identification number to place on the questionnaire. This number will remain confidential to the chief researcher. All information from the questionnaire will be recorded and stored using this identification number. All data will be stored in a locked room at the School of Physiotherapy, and a copy of the master sheet of students names and identification codes will be stored in a separate secure location within the School of Physiotherapy. It will not be possible to identify your child or any other person participating in this study in any report on this research.

What if I want more information on the study?
If you require any further information regarding the study you are encouraged to contact the chief researcher or your child's school teacher and further clarification of your questions will be made available. Additionally on completion of the research a research report will be forwarded to your child's school for the school communities information.

What if I want to Refuse or Withdraw my child from participating in the study?
Your child and yourself may refuse or withdraw from participating in the study at any time. If you choose to do this then your child will not be disadvantaged or prejudiced in any way, and arrangements will be made with the school to have your child participate in another activity during the time the other class members are completing the questionnaire. In the event that you withdraw you or your child needs to inform the chief researcher of this and all of your child's data will be destroyed.

Participant Consent Form

Title of Study: Survey to Identify Risk Factors Associated with School Children's Use of Information Technology.

Chief Researcher: Ms Courtenay Harris, PhD student
School of Physiotherapy Curtin University of Technology.
0417993269

Parent consent

You are voluntarily making a decision to allow your child to participate in this research project. Your signature certifies that you have decided to allow your child to participate, having read and understood the information presented. Your signature also certifies that you have had the opportunity to ask questions and further clarify any information. You will be given a copy of this form to keep.

I, (the undersigned parent / guardian / custodian) ______________________________

consent to allow my child ____________________________________ (child's name) to participate in this study.

I give my permission for any results of this study to be used in any report or research paper, on the understanding that my child's confidentiality will be preserved. I understand that I may withdraw my child from the study at anytime without prejudice. If I do withdraw consent, I will contact the investigator at the earliest opportunity.

Signature:______________________________________ (parent / guardian / custodian)

Date: ____

Student Consent

I, (the undersigned student) ____

agree to participate in this research project. I give permission for the results of this study to be used in research reports or papers. I am aware that my confidentiality in participating in this study will be preserved. I understand that I can choose to withdraw from this study at any time without prejudice. If I choose to withdraw from the study I will notify the chief researcher.

Signature: _____________________________________ (student's name)

Date: ____

Participant Consent Form

Title of Study: Survey to Identify Risk Factors Associated with School Children's Use of Information Technology.

Chief Researcher: Ms Courtenay Harris, PhD student
School of Physiotherapy Curtin University of Technology.
0417993269

Parent consent

I, (the undersigned parent / guardian / custodian) ________________________________

DO / DO NOT *(please circle)* consent for my child ____________________________

to participate in the above mentioned study.

Signature:____ (parent / guardian / custodian)

Date: ____

PLEASE RETURN TO MR MILLER BY NOVEMBER 7, 2006.

Participant Withdrawal Form

Title of Study: Survey to Identify Risk Factors Associated with School Children's Use of Information Technology.

Chief Researcher: Ms Courtenay Harris, PhD student
School of Physiotherapy Curtin University of Technology.
0417993269

Parent withdrawal
You are requesting that your child NOT participate in this research project.
Your signature certifies that you have decided to withdraw your child from participating in the research.

I, (the undersigned parent / guardian / custodian) ______________________________
DO NOT consent for my child _____________________________________ (child's name) to participate in the above mentioned study.

I understand that as my child will be withdrawn from the study they will NOT be prejudiced in any way for not participating.

Signature:______________________________________ (parent / guardian / custodian)

Date: ____

Dear <Principal's name>,

I am writing this message to request your cooperation for your school's participation in a research program that is concerned with students' use of Information Technology and the association with musculoskeletal problems.

This research is being undertaken by PhD student Ms Courtenay Harris under the supervision of Dr Leon Straker from the Curtin University, School of Physiotherapy.

Courtenay has specifically requested your school to fit into a balanced sample taken from across the Perth metropolitan and WA regional areas. It is hoped that this survey will be conducted in term four of this year. It is expected to take students between twenty and thirty minutes to complete the questionnaires.

I have attached further information to this letter that should assist you in understanding the significance and dimensions of this research.

Courtenay will contact you in the coming weeks.

Yours sincerely

Sam Oriti
Learning Technologies Consultant
Catholic Education Office of WA

Appendix B

Ethics Application – Form B Changes

Curtin
University of Technology

Form B

PROGRESS REPORT/ APPLICATION FOR RENEWAL

This form is to be completed and returned to
The Secretary, Human Research Ethics Committee
C/- Office of Research & Development,
12 months following initial project approval i.e., prior to the expiry date. If any of the points below apply prior to the expiry date, this form should be submitted to the Committee at that time.

Approval No
HR 205/2002

Expiry Date «Expiry_Date»

PROJECT TITLE: Development of a Model of Musculoskeletal Problems Associated with Children's Use of Information Technology

1A	**Has this project been completed?**	YES ☐	NO X
1B	**OR** Do you wish to apply for a renewal of the project?	YES	NO X
	If YES please state the expected completion date.	____	
	If NO please state why, eg abandoned/withdrawn/no funding etc ____		
2	Has this project been modified or changed in any manner that varies from the approved proposal?	YES	NO X
	If yes, please provide details.		
3	**Have any ethically related issues emerged in regard to this project since you received Ethics' Committee approval?** (e.g. breach of confidentiality, harm caused, inadequate consent or disputes on these).	**YES** ☐	**NO X**
	If yes, please provide details (Attach additional comments on a separate sheet of paper if necessary)		
4	Have any ethically related issues in regard to this project been brought to your attention by others? (i.e. study respondents, organisations that have given consent, colleagues, the general community etc).	YES X	NO
	If yes, please provide details: The Parent Information Sheet does not contain updated information regarding the research for the parents of students participating in the research. I am now not recording names of students, the surveys are anonymous. I also did not include information to parents on height and weight measurement procedures. This has now been included into the new form. Additionally the contact numbers for Dr Leon Straker and the Curtin Ethics Committee were omitted from the original form. These have now been included in the new Parent Information Form as attached. In general, the Parent Information Form has been updated to ensure the parents of children participating are fully informed about the research.		

5
Investigator: COURTENAY HARRIS Signature: ____________
School: PHYSIOTHERAPY (if available)
Dept Supv: Dr LEON STRAKER Signature ____________ Date:20 /08 /06

Office Use Only
APPROVED: ____________
Executive Officer

DATE: ____/____/____

KIDS AND COMPUTERS

Parent Information Sheet

Title of Study: Survey to Identify Risk Factors Associated with Children's Use of Information Technology (IT).

Chief Researcher: Ms Courtenay Harris, PhD student
School of Physiotherapy Curtin University of Technology.

This study involves surveying 1500 West Australian children from years 1, 6, 9 and 11 during term 3 and 4 of 2006. This research will help us to better understand how kids use information technology and therefore help us to give recommendations on how kids should safely use them.

Procedures:
To gain information about your child's activities a questionnaire needs to be completed. The questionnaire is about 14 pages long and should take about 30 –40 minutes to complete. For students in Year One a questionnaire will be sent home and you will be asked to complete it with your child, and return it to school. For students in Years 6, 9 and 11 the questionnaire will be done in class with their teacher and the researcher.

If you DO NOT wish for your child to participate you MUST return the enclosed withdrawal form to school prior to completion of the questionnaires. If you choose to do this then your child will not be disadvantaged or prejudiced in any way, and arrangements will be made with the school to have your child participate in another activity during the time the other class members are completing the questionnaire.

There are no risks associated with participation in this research.

Your child will be expected to answer questions about the activities they do and how it affects their body. **We will not be collecting your child's name or address; the survey is anonymous.** Your child's height and weight will also be measured and recorded, whilst they are fully dressed in the classroom. It will not be possible to identify your child or any other person participating in this study in any report on this research. All of the completed questionnaires will be stored at the Physiotherapy School of Curtin University in locked storage.

This research has been approved by Curtin University of Technology Human Research Ethics Committee.

If you would like more information about the study please contact Courtenay Harris on 0417993269, Dr Leon Straker, School of Physiotherapy on 92664644 or the Curtin Human Research Ethics Committee on 92662784. A report on this research will be forwarded to your child's school. THANKYOU.

Appendix C

Ethics Application – Form B Changes

Parent and Guardian Information Forms

Long Form

Curtin University of Technology

Form B

PROGRESS REPORT/ APPLICATION FOR RENEWAL

This form is to be completed and returned to

The Secretary, Human Research Ethics Committee
C/- Office of Research & Development,

12 months following initial project approval i.e., prior to the expiry date. If any of the points below apply prior to the expiry date, this form should be submitted to the Committee at that time.

Approval No
HR 205/2002

Expiry Date «Expiry_Date»

PROJECT TITLE: Development of a Model of Musculoskeletal Problems Associated with Children's Use of Information Technology

1A	**Has this project been completed?**	YES ☐	NO X
1B	**OR** Do you wish to apply for a renewal of the project?	YES	NO X
	If YES please state the expected completion date.	____	
	If NO please state why, eg abandoned/withdrawn/no funding etc ____		
2	Has this project been modified or changed in any manner that varies from the approved proposal?	YES	NO X
	If yes, please provide details.		
3	**Have any ethically related issues emerged in regard to this project since you received Ethics' Committee approval?** (e.g. breach of confidentiality, harm caused, inadequate consent or disputes on these).	**YES** ☐	**NO X**
	If yes, please provide details (Attach additional comments on a separate sheet of paper if necessary)		
4	Have any ethically related issues in regard to this project been brought to your attention by others? (i.e. study respondents, organisations that have given consent, colleagues, the general community etc).	YES X	NO
	If yes, please provide details: Participating schools in different areas have requested a one page Parent Information Sheet. Many of the parents are from non-English speaking backgrounds and Principals feel they will be unable to understand the research information in its current form. A one page format with simplified information has been requested. A new Parent Information form has been drafted and is attached for approval.		
5	Investigator: COURTENAY HARRIS Signature: ____ School: PHYSIOTHERAPY (if available) Dept Supv: Dr LEON STRAKER Signature ____ Date:20 /08 /06		

Office Use Only

APPROVED: ____________________
Executive Officer

DATE: ____ / ____ / ____

KIDS AND COMPUTERS

Parent Information Sheet

Title of Study: Survey to Identify Risk Factors Associated with Children's Use of Information Technology (IT).

Chief Researcher: Ms Courtenay Harris, PhD student , 0417993269
School of Physiotherapy, Curtin University of Technology.

Purpose of the Study:
Children are participating in a range of activities everyday at school and home. Many of these activities involve the use of new technology such as desk top / laptop / palm computers, video games, electronic hand held games. These activities are engaging and research indicates that children are continuing to participate in these activities for longer durations and more frequently. Research to date on the effects of children participating in these types of activities indicate that some children experience discomfort as a result of their interaction.

This study will help us to better understand how children spend their time, the activities they participate in, and what activities and personal characteristics may contribute to children experiencing discomfort. In particular this study will help to identify factors affecting children with their use of both old and new Information Technology, eg. Reading and writing, computers, electronic games, watching television and playing video games.

This information will assist academics, educationalists and parents to understand the risk factors for school children's use of IT. This will further assist in making recommendations for wise use of IT by children. This will therefore enable and encourage children to use this valuable resource in educational, recreational and communication environments in a safe and productive manner.

Participants
This study involves surveying 1500 West Australian children from years 1, 6, 9 and 11 during 2006. Surveying of Students will be occurring at the schools and colleges during terms 3 and 4.

Procedures:
If you agree for your child to be in this study, you and / or your child will be asked to complete a questionnaire during school time. The questionnaire is approximately 14 pages and should take about 30 –40 minutes to complete. For students aged 5 or 6 years then you as the parent with your child will need to complete the questionnaire. If your child is in year 6, 9 or 11 then it is expected that your child will complete the questionnaire themselves at school with their teacher and the chief researcher present.

Your child will be expected to answer questions about the activities they do and how it affects their body. **We will not be collecting your child's name or address; the survey is anonymous.** Your child's height and weight will also be measured and recorded, whilst they are fully dressed in the classroom. Your child's teacher will also answer a question regarding their current level in a subject. When the questionnaires are completed they will be taken by the chief researcher to collate the data.

Risks, discomfort and benefits
Your child's participation in the study will only occur if you and your child voluntarily consent to participate. Please complete the Consent Form attached and return to your child's teacher as soon as possible before November 7, 2006.

The costs to you and your child will be the time taken to complete the questionnaire, which we anticipate will be 30 – 40 minutes. There are no risks associated with participation in this research.

The benefits of participating in this study is that you and your child will assist the researcher in understanding the effects of a range of activities on children at school and home. Information about the findings of this study and recommendations for safe use of IT by children will be made available to participants via the school they attend.

Approval has been gained from Curtin University of Technology Human Research Ethics Committee prior to commencement of this study.

Will my child's personal information be kept confidential?
The questionnaires are anonymous. All data will be stored in a locked room at the School of Physiotherapy. It will not be possible to identify your child or any other person participating in this study in any report on this research.

What if I want more information on the study?
If you require any further information regarding the study you are encouraged to contact the chief researcher or your child's school teacher and further clarification of your questions will be made available. Additionally you can contact Associate Professor Dr Leon Straker (Supervisor) at the School of Physiotherapy on 92664644, or the Curtin Human Research Ethics Committee on 92662784.

What if I want to Refuse or Withdraw my child from participating in the study?
Your child and yourself may refuse or withdraw from participating in the study at any time. If you choose to do this then your child will not be disadvantaged or prejudiced in any way, and arrangements will be made with the school to have your child participate in another activity during the time the other class members are completing the questionnaire. In the event that you withdraw you or your child needs to inform the chief researcher of this and all of your child's data will be destroyed.

Appendix D

YAQ II- Young People's Activity Questionnaire

Curtin University of Technology

Young people's Activity Questionnaire

YAQ

Dear Student,

Many of the activities you do everyday at home and school effect you in different ways. They effect the way you think, move, act and play .The questions in this survey ask you about these activities and how you think they effect you. Your answers will help us to provide guidelines for use of these activities so that you can enjoy doing them.

Thankyou very much for answering these questions

1. First some questions about you and your school.

a. Which school do you go to? [ ]

b. What year are you in at school? [ ] year/grade

c. Who is your home class teacher? [ ]

d. What suburb do you live in? [ ]

e. When where you born? [ ] day [ ] month [ ] year

f. Are you a boy or girl? 1☐ boy 2☐ girl

g. What are your initials? [ ]

h. Do you wear glasses or contact lenses? 1☐ yes 2☐ no

i. Which hand do you usually write with? 1☐ left 2☐ right 3☐ either

j. In the last month have you felt any soreness, pain or discomfort in your body?
1☐ yes 2☐ no
└▶If *'no'* go to question r ⇒▶

k. In the last month, how often did you feel **any** soreness, pain or discomfort?
1☐ didn't 2☐ 1 x month 3☐ 1 x week 4☐ 2-3 x week 5☐ daily

l. In the last month, did you ever have to stop doing an activity because of the soreness?
1☐ yes 2☐ no

m. In the last month, did you take any medicine to reduce the soreness?
1☐ yes 2☐ no

n. In the last month, did you see a doctor/physiotherapist/etc. because of the soreness?
1☐ yes 2☐ no

o. Circle each body part on the picture where you felt soreness in the last month.

p. For each area you circled, rate how much soreness you had on a scale from 0 (no soreness) to 10 (extreme soreness).

- a eyes [ ]
- b head [ ]
- c neck [ ]
- d mid back [ ]
- e low back [ ]
- f left shoulder/arm [ ]
- g left elbow/hand [ ]
- h right shoulder/arm [ ]
- i right elbow/hand [ ]
- j legs [ ]
- k stomach [ ]

q. What do you think caused this soreness?

....

....

r. How many times in an average week do you do these types of exercise for more that 15 minutes at a time?

Hard exercise that makes you puff and your heart beats rapidly – for example running, hockey, vigorous dancing) ☐

Medium exercise that is active but not exhausting – for example fast walking, swimming, biking, skate boarding ☐

Light exercise that is not demanding – for example bowling, yoga, golf, easy walking) ☐

s. When getting ready to go to school how often do you feel like you have butterflies in your stomach?
1☐ don't 2☐ 1 x month 3☐ 1 x week 4☐ 2-3 x week 5☐ daily

t. How much do you enjoy going to school?
1☐ really don't enjoy it 2☐ don't enjoy it 3☐ so so 4☐ like it 5☐ really like it

Now some questions about your health.

u. Have you ever had a problem with your muscles, bones or joints? 1☐ yes 2☐ no =▶ *if 'no' go to W.*
└▶ *if 'yes' go to next question*

v. Please describe the problem with your muscles, bones or joints. (What it was [for example broken bone, scoliosis, arthritis], how long ago you had it, how it affects you now, why do think you had it)

....

....

....

....

2. Now some questions about…

…watching TV or videos.

a. In the last month, how often did you watch TV/videos?

1☐ didn't   2☐ 1 x month   3☐ 1 x week   4☐ 2-3 x week   5☐ daily

▶ *If* 'didn't' *go to the next page* ⇒▶

b. In the last month, for how long did you <u>usually</u> watch TV/videos each time?

1☐ < 30 minutes   2☐ 30-60 minutes   3☐ 1-2 hours   4☐ 2-5 hours   5☐ >5 hours

c. In the last month, what was the <u>longest time</u> you watched TV/videos without a break?

1☐ < 30 minutes   2☐ 30-60 minutes   3☐ 1-2 hours   4☐ 2-5 hours   5☐ >5 hours

d. In the last month, why did you watch TV/videos?

1☐ mostly schoolwork/homework   2☐ mostly own fun   3☐ both school work and fun

e. In the last month, how often did you feel any soreness anywhere when you watched TV/videos?

1☐ didn't   2☐ 1 x month   3☐ 1 x week   4☐ 2-3 x week   5☐ daily

▶ *If* 'didn't' *go to the next page* ⇒▶

f. In the last month, did you ever stop watching TV/videos because of the soreness?

1☐ yes   2☐ no

g. In the last month, did you take any medicine to reduce the soreness you felt when watching TV/videos?

1☐ yes   2☐ no

h. In the last month, did you see a doctor/physiotherapist/etc. because of the soreness you felt when watching TV/videos?

1☐ yes   2☐ no

i. Circle each body part on the picture where you felt soreness while watching TV or videos in the last month.

j. For each area you circled, rate how much soreness you had on a scale from 0 (no soreness) to 10 (extreme soreness).

a eyes ☐
b head ☐
c neck ☐
d mid back ☐
e low back ☐
f left shoulder/arm ☐
g left elbow/hand ☐
h right shoulder/arm ☐
i right elbow/hand ☐
j legs ☐

k. What do you think caused this soreness?

……

3. Now some questions about…

…reading book and magazines.

a. In the last month, how often did you read from books, magazines or newspapers?

1☐ didn't   2☐ 1 x month   3☐ 1 x week   4☐ 2-3 x week   5☐ daily

└► *If* 'didn't' *go to the next page* ⇒►

b. In the last month, for how long did you usually read from books/magazines each time?

1☐ < 30 minutes   2☐ 30-60 minutes   3☐ 1-2 hours   4☐ 2-5 hours   5☐ >5 hours

c. In the last month, what was the longest time you read from books/magazines without a break?

1☐ < 30 minutes   2☐ 30-60 minutes   3☐ 1-2 hours   4☐ 2-5 hours   5☐ >5 hours

d. In the last month, why did you read from books/magazines?

1☐ mostly schoolwork/homework   2☐ mostly own fun   3☐ both school work and fun

e. In the last month, how often did you feel any soreness anywhere when you read from books/magazines?

1☐ didn't   2☐ 1 x month   3☐ 1 x week   4☐ 2-3 x week   5☐ daily

└► *If* 'didn't' *go to the next page* ⇒►

f. In the last month, did you ever stop reading from books/magazines because of the soreness?

1☐ yes   2☐ no

g. In the last month, did you take any medicine to reduce the soreness you felt when reading from books/magazines?

1☐ yes   2☐ no

h. In the last month, did you see a doctor/physiotherapist/etc. because of the soreness you felt when reading from books/magazines?

1☐ yes   2☐ no

i. Circle each body part on the picture where you felt soreness while reading in the last month.

j. For each area you circled, rate how much soreness you had on a scale from 0 (no soreness) to 10 (extreme soreness).

a eyes ☐
b head ☐
c neck ☐
d mid back ☐
e low back ☐
f left shoulder/arm ☐
g left elbow/hand ☐
h right shoulder/arm ☐
i right elbow/hand ☐
j legs ☐

k. What do you think caused this soreness?

....

4. Now some questions about…

… drawing or writing.

a. In the last month, how often did you write or draw on paper?

1☐ didn't 2☐ 1 x month 3☐ 1 x week 4☐ 2-3 x week 5☐ daily

└▶ *If* 'didn't' *go to the next page* ⇒▶

b. In the last month, for how long did you usually write or draw each time?

1☐ < 30 minutes 2☐ 30-60 minutes 3☐ 1-2 hours 4☐ 2-5 hours 5☐ >5 hours

c. In the last month, what was the longest time you wrote or drew without a break?

1☐ < 30 minutes 2☐ 30-60 minutes 3☐ 1-2 hours 4☐ 2-5 hours 5☐ >5 hours

d. In the last month, why did you write or draw?

1☐ mostly schoolwork/homework 2☐ mostly own fun 3☐ both schoolwork and fun

e. In the last month, how often did you feel any soreness anywhere when you wrote or drew?

1☐ didn't 2☐ 1 x month 3☐ 1 x week 4☐ 2-3 x week 5☐ daily

└▶ *If* 'didn't' *go to the next page* ⇒▶

f. In the last month, did you ever stop writing or drawing because of the soreness?

1☐ yes 2☐ no

g. In the last month, did you take any medicine to reduce the soreness you felt when writing or drawing?

1☐ yes 2☐ no

h. In the last month, did you see a doctor/physiotherapist/etc. because of the soreness you felt when writing or drawing?

1☐ yes 2☐ no

i. Circle each body part on the picture where you felt soreness while drawing or writing in the last month.

j. For each area you circled, rate how much soreness you had on a scale from 0 (no soreness) to 10 (extreme soreness).

a eyes ☐
b head ☐
c neck ☐
d mid back ☐
e low back ☐
f left shoulder/arm ☐
g left elbow/hand ☐
h right shoulder/arm ☐
i right elbow/hand ☐
j legs ☐

k. What do you think caused this soreness?

....

5. Now some questions about…

…playing electronic games.

a. In the last month, how often did you play electronic games (hand held games like GameBoy and TV/console based games like PlayStation)?

1☐ didn't 2☐ 1 x month 3☐ 1 x week 4☐ 2-3 x week 5☐ daily

└► *If* 'didn't' *go to the next page* ⇒►

b. List the electronic game equipment you use at least monthly.

c. In the last month, for how long did you usually play electronic games each time?

1☐ < 30 minutes 2☐ 30-60 minutes 3☐ 1-2 hours 4☐ 2-5 hours 5☐ >5 hours

d. In the last month, what was the longest time you played electronic games without a break?

1☐ < 30 minutes 2☐ 30-60 minutes 3☐ 1-2 hours 4☐ 2-5 hours 5☐ >5 hours

e. In the last month, why did you play electronic games?

1☐ mostly schoolwork/homework 2☐ mostly own fun 3☐ both school work and fun

f. In the last month, how often did you feel any soreness anywhere when you played electronic games?

1☐ didn't 2☐ 1 x month 3☐ 1 x week 4☐ 2-3 x week 5☐ daily

└► *If* 'didn't' *go to the next page* ⇒►

g. In the last month, did you ever stop playing electronic games because of the soreness?

1☐ yes 2☐ no

h. In the last month, did you take any medicine to reduce the soreness you felt when playing electronic games?

1☐ yes 2☐ no

i. In the last month, did you see a doctor/physiotherapist/etc. because of the soreness you felt when playing electronic games?

1☐ yes 2☐ no

j. Circle each body part on the picture where you felt soreness while playing electronic games in the last month.

k. For each area you circled, rate how much soreness you had on a scale from 0 (no soreness) to 10 (extreme soreness).

a eyes ☐
b head ☐
c neck ☐
d mid back ☐
e low back ☐
f left shoulder/arm ☐
g left elbow/hand ☐
h right shoulder/arm ☐
i right elbow/hand ☐
j legs ☐

l. What do you think caused this soreness?

……

6. Now some questions about…

…playing a musical instrument.

a. In the last month, how often did you play a musical instrument?

1☐ didn't 2☐ 1 x month 3☐ 1 x week 4☐ 2-3 x week 5☐ daily

↳► *If* 'didn't' *go to the next page* ⇒►

b. About what age were you when you started playing a musical instrument?

☐ years old

c. List the musical instruments you play at least monthly.

d. In the last month, for how long did you usually play a musical instrument each time?

1☐ < 30 minutes 2☐ 30-60 minutes 3☐ 1-2 hours 4☐ 2-5 hours 5☐ >5 hours

e. In the last month, what was the longest time you played a musical instrument without a break?

1☐ < 30 minutes 2☐ 30-60 minutes 3☐ 1-2 hours 4☐ 2-5 hours 5☐ >5 hours

f. In the last month, why did you play a musical instrument?

1☐ mostly schoolwork/homework 2☐ mostly own fun 3☐ both school work and fun

g. In the last month, how often did you feel any soreness anywhere when you played a musical instrument?

1☐ didn't 2☐ 1 x month 3☐ 1 x week 4☐ 2-3 x week 5☐ daily

↳► *If* 'didn't' *go to the next page* ⇒►

h. In the last month, did you ever stop playing a musical instrument because of the soreness?

1☐ yes 2☐ no

i. In the last month, did you take any medicine to reduce the soreness you felt when playing a musical instrument?

1☐ yes 2☐ no

j. In the last month, did you see a doctor/physiotherapist/etc. because of the soreness you felt when playing a musical instrument?

1☐ yes 2☐ no

k. Circle each body part on the picture where you felt soreness while playing a musical instrument in the last month.

l. For each area you circled, rate how much soreness you had on a scale from 0 (no soreness) to 10 (extreme soreness).

a eyes ☐
b head ☐
c neck ☐
d mid back ☐
e low back ☐
f left shoulder/arm ☐
g left elbow/hand ☐
h right shoulder/arm ☐
i right elbow/hand ☐
j legs ☐

m. What do you think caused this soreness?

……………………………………………………………………………………………………

7. Now some questions about…

…other activities.

a. In the last month, how often did you do other activities where you use your hands a lot (eg sewing, yoyo, woodwork/metalwork, making models, making jewelry, playing cards)?

1☐ didn't 2☐ 1 x month 3☐ 1 x week 4☐ 2-3 x week 5☐ daily

└▶ *If* 'didn't' *go to the next page* ⇒▶

b. List the activities you do at least monthlyi where you use your hands a lot (crafts, playing cards, etc.)

c. In the last month, for how long did you usually do these activities each time?

1☐ < 30 minutes 2☐ 30-60 minutes 3☐ 1-2 hours 4☐ 2-5 hours 5☐ >5 hours

d. In the last month, what was the longest time you did these activities without a break?

1☐ < 30 minutes 2☐ 30-60 minutes 3☐ 1-2 hours 4☐ 2-5 hours 5☐ >5 hours

e. In the last month, why did you do these activities?

1☐ mostly schoolwork/homework 2☐ mostly own fun 3☐ both school work and fun

f. In the last month, how often did you feel any soreness anywhere when you did these activities?

1☐ didn't 2☐ 1 x month 3☐ 1 x week 4☐ 2-3 x week 5☐ daily

└▶ *If* 'didn't' *go to the next page* ⇒▶

g. In the last month, did you ever stop doing these activities because of the soreness?

1☐ yes 2☐ no

h. In the last month, did you take any medicine to reduce the soreness you felt when doing these activities?

1☐ yes 2☐ no

i. In the last month, did you see a doctor/physiotherapist/etc. because of the soreness you felt when doing these activities?

1☐ yes 2☐ no

j. Circle each body part on the picture where you felt soreness in the last month.

k. For each area you circled, rate how much soreness you had on a scale from 0 (no soreness) to 10 (extreme soreness).

a eyes ☐
b head ☐
c neck ☐
d mid back ☐
e low back ☐
f left shoulder/arm ☐
g left elbow/hand ☐
h right shoulder/arm ☐
i right elbow/hand ☐
j legs ☐

l. What do you think caused this soreness?

....

8. Now some questions about…

…physical activities like sport and exercise.

a. In the last month, how often did you do vigorous physical activity (activities that make you puff or your heart beat faster like running, football, netball, hockey, dancing, bike riding)?

1☐ didn't 2☐ 1 x month 3☐ 1 x week 4☐ 2-3 x week 5☐ daily

└► *If* 'didn't' *go to the next page* ⇒►

b. List the vigorous physical activities you do at least monthly.

c. In the last month, for how long did you usually do these activities each time?

1☐ < 30 minutes 2☐ 30-60 minutes 3☐ 1-2 hours 4☐ 2-5 hours 5☐ >5 hours

d. In the last month, what was the longest time you did these activities without a break?

1☐ < 30 minutes 2☐ 30-60 minutes 3☐ 1-2 hours 4☐ 2-5 hours 5☐ >5 hours

e. In the last month, why did you do these activities?

1☐ mostly schoolwork/homework 2☐ mostly own fun 3☐ both

f. In the last month, how often did you feel any soreness anywhere when you did these activities?

1☐ didn't 2☐ 1 x month 3☐ 1 x week 4☐ 2-3 x week 5☐ daily

└► *If* 'didn't' *go to the next page* ⇒►

g. In the last month, did you ever stop doing these activities because of the soreness?

1☐ yes 2☐ no

h. In the last month, did you take any medicine to reduce the soreness you felt when doing these activities?

1☐ yes 2☐ no

i. In the last month, did you see a doctor/physiotherapist/etc. because of the soreness you felt when doing these activities?

1☐ yes 2☐ no

j. Circle each body part on the picture where you felt soreness in the last month.

k. For each area you circled, rate how much soreness you had on a scale from 0 (no soreness) to 10 (extreme soreness).

- a eyes ☐
- b head ☐
- c neck ☐
- d mid back ☐
- e low back ☐
- f left shoulder/arm ☐
- g left elbow/hand ☐
- h right shoulder/arm ☐
- i right elbow/hand ☐
- j legs ☐

l. What do you think caused this soreness?

……

9. Now some questions about…

…using a desktop or laptop computer

a. Have you ever used a computer?

1☐ yes   2☐ no   =► *if* 'no' *go to the last page* =►.

└► *if* 'yes' *go to next question*

b. About what age were you when you started using a computer?

☐ years old

the rest of this page is about using computers at SCHOOL only

c. In the last month, how often did you use a computer at **school**?

1☐ didn't   2☐ 1 x month   3☐ 1 x week   4☐ 2-3 x week   5☐ daily

└► *If* 'didn't' *go to the next page* =►

d. In the last month, for how long did you <u>usually</u> use a computer at **school** each time?

1☐ < 30 minutes   2☐ 30-60 minutes   3☐ 1-2 hours   4☐ 2-5 hours   5☐ >5 hours

e. In the last month, what was the <u>longest time</u> you used a computer at **school** without a break?

1☐ < 30 minutes   2☐ 30-60 minutes   3☐ 1-2 hours   4☐ 2-5 hours   5☐ >5 hours

f. In the last month, how often did you feel any soreness anywhere when you used a computer at **school**?

1☐ didn't   2☐ 1 x month   3☐ 1 x week   4☐ 2-3 x week   5☐ daily

└► *If* 'didn't' *go to the next page* =►

g. In the last month, did you ever stop using a computer at **school** because of the soreness?

1☐ yes   2☐ no

h. In the last month, did you take any medicine to reduce the soreness you felt when using a computer at **school**?

1☐ yes   2☐ no

i. In the last month, did you see a doctor/physiotherapist/etc. because of the soreness you felt when using a computer at **school**?

1☐ yes   2☐ no

j. Circle each body part on the picture where you felt soreness in the last month.

k. For each area you circled, rate how much soreness you had on a scale from 0 (no soreness) to 10 (extreme soreness).

a eyes ☐
b head ☐
c neck ☐
d mid back ☐
e low back ☐
f left shoulder/arm ☐
g left elbow/hand ☐
h right shoulder/arm ☐
i right elbow/hand ☐
j legs ☐

l. What do you think caused this soreness?

………

Now some extra questions about your use of computers AT SCHOOL.

m. When using a computer at **school** which of these postures do you often use? (tick all correct boxes)
1☐ sitting at desk/table 2☐ sitting on floor 3☐ sitting on sofa/beanbag 4☐ lying down 5☐ standing 6☐ other

In the last month, how often did you do the following activities on a computer at **school**? (tick one box only for each activity)

n. Play games	1☐ didn't	2☐ 1 x month	3☐ 1 x week	4☐ 2-3 x week	5☐ daily
o. Create pictures or music	1☐ didn't	2☐ 1 x month	3☐ 1 x week	4☐ 2-3 x week	5☐ daily
p. Write letters, stories etc.	1☐ didn't	2☐ 1 x month	3☐ 1 x week	4☐ 2-3 x week	5☐ daily
q. Use educational software	1☐ didn't	2☐ 1 x month	3☐ 1 x week	4☐ 2-3 x week	5☐ daily
r. Surf the Net	1☐ didn't	2☐ 1 x month	3☐ 1 x week	4☐ 2-3 x week	5☐ daily
s. Send/receive emails	1☐ didn't	2☐ 1 x month	3☐ 1 x week	4☐ 2-3 x week	5☐ daily
t. Chat room	1☐ didn't	2☐ 1 x month	3☐ 1 x week	4☐ 2-3 x week	5☐ daily
u. Other activities	1☐ didn't	2☐ 1 x month	3☐ 1 x week	4☐ 2-3 x week	5☐ daily

v. When you are using a computer at **school** who usually decides what you do?
1☐ me 2☐ friend 3☐ teacher 4☐ other person

w. How often can you choose what you do when using a computer at **school**?
1☐ always 2☐ usually 3☐ sometimes 4☐ rarely 5☐ never

x. Who else is usually with you when you are using a computer at **school**?
1☐ no one 2☐ friend 4☐ teacher 5☐ other

y. When using a computer at **school** who do you usually talk with?
1☐ no one 2☐ friend 4☐ teacher 5☐ other

z. Thinking about the <u>last seven days</u>, in total how many hours have you spent using a computer at **school**? ☐ hours

az. Whose computer do you use at school?
1☐ school laptop 2☐ school desktop 3☐ school palm top 4☐ own laptop 5☐ own palmtop 6☐ other

Now the last questions about your use of computers AT SCHOOL.

Think about each time in the last week you used a computer at **school** while you are answering the following questions. (Tick one box per question ☑)

	strongly agree	moderately agree	slightly agree	don't agree or disagree	slightly disagree	moderately disagree	strongly disagree
za. When using a computer at school, I felt I could make the computer do what I wanted it to.	1☐	2☐	3☐	4☐	5☐	6☐	7☐
zb. I felt the computer was more in charge of what happened than I was.	1☐	2☐	3☐	4☐	5☐	6☐	7☐
zc. When using a computer at school, I thought about other things.	1☐	2☐	3☐	4☐	5☐	6☐	7☐
zd. When using a computer at school, I noticed other things going on around me.	1☐	2☐	3☐	4☐	5☐	6☐	7☐
ze. When using a computer at school, I was totally absorbed in what I was doing.	1☐	2☐	3☐	4☐	5☐	6☐	7☐
zf. Using a computer at school excited my curiosity.	1☐	2☐	3☐	4☐	5☐	6☐	7☐
zg. Getting involved using a computer at school made me curious.	1☐	2☐	3☐	4☐	5☐	6☐	7☐
zh. Using a computer at school fired up my imagination.	1☐	2☐	3☐	4☐	5☐	6☐	7☐
zi. Using a computer at school bored me.	1☐	2☐	3☐	4☐	5☐	6☐	7☐
zj. Using a computer at school was interesting in itself.	1☐	2☐	3☐	4☐	5☐	6☐	7☐
zk. Using a computer at school was fun for me.	1☐	2☐	3☐	4☐	5☐	6☐	7☐

10. Now some questions about…

…using a computer at HOME only

this page is about using computers at HOME only
(this includes using a computer at a friend's home)

a. Do you have access to a computer at **home**?
1☐ yes   2☐ no   ⇒▶ *if* 'no' *go to the next page* ⇒▶.

b. How many desktop computers do you have access to at **home**?
☐

c. How many laptop computers do you have access to at **home**?
☐

d. In the last month, how often did you use a computer at **home**?
1☐ didn't   2☐ 1 x month   3☐ 1 x week   4☐ 2-3 x week   5☐ daily
↳▶ *If* 'didn't' *go to the next page* ⇒▶

e. In the last month, for how long did you <u>usually</u> use a computer at **home** each time?
1☐ < 30 minutes   2☐ 30-60 minutes   3☐ 1-2 hours   4☐ 2-5 hours   5☐ >5 hours

f. In the last month, what was the <u>longest time</u> you used a computer at **home** without a break?
1☐ < 30 minutes   2☐ 30-60 minutes   3☐ 1-2 hours   4☐ 2-5 hours   5☐ >5 hours

g. In the last month, how often did you feel any soreness anywhere when you used a computer at **home**?
1☐ didn't   2☐ 1 x month   3☐ 1 x week   4☐ 2-3 x week   5☐ daily
↳▶ *If* 'didn't' *go to the next page* ⇒▶

h. In the last month, did you ever stop using a computer at **home** because of the soreness?
1☐ yes   2☐ no

i. In the last month, did you take any medicine to reduce the soreness you felt when using a computer at **home**?
1☐ yes   2☐ no

j. In the last month, did you see a doctor/physiotherapist/etc. because of the soreness you felt when using a computer at **home**?
1☐ yes   2☐ no

k. Circle each body part on the picture where you felt soreness in the last month.

l. For each area you circled, rate how much soreness you had on a scale from 0 (no soreness) to 10 (extreme soreness).

- a eyes ☐
- b head ☐
- c neck ☐
- d mid back ☐
- e low back ☐
- f left shoulder/arm ☐
- g left elbow/hand ☐
- h right shoulder/arm ☐
- i right elbow/hand ☐
- j legs ☐

m. What do you think caused this soreness?

……

Now some extra questions about your use of computers AT HOME.

n. Do you have internet/email access at **home**?

[1] ☐ yes [2] ☐ no

o. When using a computer at **home**, which room are you usually in? (tick all correct boxes)

[1] ☐ shared area eg living room or shared study [2] ☐ your own bedroom or study [3] ☐ someone else's bedroom or study [4] ☐ some other room [5] ☐ varies, use it in different rooms

p. When using a computer at **home** which of these postures do you often use? (tick all correct boxes)

[1] ☐ sitting at desk/table [2] ☐ sitting on floor [3] ☐ sitting on sofa/beanbag [4] ☐ lying down [5] ☐ standing [6] ☐ other

In the last month, how often did you do the following activities on a computer at **home**? (tick one box only for each activity)

q. Play games	[1] ☐ didn't	[2] ☐ 1 x month	[3] ☐ 1 x week	[4] ☐ 2-3 x week	[5] ☐ daily
r. Create pictures or music	[1] ☐ didn't	[2] ☐ 1 x month	[3] ☐ 1 x week	[4] ☐ 2-3 x week	[5] ☐ daily
s. Write letters, stories etc.	[1] ☐ didn't	[2] ☐ 1 x month	[3] ☐ 1 x week	[4] ☐ 2-3 x week	[5] ☐ daily
t. Use educational software	[1] ☐ didn't	[2] ☐ 1 x month	[3] ☐ 1 x week	[4] ☐ 2-3 x week	[5] ☐ daily
u. Surf the Net	[1] ☐ didn't	[2] ☐ 1 x month	[3] ☐ 1 x week	[4] ☐ 2-3 x week	[5] ☐ daily
v. Send/receive emails	[1] ☐ didn't	[2] ☐ 1 x month	[3] ☐ 1 x week	[4] ☐ 2-3 x week	[5] ☐ daily
w. Chat room	[1] ☐ didn't	[2] ☐ 1 x month	[3] ☐ 1 x week	[4] ☐ 2-3 x week	[5] ☐ daily
x. Other activities, eg home work	[1] ☐ didn't	[2] ☐ 1 x month	[3] ☐ 1 x week	[4] ☐ 2-3 x week	[5] ☐ daily

y. When you are using a computer at **home** who usually decides what you do?

[1] ☐ me [2] ☐ friend [3] ☐ parent [4] ☐ other person

z. How often can you choose what you do when using a computer at **home**?

[1] ☐ always [2] ☐ usually [3] ☐ sometimes [4] ☐ rarely [5] ☐ never

zz. Who else is usually with you when you are using a computer at **home**?

[1] ☐ no one [2] ☐ friend [3] ☐ brother/sister [4] ☐ parent [5] ☐ other

aa. When using a computer at **home** who do you usually talk with?

[1] ☐ no one [2] ☐ friend [3] ☐ brother/sister [4] ☐ parent [5] ☐ other

ab. Does your mother/guardian use a computer?

[1] ☐ yes [2] ☐ no [3] ☐ don't know

ac. Does your father/guardian use a computer?

[1] ☐ yes [2] ☐ no [3] ☐ don't know

ad. Thinking about the <u>last seven days</u>, in total how many hours have you spent using a computer at **home**? ☐ hours

ae. Tick the types of computers you use at **home**?

[1] ☐ desktop [2] ☐ laptop [3] ☐ palmtop

Now the last questions about your use of computers AT HOME.

Think about each time in the last week you used a computer at **home** while you are answering the following questions. (Tick one box per question ☑)

	strongly agree	moderately agree	slightly agree	don't agree or disagree	slightly disagree	moderately disagree	strongly disagree
ae. When using a computer at home, I felt I could make the computer do what I wanted it to.	1☐	2☐	3☐	4☐	5☐	6☐	7☐
af. I felt the computer was more in charge of what happened than I was.	1☐	2☐	3☐	4☐	5☐	6☐	7☐
ag. When using a computer at home, I thougbht about other things.	1☐	2☐	3☐	4☐	5☐	6☐	7☐
ah. When using a computer at home, I noticed other things going on around me.	1☐	2☐	3☐	4☐	5☐	6☐	7☐
ai. When using a computer at home, I was totally absorbed in what I was doing.	1☐	2☐	3☐	4☐	5☐	6☐	7☐
aj. Using a computer at home excited my curiosity.	1☐	2☐	3☐	4☐	5☐	6☐	7☐
ak. Getting involved in a computer at home made me curious.	1☐	2☐	3☐	4☐	5☐	6☐	7☐
al. Using a computer at home fired up my imagination.	1☐	2☐	3☐	4☐	5☐	6☐	7☐
am. Using a computer at home bored me.	1☐	2☐	3☐	4☐	5☐	6☐	7☐
an. Using a computer at home was interesting in itself.	1☐	2☐	3☐	4☐	5☐	6☐	7☐
ao. Using a computer at home was fun for me.	1☐	2☐	3☐	4☐	5☐	6☐	7☐

11. Finally, some questions about how you feel generally when you use computers <u>anywhere.</u>

Please answer the next set of questions also by putting a tick in the box that best shows what you think.	strongly agree	moderately agree	slightly agree	don't agree or disagree	slightly disagree	moderately disagree	strongly disagree
a. Computers do not scare me at all.	1☐	2☐	3☐	4☐	5☐	6☐	7☐
b. I do not feel anxious when other people talk about computers.	1☐	2☐	3☐	4☐	5☐	6☐	7☐
c. I get butterflies in the stomach when I think of trying to use a computer.	1☐	2☐	3☐	4☐	5☐	6☐	7☐
d. I would feel comfortable working with a computer.	1☐	2☐	3☐	4☐	5☐	6☐	7☐
e. Computers make me feel uneasy and confused.	1☐	2☐	3☐	4☐	5☐	6☐	7☐
f. I'm no good with computers.	1☐	2☐	3☐	4☐	5☐	6☐	7☐
g. Generally I would feel OK about trying a new problem on the computer.	1☐	2☐	3☐	4☐	5☐	6☐	7☐
h. I'm not the type to do well with computers.	1☐	2☐	3☐	4☐	5☐	6☐	7☐
i. I think using a computer would be very hard for me.	1☐	2☐	3☐	4☐	5☐	6☐	7☐
j. I have a lot of confidence in my ability when it comes to working with computers.	1☐	2☐	3☐	4☐	5☐	6☐	7☐

Before you finish this questionnaire please go to the front of the room and measure your height and weight.

k. Height	cms
l. Weight	kgs

Teachers Use Only: Please circle the appropriate boxes for Numeracy and Literacy

m. Numeracy	Well Below Average	Below Average	Average	Above Average	Well Above Average
n. Literacy	Well Below Average	Below Average	Average	Above Average	Well Above Average

Thank you for your time and effort in completing this important questionnaire.

Appendix E

YOAQ – Year One's Activity Questionnaire

Curtin University of Technology

Year One's Activity Questionnaire

YOAQ

Many of the activities your child does everyday at home and school affects them in different ways. They affect the way they think, move, act and play .The questions in this survey asks you about your child's activities and how you think they affect them. Your answers will help us to provide guidelines for use of these activities so that your child can enjoy doing them.

There are three sections in this questionnaire

1. *Questions asking general information about your child*
2. *Questions about a range of activities that your child performs*
3. *Questions about your child's use of computers at school and home*

Please fill in the boxes provided by either ticking the box, or writing your answer in the space available. Please include your child in answering the questions where they are able.

Thank you for answering these questions

Chief Researcher: **Ms Courtenay Harris**
Asscociate Professor: **Dr Leon Straker (School of Physiotherapy)**
Professor : **Dr Clare Pollock (School of Psychology)**

1. Questions about your child and their school.

a. Which school does your child go to? ☐

b. Who is your child's class teacher? ☐

c. What suburb do you live in? ☐

d. When was your child born? ☐ day ☐ month ☐ year

e. Is your child a boy or girl? 1☐ boy 2☐ girl

f. Does your child wear glasses or contact lenses? 1☐ yes 2☐ no

g. Which hand does your child usually write with? 1☐ left 2☐ right 3☐ either

h. How many times in an average week does your child do the following types of exercise for more than 15 minutes at a time?

Hard exercise that makes you puff and your heart beat fast – for example running, hockey, swimming training, dancing) ☐

Medium exercise that is active but not exhausting – for example fast walking, gym, biking, skate boarding ☐

Light exercise that is not demanding – for example bowling, easy walking, playing or climbing outside or at the park) ☐

Please ask your child the following two questions

i. "When getting ready for school how often do you feel like you have butterflies in your stomach?"
1☐ don't 2☐ 1 x month 3☐ 1 x week 4☐ 2-3 x week 5☐ daily

j. "How much do you enjoy going to school?"
1☐ really don't enjoy it 2☐ don't enjoy it 3☐ so so 4☐ like it 5☐ really like it

Now some questions about your child's health.

k. Has your child ever had a problem with their muscles, bones or joints? ☐ yes ☐ no ═► *if 'no' go to 'm'.*

l. Please describe the problem with their muscles, bones or joints. (What it was [for example broken bone, arthritis], how long ago did they have it, how did it affect them, why do you think they had this problem)

....

....

....

....

m. In the last month did your child feel any soreness, pain or discomfort in their body?
☐ yes ☐ no
└► If *'no'* go to question 2 ═►

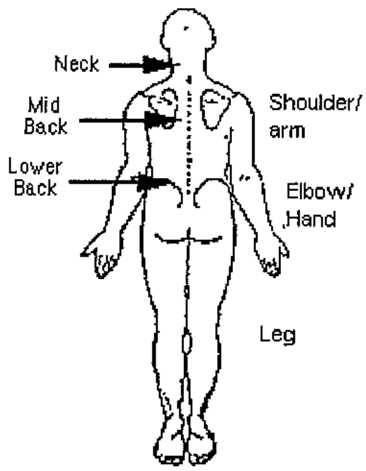
n. In the last month, how often did they feel **any** soreness, pain or discomfort?
☐ 1 x month ☐ 1 x week ☐ 2-3 x week ☐ daily

o. In the last month, did your child ever have to stop doing an activity because of the soreness?
☐ yes ☐ no

p. In the last month, did your child take any medicine to reduce the soreness?
☐ yes ☐ no

q. In the last month, did your child see a doctor/physiotherapist/etc. because of the soreness?
☐ yes ☐ no

r. Circle each body part on the picture where your child felt any soreness in the last month.



s. What do you think caused this soreness?

___

2. *Now some questions about* ***GENERAL ACTIVITIES*** *your child does* ***each month.***

In the last month, how often did your child do the following activities? *Tick one box only for each activity.*

a. Watching TV shows and DVDs	☐ not at all	☐ 1 x month	☐ 1 x week	☐ 2-3 x week	☐ daily
b. Writing and Drawing with pens and pencils	☐ not at all	☐ 1 x month	☐ 1 x week	☐ 2-3 x week	☐ daily
c. Reading Books / Magazines	☐ not at all	☐ 1 x month	☐ 1 x week	☐ 2-3 x week	☐ daily
d. Using a Mobile Phone for Calls or Texts	☐ not at all	☐ 1 x month	☐ 1 x week	☐ 2-3 x week	☐ daily
e. Playing a Musical Instrument	☐ not at all	☐ 1 x month	☐ 1 x week	☐ 2-3 x week	☐ daily

In the last month, for how long did your child usually do the following activities each time? *Tick one box only for each activity*

f. Watching TV shows and DVDs	☐ never	☐ < 30 minutes	☐ 30-60 minutes	☐ 1-2 hours	☐ 2-5 hours	☐ >5 hours
g. Writing and Drawing with pens and pencils	☐ never	☐ < 30 minutes	☐ 30-60 minutes	☐ 1-2 hours	☐ 2-5 hours	☐ >5 hours
h. Reading Books / Magazines	☐ never	☐ < 30 minutes	☐ 30-60 minutes	☐ 1-2 hours	☐ 2-5 hours	☐ >5 hours
i. Using a Mobile Phone for Calls or Texts	☐ never	☐ < 30 minutes	☐ 30-60 minutes	☐ 1-2 hours	☐ 2-5 hours	☐ >5 hours
j. Playing a Musical Instrument	☐ never	☐ < 30 minutes	☐ 30-60 minutes	☐ 1-2 hours	☐ 2-5 hours	☐ >5 hours

In the last month, what was the longest time your child performed the following activities without a break? *Tick one box only for each activity*

k. Watching TV shows and DVDs	☐ never	☐ < 30 minutes	☐ 30-60 minutes	☐ 1-2 hours	☐ 2-5 hours	☐ >5 hours
l. Writing and Drawing with pens and pencils	☐ never	☐ < 30 minutes	☐ 30-60 minutes	☐ 1-2 hours	☐ 2-5 hours	☐ >5 hours
m. Reading Books / Magazines	☐ never	☐ < 30 minutes	☐ 30-60 minutes	☐ 1-2 hours	☐ 2-5 hours	☐ >5 hours
n. Using a Mobile Phone for Calls or Texts	☐ never	☐ < 30 minutes	☐ 30-60 minutes	☐ 1-2 hours	☐ 2-5 hours	☐ >5 hours
o. Playing a Musical Instrument	☐ never	☐ < 30 minutes	☐ 30-60 minutes	☐ 1-2 hours	☐ 2-5 hours	☐ >5 hours

Now some final questions about ***GENERAL ACTIVITIES*** *your child does each month.*

p. In the last month, how often did your child feel any soreness in their muscles, bones or joints when they did any of these activities (**watch TV, read, write, use a mobile phone, play an instrument**?)

☐ not at all ☐ 1 x month ☐ 1 x week ☐ 2-3 x week ☐ daily

└► *If* 'not at all' *go to question 3 below* ═►

q. Which activity were they doing when they felt the soreness?

---

3. Questions about your child ***PLAYING ELECTRONIC GAMES (not on the computer).***

a. Do you have access to electronic games at home (not on a computer)?

☐ yes ☐ no

b. In the last month, how often did your child play with electronic game devices? For example GameBoyTM, PSP, PlayStation, Xbox, hand held electronic games like 20Q, solitaire?

☐ didn't ☐ 1 x month ☐ 1 x week ☐ 2-3 x week ☐ daily

└► *If* 'didn't' *go to question 4* ═►

c. List the electronic game equipment your child is most likely to use each month.

d. In the last month, how long did your child usually play electronic games for each time?

☐ < 30 minutes ☐ 30-60 minutes ☐ 1-2 hours ☐ 2-5 hours ☐ >5 hours

e. In the last month, what was the longest time your child played electronic games without a break?

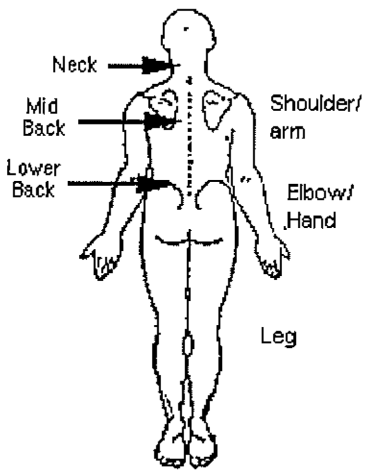
☐ < 30 minutes ☐ 30-60 minutes ☐ 1-2 hours ☐ 2-5 hours ☐ >5 hours

f. In the last month, did your child feel any soreness when they played electronic games?

☐ yes ☐ no

└► If *'no'* go to question 4 ═►

g. Circle each body part on the picture where your child felt any soreness while playing electronic games in the last month.



h. What do you think caused this soreness?

---

4. *Questions about* ***PHYSICAL ACTIVITIES LIKE SPORT AND EXERCISE.***

a. In the <u>last month</u>, how often did your child do vigorous physical activity (activities that made them puff or their heart beat faster like running, swimming, football, netball, hockey, dancing, bike riding, sport practice and games)?

1☐ didn't 2☐ 1 x month 3☐ 1 x week 4☐ 2-3 x week 5☐ daily

╚► *If* 'didn't' *go to question 5* ═►

b. List the vigorous physical activities your child is most likely to do <u>each month</u>.

c. In the <u>last month</u>, how long did your child <u>usually</u> do these activities each time?

1☐ < 30 minutes 2☐ 30-60 minutes 3☐ 1-2 hours 4☐ 2-5 hours 5☐ >5 hours

d. In the <u>last month</u>, what was the <u>longest time</u> your child did these activities without a break?

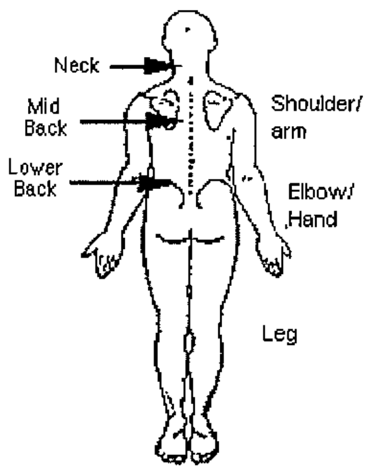
1☐ < 30 minutes 2☐ 30-60 minutes 3☐ 1-2 hours 4☐ 2-5 hours 5☐ >5 hours

e. In the <u>last month</u>, did your child feel any soreness when they did physical activities?

1☐ yes 2☐ no

╚► If *'no'* go to question 5═►

f. Circle each body part on the picture where your child felt any soreness while doing physical activities in the <u>last month</u>.



g. What do you think caused the soreness?

____

5. *Questions about* ***USING A DESKTOP OR LAPTOP COMPUTER***

a. Has your child ever used a computer?

₁☐ yes ₂☐ no ⇒▶ *if 'no' go to Question 6* ⇒▶.

↳▶ *if 'yes' go to next question*

b. About what age was your child when they started using a computer?

☐ years old

The following questions relate to your child's use of computers at <u>SCHOOL ONLY</u>

c. In the <u>last month</u>, how often did your child use a computer at **school**?

₁☐ didn't ₂☐ 1 x month ₃☐ 1 x week ₄☐ 2-3 x week ₅☐ daily ₆☐ don't know

↳▶ *If 'didn't' go to question 6* ⇒▶

d. When using a computer at **school** which of these postures did your child use? (tick all boxes that apply)

₁☐ sitting at desk/table ₂☐ sitting on floor ₃☐ sitting on sofa/beanbag ₄☐ lying down ₅☐ standing ₆☐ other ₇☐ don't know

Did your child do any of the following activities on the computer at **school** in the <u>last month</u>?

e. Play games	₁☐ yes	₂☐ no	₃☐ don't know
f. Create pictures or music	₁☐ yes	₂☐ no	₃☐ don't know
g. Write letters, stories etc.	₁☐ yes	₂☐ no	₃☐ don't know
h. Use educational software	₁☐ yes	₂☐ no	₃☐ don't know
i. Surf the Net	₁☐ yes	₂☐ no	₃☐ don't know
j. Send/receive emails	₁☐ yes	₂☐ no	₃☐ don't know
k. Chat room	₁☐ yes	₂☐ no	₃☐ don't know
l. Other activities	₁☐ yes	₂☐ no	₃☐ don't know

m. When your child is using a computer at **school** who usually decides what they do?

₁☐ your child ₂☐ child's friend ₃☐ teacher ₄☐ other person ₅☐ don't know

n. How often can your child choose what they do when using a computer at **school**?

₁☐ always ₂☐ usually ₃☐ sometimes ₄☐ rarely ₅☐ never ₆☐ don't know

o. Who else is usually with your child when they are using a computer at **school**?

₁☐ no one ₂☐ child's friend ₄☐ teacher ₅☐ other ₅☐ don't know

p. When using a computer at **school** who does your child usually talk with?

1☐ no one 2☐ child's friend 4☐ teacher 5☐ other 6☐ don't know

q. What type of computer does your child use at school?

1☐ laptop 2☐ desktop 3☐ both laptop and desktop 4☐ don't know

r. In the <u>last month</u>, when using a computer at school how often did your child use a computer in their classroom?

1☐ not at all 2☐ 1 x month 3☐ 1 x week 4☐ 2-3 x week 5☐ daily 6☐ don't know

s. In the <u>last month</u>, when using a computer at school how often did your child use a computer in a computer lab?

1☐ not at all 2☐ 1 x month 3☐ 1 x week 4☐ 2-3 x week 5☐ daily 6☐ don't know

Now the last questions about your child's use of computers <u>***AT SCHOOL.***</u>

<u>***Please ask your child the following questions***</u>

t. "Did you use a computer at school <u>last week</u>?"

1☐ yes 2☐ no =► *if* 'no' *go to question x* =►.

╚► *if* 'yes' *go to next question*

u. "When you used a computer at school how much did you think about other things at the same time?"

1☐ not at all 2☐ a little 3☐ a lot

v. "When using a computer at school, how much did you notice other things going on around you?"

1☐ not at all 2☐ a little 3☐ a lot

w. "When using a computer at school, how much did you feel totally involved in what you were doing?"

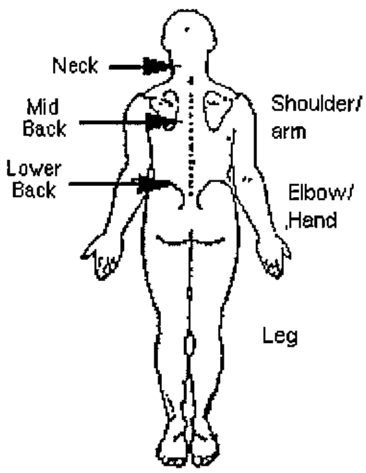
1☐ not at all 2☐ a little 3☐ a lot

x. In the <u>last month</u>, did your child feel any soreness when they used the computer at school?

1☐ yes 2☐ no

╚► If *'no'* go to question 6 =►

y. Circle each body part on the picture where your child felt any soreness using the computer at school in the <u>last month</u>.



z. What do you think caused the soreness?

6. *Now some questions about* **using a computer at <u>HOME only</u>**

(this includes using a computer at a friends home)

a. Does your child have access to a computer at **home**?
1☐ yes 2☐ no

b. How many desktop computers do you have at **home**?
☐

c. How many laptop computers do you have at **home**?
☐

d. Do you have internet/email access at **home**?
1☐ yes 2☐ no

e. Does your child's mother/guardian use a computer?
1☐ yes 2☐ no 3☐ don't know

f. Does your child's father/guardian use a computer?
1☐ yes 2☐ no 3☐ don't know

g. In the last month, how often did your child use a computer at **home**?
1☐ didn't 2☐ 1 x month 3☐ 1 x week 4☐ 2-3 x week 5☐ daily
└► *If* 'didn't' *go to question 7* ═►

h. In the last month, how long did your child usually use a computer at **home** each time?
1☐ < 30 minutes 2☐ 30-60 minutes 3☐ 1-2 hours 4☐ 2-5 hours 5☐ >5 hours

i. In the last month, what was the longest time your child used a computer at **home** without a break?
1☐ < 30 minutes 2☐ 30-60 minutes 3☐ 1-2 hours 4☐ 2-5 hours 5☐ >5 hours

j. When using a computer at **home**, which room is your child usually in? (tick all boxes that apply)
1☐ shared area eg living room or shared study 2☐ their own bedroom or study 3☐ someone else's bedroom or study 4☐ some other room 5☐ varies, use it in different rooms

k. When using a computer at **home** which of these postures does your child use? (tick all boxes that apply)
1☐ sitting at desk/table 2☐ sitting on floor 3☐ sitting on sofa/beanbag 4☐ lying down 5☐ standing 6☐ other

Did your child do any of the following activities on the computer at **home** in the last month?

l. Play games	₁☐ yes	₂☐ no
m. Create pictures or music	₁☐ yes	₂☐ no
n. Write letters, stories etc.	₁☐ yes	₂☐ no
o. Use educational software	₁☐ yes	₂☐ no
p. Surf the Net	₁☐ yes	₂☐ no
q. Send/receive emails	₁☐ yes	₂☐ no
r. Chat room	₁☐ yes	₂☐ no
s. Other activities	₁☐ yes	₂☐ no

t. When your child is using a computer at **home** who usually decides what they do?
1☐ child 2☐ child's friend 3☐ parent 4☐ brother/ sister 5☐ other person

u. How often can your child choose what they do when using a computer at **home**?
1☐ always 2☐ usually 3☐ sometimes 4☐ rarely 5☐ never

v. Who else is usually with your child when they are using a computer at **home**?
1☐ no one 2☐ child's friend 3☐ brother/sister 4☐ parent 5☐ other

w. When using a computer at **home** who does your child usually talk with?
1☐ no one 2☐ child's friend 3☐ brother/sister 4☐ parent 5☐ other

x. Thinking about the last seven days, in total how many hours has your child spent using a computer at **home**? ☐ hours

y. Tick the types of computers your child uses at **home**? (tick all boxes that apply)
1☐ desktop 2☐ laptop 3☐ other

Now the last questions about your child's use of computers ***<u>AT HOME</u>.***

<u>Please ask your child the following questions</u>

z. "Did you use a computer at home <u>last week</u>?"

[1]☐ yes [2]☐ no =► *if* 'no' *go to question zd* =►.

└► *if* 'yes' *go to next question*

za. "When you used a computer at home how much did you think about other things at the same time?"

[1]☐ not at all [2]☐ a little [3]☐ a lot

zb. "When using a computer at home, how much did you notice other things going on around you?"

[1]☐ not at all [2]☐ a little [3]☐ a lot

zc. "When using a computer at home, how much did you feel totally involved in what you were doing?"

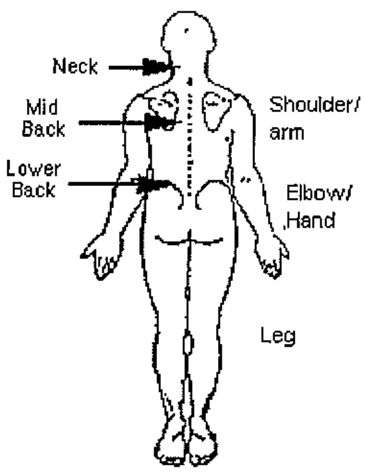
[1]☐ not at all [2]☐ a little [3]☐ a lot

zd. In the <u>last month</u>, did your child feel any soreness when they used the computer at home?

[1]☐ yes [2]☐ no

=► *if* 'no' *go to question 7* =►.

ze. Circle each body part on the picture where your child felt soreness using the computer at home in the <u>last month</u>.



zf. What do you think caused the soreness?

____

7. Finally, some questions about how your child generally feels when they use computers anywhere. ***(if your child hasn't used a computer please finish the survey now)***

Please ask your child the following two questions

a. "When using a computer how often do you feel like you have butterflies in your stomach?"
1☐ don't 2☐ 1 x month 3☐ 1 x week 4☐ 2-3 x week 5☐ daily

b. "How much do you enjoy using a computer?"
1☐ really don't enjoy it 2☐ don't enjoy it 3☐ so so 4☐ like it 5☐ really like it

Thank you for your time and effort in completing this important questionnaire. Please return this questionnaire to your child's class teacher.

Appendix F

Harris, C., Straker, L., Pollock, C. & Trinidad, S. (2005). Musculo-skeletal outcomes in children using information technology–the need for a specific etiological model. *International Journal of Industrial Ergonomics, 35*, 131-138.

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Musculo-skeletal outcomes in children using information technology–the need for a specific etiological model

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Abstract

Children's exposure to information technology (IT) is increasing in leisure, home and educational environments. Recent studies suggest that with this increased exposure there are associated learning, psychosocial and musculoskeletal outcomes. Models have been developed that attempt to represent the relationships between exposure to risk factors aud precipitation of musculoskeletal outcomes. These models, based on adults performing work-related tasks in work environments, typically offices, have limited application to children using IT as they do not address children or IT specifically, and they do not investigate IT use as a leisure task or in different environments. This paper will discuss the limitations of adult workplace models, the unique characteristics of children's use of IT and propose a set of variables required in an etiological model of musculoskeletal outcomes of children using IT.

Relevance to Industry

Musculoskeletal disorders associated with adult's occupational computer use is a significant occupational health and productivity issue. If children are exposed to similar risks and develop similar disorders this may cause significant costs and liabilities to the education industry. Further, when these children commence paid employment they may be already suffering from musculoskeletal disorders, or predisposed to them due to years of childhood exposure.

Keywords: Children; Information technology; Computers; Ergonomics; Musculoskeletal symptoms; Theoretical model; Etiology

1. Introduction

The etiology of musculoskeletal symptoms associated with the use of information technology has predominately been defined by studies of

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adults in their work environments. Risk factors identified in the literature as resulting in musculoskeletal injuries and/or musculoskeletal disorders (MSDs), include: Individual factors (e.g. genetics, age, gender, anthropometry, psychosocial profile, cognition, physiology); physical environment and biomechanical factors (e.g. force, posture, movement and vibration) and task demands/work organization (e.g. repetitive paced tasks) (Armstrong et al., 1993; Kuorinka and Forcier, 1995; Kumar, 2001; Li and Buckle, 1999; Mathiassen, 1993; Moon and Sauter, 1996). Additionally, models have been developed to investigate this causal relationship between information technology (IT) use and outcomes experienced by the user and to provide IT users with workplace guidelines to assist in controlling some of the associated risks for musculoskeletal outcomes.

When examining children's use of IT it is evident that their use of this medium is very different to adults in the work environment. Even though many risk factors may be similar, due to the nature of children and their environments, it is proposed by the authors that risk factors and models of causal relationships between IT use and outcomes would vary for children.

IT use by children is rapidly growing. Children are using IT in their education, leisure pursuits and communication, in both school and home environments. Research on the ergonomics of IT use by children has begun to investigate the potential effects of IT use on a child's health, satisfaction and productivity (Straker and Pollock, in press). Several studies have suggested children with usage of IT may be at risk of the development of physical problems (Bennett, 2002; Gillepsie, 2002; Rowe and Jacobs, 2002; Royster and Yearout, 1999).

Developing a model that assists in understanding the causation of musculoskeletal problems in children using IT is necessary so that academics, educationalists and parents can develop a better understanding of the risk factors for school children's use of IT. This will support the development of recommendations for effective use of IT by children, which in turn will encourage children to use this valuable resource in educational, recreational and communication environments in a safe and productive manner.

2. General models/theories for MSD outcomes with IT use

Whilst there is no study to date that has demonstrated a clear and indisputable causal or dose–response relationship between any of the risk factors and precipitation of injuries for any risk factor (Kumar, 2001), results from epidemiological studies have contributed to evidence of causality in the relationship between workplace risk factors and MSDs.

Bernard (1997) and contributors developed a framework for evaluating evidence for the causality of workplace risk factors and MSD outcomes. In their review of epidemiological studies they found that evidence for associations between MSDs and risk factors varied from "strong evidence" to "no evidence". Specific risk factors of repetition, force, posture, vibration or a combination of risk factors were shown to have associations with MSDs. For example, they found strong evidence that neck MSDs were related to prolonged durations of static contraction of neck/shoulder musculature (posture). Additionally, they found strong evidence for MSDs associated with a combination of risk factors, for example upper limb posture and force. Work-related risk factors most consistently identified included: repetitive (monotonous) hand work, high physical load, static load, vibrating tools with hand and elbow pain, and increasing intensity or duration of exposure. There are also reports that stress symptoms may predict MSDs.

Models have been developed that attempt to represent the relationships between exposure to risk factors and precipitation of MSD outcomes (Armstrong et al., 1993; Kumar, 2001; Mathiassen, 1993; Moon and Sauter, 1996). Although varied, these models show that MSD outcomes are linked to the interaction of a number of risk factors, and it is thought that MSD outcomes can follow a dose–response relationship (Armstrong et al., 1993). It is recognized by most of these models that MSDs cannot be fully explained through physical causes alone, but that psychological, social and environmental factors will influence the precipitation of MSDs. This multidimensional perspective is illustrated in the following three current theories of MSD precipitation.

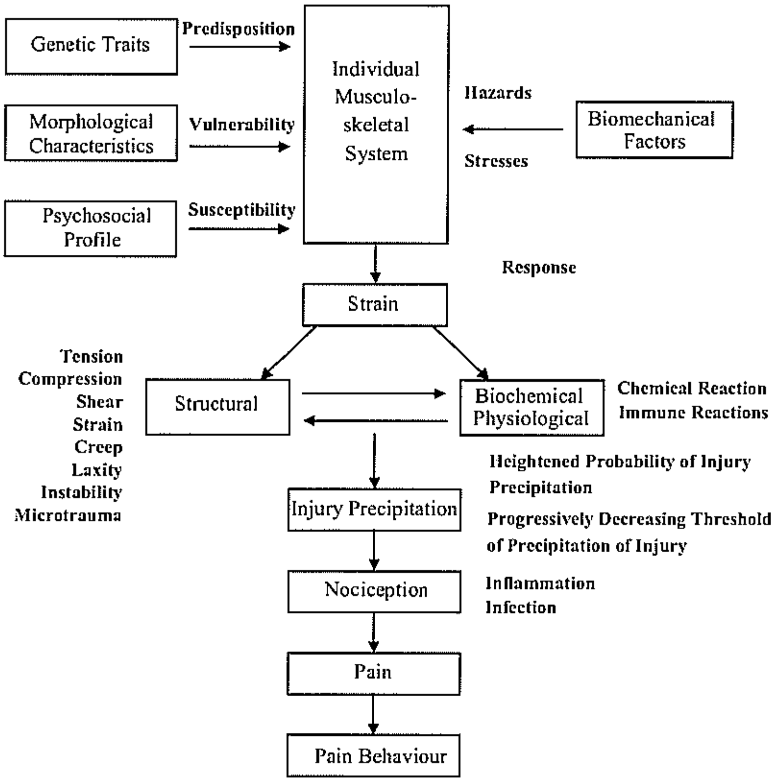

Fig. 1. Multivariate intervention theory of musculoskeletal injury precipitation (Kumar, 2001).

2.1. *Adult models*

The Multivariate Interaction Theory of Musculoskeletal Injury Precipitation by Kumar (2001) demonstrates how a musculoskeletal injury is an interactive process between genetic, morphological, psychosocial and biomechanical factors. Within these categories there are many variables that may effect precipitation of a musculoskeletal injury (Fig. 1).

The exposure-effect model, as discussed by Mathiassen (1993), shows how the interaction of external (outside the individual) and internal (within the individual) exposure variables interact to result in a response. Initially, the response is acute, either during the activity or after the activity, and can lead to chronic effects. The model demonstrates how the acute response provides continued internal exposures (Fig. 2).

Specific models discussing risk factors and outcomes associated with an individual's exposure to IT are limited. One model is the ecological model of MSDs in visual display terminal work proposed by Sauter and Swanson (1996). This model discusses the relationship between psychosocial factors and MSDs in office work. As computer work is a major task in office environments this task is incorporated into the model. This model has detail on how cognitive processes such as detection and awareness of MSDs may be effected by psychosocial processes. The model is specific to office work and computer terminals in offices only (Fig. 3).

3. Limitations of the current theories and models

Many of the risk factors affecting the adult working population would be similar to issues

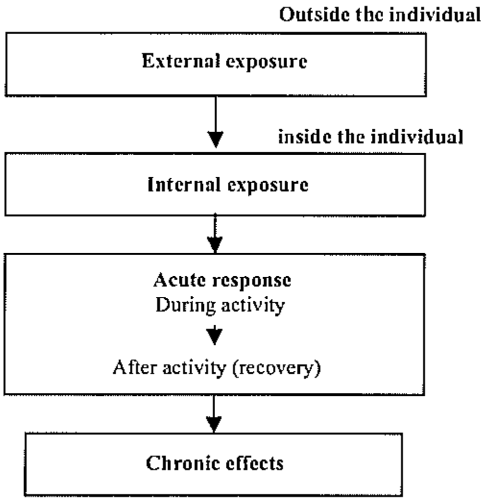

Fig. 2. Exposure-effect model (Mathiassen, 1993).

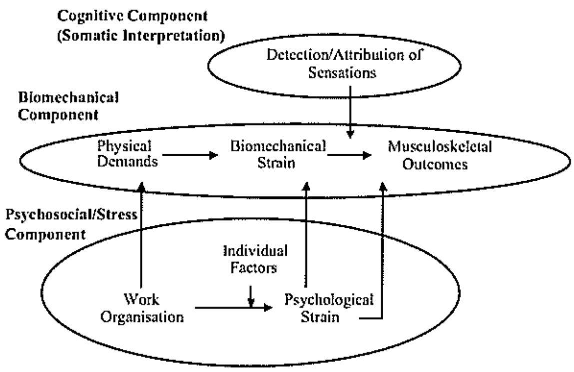

Fig. 3. Ecological model of musculoskeletal disorders in VDT work (Moon and Sauter, 1996).

facing children, for example prolonged static seated postures during IT tasks, manual handling, biomechanics of work station design and individual factors such as height. However growing children interacting with a range of IT in different environments, for a variety of purposes, will have unique risk factors associated with their use of IT.

These models based on adults performing work-related tasks in work environments, typically offices, are limited as they do not address children or IT specifically, and they do not investigate IT use as a leisure task or in different environments. The models may therefore not be appropriate when applied to different user groups in different environments performing different tasks, e.g. school environments with children using IT.

3.1. Children are different

Children and adult musculoskeletal systems are different. The New Zealand Department of Labour (1991) acknowledges that young workers are at a greater risk of manual handling injuries than adults because they are still developing physically (Whitfield et al., 2001). Perhaps this is due to children being less able to withstand stresses that are usual to the adult spine (Grimmer and Williams, 2000).

Age is reported to affect the postures adopted for IT use, and the age related postural differences are likely to be at least partially a function of the height of the child (Briggs et al., 2004). Briggs et al. (2004) report that age of the user influences the posture assumed for head tilt, neck flexion and downward gaze angle during a reading task, but had no significant influence on trunk position.

3.2. It use is different

Risk factors pertaining to IT such as types of IT used, IT task purpose and physical IT environment are currently not discussed in the existing models and are emerging as important risk factors that may effect MSD outcomes with children's IT use. The type of IT used has been shown to influence the user's posture. Briggs et al. (2004) in their study of sitting posture with different types of IT found that head tilt varied according to IT type. Additionally, Greig et al. (2001) demonstrated in their study on EMG activity of cervical erector spinae (CES) and trapezius muscles, that muscle activity varied according to IT type being used. When reading books and using laptops CES and trapezius activity was significantly greater than for desktop computer use.

In regards to physical IT environments it is generally reported that to minimise discomfort during computer use adjustability within the workstation is required (Jacobs and Bettencourt, 1995). Individual adjustable workstations for IT tasks are often seen in office work environments.

However this is not often evident in school and home environments. Murphy and Risser (1999) found in their study of children from grades six to eight, that 35% of students could not find a chair that was congruent with their body dimensions.

Observations of Australian and North American school environments show school chairs are usually non-adjustable and do not take into consideration children's growth spurts. They are mostly bucket seats or stiff backed chairs. Monitor heights are reported to be non-adjustable and not of correct height (Gates, 1998). School lighting is usually reported to be designed for paperwork on desks rather than computer workstations (Gates, 1998).

Adults and children use IT for leisure but this is not considered in current models. It is shown in the RASCALS study with children that there is a negative relationship between increased computer use and decreased weekend vigorous activity (Straker et al., 2003). This research may support the proposal that IT use for leisure could result in a decrease in fitness levels, as the continuation of IT engagement requires potentially prolonged static sedentary postures. Additionally, children maybe at risk of musculoskeletal problems because many of the tasks they engage in at school and after hours have similar postural requirements. Royster and Yearout (1999) survey reveals that many students are regularly involved in similar tasks out of school hours, for example, playing a musical instrument, playing video games and using a computer.

IT tasks can be performed in a range of environments, eg home, work and school. The portability of IT also allows for use outdoors, whilst travelling in vehicles, on holidays, during excursions or "anywhere" (Harris and Straker, 2000). Therefore with the use of IT in non-traditional settings there is a potential for different risk factors, depending on environmental conditions, available workstation equipment and postures utilized (Fig. 4).

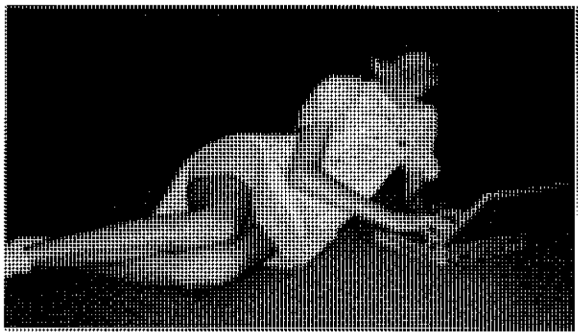

Fig. 4. Illustration of one common posture found in IT use in children.

3.3. Possible interaction between children and IT use

This potential for risk factors is also demonstrated with the interaction of children using a range of IT for different purposes in various environments. For example, children are reported to be more flexible than adults, allowing them to adopt postures for IT use that an adult worker may not use, for example lying prone on the floor or kneeling on the floor using a bed as a desk.

The purpose of the IT task affects the motivation to engage in the task. The IT task purpose will often dictate the duration required for the IT task, the work posture and environment it is performed in. In regards to children, a student required to complete an assignment, or engrossed in a computer game, may adopt an awkward posture for prolonged periods in order to complete the required task (Gillepsie, 2002).

The authors observations of children using IT show that IT can thoroughly engage children even though they are reportedly experiencing pain. Harris and Straker (2000) found in their study that 26% of participants they surveyed reported that if they experienced discomfort with IT use they would still continue on with the task. Due to the involvement in the IT process children are able to ignore these symptoms and may not be aware of minimising injury by taking breaks and resting (Gates, 1998; Royster and Yearout, 1999).

It is evident that existing models based on adults' performance of work-related tasks do not take into consideration all issues related to the performance of IT tasks. Similarly, the models are limited in providing a useful understanding of causal links between risk factors and outcomes with children's use of IT. It is therefore necessary to develop a model specific to children and their use of all IT to help understand how exposure to this medium effects the child user.

4. Physical and psychosocial risk factors relating to children's use of information technology

Risk factors reported in the literature that are pertinent to children, IT tasks and the development of potential etiological models involve both physical and psychological/social factors.

Physical risk factors reported include: prolonged sitting, IT laboratory arrangements, mismatch between student size and school furniture, lack of awareness of posture in school, non-traditional postures utilized, manual handling and duration of IT use.

Evidence in the literature for these risk factors is limited. However, Harris and Straker's (2000) study on school children aged 10–17 years found an association between increased time in one sitting and reports of musculoskeletal discomfort. This association between MSDs and duration of exposure to IT is supported in the literature pertaining to adults, for example Buckle and Devereux (1999), states there is epidemiological evidence of shoulder and neck MSD with adult IT use when exposure exceeds four hours.

In regards to psychosocial risk factors etiological mechanisms are poorly understood, however there is increasing evidence that psychosocial factors related to home and work environments play a role in the development of MSDs (Bernard, 1997). Adult psychosocial factors that have been linked to upper extremity MSDs, include: perceived increases in work demands, monotonous work, dissatisfaction, limited job control, low job clarity, low social support, and conditions such as depression, stress and anxiety (Bernard, 1997; Moon and Sauter, 1996). Some of the psychosocial factors discussed in the literature pertaining to children include student behaviour and the attitudes of educationalists and parents (Royster and Yearout, 1999).

In theory, these factors may act biologically through increased muscle tension and exacerbate task-related biomechanical strain, physiological vulnerability, or symptom attribution and reporting (Bernard, 1997; Buckle and Devereux, 1999; Moon and Sauter, 1996).

Zandvliet and Straker (2001) suggests tentative and emerging links between the physical and psychosocial learning environments for children when using new IT. They reported that psychosocial factors may influence students satisfaction and productivity in learning environments. Psychosocial factors proposed to be important for educational productivity with IT use include: student cohesion and autonomy, involvement, task orientation and co-operation (Zandvliet and Straker, 2001).

5. Characteristics of a model of musculoskeletal problems associated with children's use of information technology

Evidence to date demonstrates that MSD outcomes are affected by a range of risk factors including physical, psychosocial and environmental factors. Therefore a model of musculoskeletal problems associated with schools children's use of IT needs to be multidimensional.

It would be useful for the model to incorporate factors related to the individual user, the environment and outcomes. Variables relating to the user would need to involve physical, psychological and social aspects. User physical factors could include pre-existing MSDs, age, gender, stature and physical activity levels. There is evidence in the literature that these factors affect the user's ability to be comfortable with their IT work station and predisposition to MSD outcomes. User psychological factors could include sustained attention, computer anxiety, internalisation and control. Adult literature demonstrates that these factors for adults have been associated with adult's report of MSDs and user's motivation to engage in IT use. User social factors include socio-economic status as this may relate to a child's exposure to IT, access to IT, school attended and available leisure options.

Environmental variables include physical aspects, task aspects and social aspects. Physical environment factors could include location and workstation set-up, as these factors are demonstrated in the literature to influence the user's posture and comfort with IT use. Task environment factors could include frequency and duration of IT use, types of IT used, IT access, purpose of IT use and IT tasks. IT time on task has been shown to affect the user's discomfort. Other task factors influence the time on task and postures and locations utilised for the IT use. Social environment factors could include working alone or with others, including peers, parents/carer and teachers.

Outcomes associated with the interaction of risk factors include musculoskeletal discomfort, MSDs and loss of function.

6. Conclusion

The impact of the increasing use of IT by children needs to be understood. Current models of musculoskeletal problems associated with IT use in adults are not adequate. This paper presented the framework for a model of IT use by children and musculoskeletal problems. New models should be developed with the framework and tested. Once validated such a model would be valuable to guide further research and to form the basis of health promotion information aimed at encouraging effective use of IT by children.

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Appendix G

Harris, C., Straker, L. & Pollock, C. (2007). Children's Exposure and Use of Information Technology, *Proceedings from The 43rd Annual Conference of the Human Factors and Ergonomics Society*, Perth, Western Australia, November, 2007.

43rd Annual Conference of the Human Factors and Ergonomics Society of Australia

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CHILDRENS'S EXPOSURE AND USE OF INFORMATION TECHNOLOGY

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Aims

The use of information technology (IT) has been increasing globally for all ages over the last two decades. This has been assisted by the development of a range of IT products that are now portable and wireless. Additionally, large IT industries have also further developed IT for leisure interests for both adults and children. Anecdotal reports and research suggest that children today are using IT at home, school, whilst travelling in cars and public transport, and at recreational facilities such as arcades, parks, libraries, community centres and friend's homes. Additionally, research suggests that children are using computers daily, and most children have access to IT at home and school. The aim of this study was to identify the exposure children have to a range of new and old IT, and compare the use of computers in home and school environments.

Methods

1350 children aged from 5 – 17 years completed an IT Activity Questionnaire. Children were asked about their use of a range of IT and activities, including watching TV, writing / drawing, reading, using mobile phones, playing electronic games, using computers at home and school, playing musical instruments and physical activities. Additionally each child's teacher completed questions about the student's academic performance, and each child was weighed and measured.

Results

99% of children in this study use either laptop or desktop computers. 98% of the children surveyed used computers at school at least once over the last month, with most students using computers in this environment 2 – 3 times per week for between 30 to 60 minutes in one sitting. 99% of the children surveyed have access to home computers, with 96% of respondents having internet access. 82% of the respondents' mothers and fathers use computers. Most students at home use computers for 30 – 60 minutes daily, for on average 7 hours per week.

In regards to other activities such as electronic games and mobile phones, 80% respondents have access to electronic games at home but only 70% used them over the last month. 70% of respondents report using mobiles phones for phone calls and text messages.

Other activities respondents reported that they participated in over the last month include: Physcial activity (94% of respondents); reading and writing (old IT) (96% of respondents) and playing musical instruments (44% of respondents).

Conclusion

Children are involved with the use of information technology on a daily basis, in a variety of settings. This research suggests that children are embracing the use of both new and old IT in their work/ school and home environments. As IT use in the home environment has been found to be for more frequent, and for longer durations than other environments, strategies need to be developed to ensure this use is safe and productive.

Appendix H

Harris, C., Straker, L. & Pollock, C. (2009). Young people's home, school and neighbourhood can influence their computer use. *Proceedings from the International Ergonomics Association Conference*, Beijing, China, August, 2009.

Young people's home, school and neighbourhood can influence their computer use.

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ABSTRACT

Young people use computers in a range of environments and for a variety of tasks. Whilst it is acknowledged that home and school are common computer use environments for children, and that local neighbourhood may modify computer use, the impact of these environments on children's exposure patterns and computer use is not well understood. Objective: The aim of our study was to investigate the influence of home, school and neighbourhood on young people's computer use. Method: 1351 children in years 1, 6, 9 and 11 from 10 schools in metropolitan Western Australia were surveyed. Results: Most young people have access to computers at home and school, with high weekly use in both environments. Mean weekly hours and duration of use was at least 3 times greater at home than school. Neighbourhood associations were evident for frequency, duration and nature of computer use. Socially orientated computer use was more evident at home with young people from lower SES neighbourhoods. School computer exposure was more evident with young people from higher SES neighbourhoods. High use of home and school computers were associated with each other. Conclusion: Previous studies have identified a potential impact of computer exposure on young people's health and development. As aspects of computer exposure (including access, amount and nature of use) have been shown to be influenced by young people's home, school and neighbourhood, a better understanding of environmental influences is required. This will assist in understanding and managing the impact of computer use on young people's health and development.

Keywords: children; computers; exposure; neighbourhood, school; home

INTRODUCTION

The proliferation of information technology (IT), such as computers and the internet, is reportedly changing societies in many ways - including education, required job skills, how businesses function and how individuals interact, shop, find employment, pay bills, research information and spend leisure time.

Children's exposure to IT has been increasing over the past decade (Roberts, 2005, Lajunen, 2007, Gillespie 2002, Harris 2000, Straker, 2006, UCB, 2003, Jacobs, 2002). Globally, policy makers are ensuring schools are equipped with IT not only to reportedly "raise educational standards", but to ensure the next generation is a computer literate workforce. Additionally, parents who are trying to ensure children are educationally equipped for the future are providing their children with IT at home (Facer 2001).

Young people today are reported to live "media saturated lives" with TV, electronic games and computers used for 25% of their waking hours. Young people use computers at home and school within their neighbourhood.

Computers are used to play games, write documents, complete learning programs, work with pictures and music in multimedia programs, surf the internet and communicate by email and chat rooms.

Young people use computers in a variety of environments, with school and home the most common. Nearly all children in affluent communities use computers at school and the majority use computers at home. The USA Census Bureau found that in 2003 92% of children enrolled in school used a computer at school (UCB, 2003) and in Australia 90% of school aged children used a computer at school (ABS, 2006). Within the home environment, 70% of Australian households had access to a computer, with 60% also having internet access. The USA Census Board reported that, in 2003, 76% of households with school children have computer access and 67% have internet access (UCB 2003).

Young people's use of computers has been found to be influenced by environmental aspects of location of use (commonly home and school) and neighbourhood socioeconomic status (NSES). Computer access and the nature of use (frequency, duration and activity type) have been found to be influenced by the environment of use.

Access to computers

Neighbourhood socioeconomic status (NSES) has been shown to influence access to computers at school and home with young people from low SES neighbourhoods having reduced access, and those from higher SES neighbourhoods being more likely to have increased access. (Bozionelos 2004, Lowe et al, 2003, Wilson, 2003, Calvert et al 2005, Roberts, 2000). Additionally young people from higher SES neighbourhoods are reported to be more likely to attend schools with better computer equipment and have teachers with better computer skills (Bozionelos 2004).

Nature of Computer Use

Current evidence for a relationship between the environment of use and the nature of young people's computer use is limited. Whilst some research has found no correlation between NSES related factors and computer use (Anand and Krosnick 2005), other studies have reported mixed findings. The impact of NSES on exposure to computers has shown that the likelihood of ever using computers increases with higher NSES (Calvert et al 2005). Home computer use has been found to increase and school computer use to decrease with high NSES backgrounds (Lowe et al, 2003). Whereas, Olds et al, (2006) reports median screen time (including computer, TV and video games) to decrease with higher SES.

The nature of computer use including frequency, duration and computer activity used at home and school differ. Ramos (2005) report that home computer activities that are often used for longer durations involve a greater use of email, playing games, homework assignments and surfing the internet. Kent & Facer (2004) have shown these computer activities are also performed at school, along with other educationally based activities. It appears that home computer activities are often more social (e.g. chat room, multimedia, email), whereas school computer activities have involved learning programs and writing activities.

Previous studies have identified a potential impact of computer exposure on young people's health and development. As aspects of computer exposure (including access, amount and nature of use) have been shown to be influenced by young people's home, school and neighbourhood, a better understanding of environmental influences is required. This will assist in understanding and managing the impact of computer use on young people's health and development.

The aim of this paper was to investigate the impact of home, school and neighbourhood on the amount and nature of young people's exposure to computers.

METHOD

1351 children in school years 1, 6, 9 and 11 (~6, 11, 14 and 16 years of age) from 10 schools in metropolitan Western Australia were surveyed. Schools from State government, Catholic education and independent private education systems were approached to participate with the aim of an even gender mix, broad socioeconomic range and Years 1 to 11 coverage. Parents completed the survey for year 1 children, with older children completing their own survey. Table 1 shows the sample demographics.

Detailed exposure measures were gathered by survey to characterize home and school computer exposure, including frequency, usual and longest durations and mean weekly hours. NSES was assessed using the Australian Bureau of Statistics Index of Relative Socioeconomic Advantage/Disadvantage, which is based on the participant's primary residence postcode. Hierarchical multiple regression analysis was used in a 3 step model in order to examine the influence of neighbourhood variables on computer exposure.

RESULTS

General description

99% of the all participants report they had used a computer. The mean age for participants commencing use of a computer was 7 years. 81% of both mothers and fathers were reported to use computers.

Access

Nearly all children had access to computers at both home (99%) and school (100%). 95.9% of participants reported access to the internet / email at home, and all schools had internet access. Table 2 demonstrates the percentage of participant access to computers and internet at home and school according to their NSES percentile.

School computers were used in laboratories by 82.2% of participants and classrooms by 62.7%. Both laptop and desktop computers were used at school by 24.5%, with 74.2% using only desktops and 1.3% using only laptops.

Home computers were used most commonly in a shared room, e.g. living room, study (53.7%). 26.3% reported using a computer in their own bedroom or study area, and other areas were reported by 4.7 – 10.3%. A desktop computer was used at home by 82.5% of participants; a laptop computer by 33.8% and 2.1% reported using other types of computers.

Nature of Use

Frequency: At school, 97.8% of participants used computers at least monthly and 87.1% at least weekly. At home, 95.7% of participants used computers at least monthly, and 91.2% at least weekly.

Frequency of computer use at home and school were positively correlated (r_s=.214, p< .001) with each other. Table 3 demonstrates the relationship between NSES and monthly computer use. NSES was correlated with school computer use frequency (r_s=.148, p< .001), but not home computer use frequency (r_s= -.036, p= .186).

Duration: The mean total number of hours per week that participants used computers over a given week was 2.4 hours for school and 7.2 hours for home. 11.3% of participants reported usual duration of school computer use to be greater than 1 hour, whereas 45.0% of participants used a computer at home for more that 1 hour each time. Longest duration of computer use of greater than 2 hours was reported by 2% of participants at school and 30% of participants at home. Figure 1 shows the percentage of participants reporting longest duration greater than 2 hours for home and school computer use separated for boys and girls across the four year levels.

There was an association with all duration measures across both home and school environments, with an increased frequency in one environment associated with an increased frequency in the other ($.117<r_s<.695$, p< .001). NSES was correlated with both school and home computer longest duration and weekly hours (Table 3). NSES was also correlated with home monthly duration but was not correlated with school monthly duration.

Computer activities In addition to a greater computer exposure at home than school, the types of computer activities used at home and school differed. Within the home environment computer activities that could be deemed less structured and more social, for example surfing the internet, emailing, playing games, using multimedia and chat rooms, were used at least monthly by a greater percentage of participants. Computer activities involving learning programs and writing stories and letters were used at least monthly by a greater percentage of students in the school environment.

Table 4 demonstrates that NSES was significantly positively correlated with school computer activities of games, learning programs and emails indicating that participant's from areas of higher SES used these computer activities more frequently at school. NSES was significantly negatively correlated with home computer activities of writing, internet, email and chat rooms indicating that participant's from areas of lower NSES used these computer activities more frequently at home.

Computer Use Postures:

As demonstrated in Figure 2, 90% of participants reported sitting at a desk for computer work at school and home. Although minimal, more variation of posture occurred in the home, with an increase of participants using postures of lying down (1 % vs. 3.2%) and sitting on the floor (1.3% vs. 2.6%) and sofa (1.2% vs. 5.6%). NSES was not associated with computer use posture at home or school.

Computer Activity Choice:

As demonstrated in Figure 3, only 5% of participants reported always being able to choose their computer activities at school, compared to 60% in the home environment. NSES was not associated with frequency of choice of home or school computer activity.

Who usually decides computer activity?

In the school environment 75% of participants reported that the teacher usually decided the computer activities, and 20% reported they were able to choose. In the home environment 80% of participants reported personal choice, and 10% of participants reported parents choose the activities. In both environments approximately 2% of participants reported friends or others usually choose the computer activities (See Figure 4). NSES did not show any associations with who usually decides computer activity.

Who usually with when using computer:

In the school environment 70% of participants reported usually being with friends, whereas at home most participant's (61.2%) reported being with no-one, or with siblings (32.4%) when using the computer, see Figure 5. Being with friends when using a computer at home was associated with low NSES ($x^2(2)$ =11.7 p=.003). Being with teachers when using a computer at school was associated with high NSES ($x^2(2)$ =10.1 p=.006).

Who usually talk with when using computer:

At school 83% of participants reported usually talking with friends when doing computer tasks, whereas at home 39% reported talking with no-one and 30% talked with siblings. Talking with teachers when using a computer was associated with high NSES ($x^2(2)$ =8.9 p=.012).

DISCUSSION

Young people were found to have been exposed to computers from a young age, and were using computers in different environments frequently and for significant durations irrespective of their neighbourhood socioeconomic status. The near universal access to computers at home and school for young people in this study demonstrates the importance of computers in young people's daily life.

Previous studies have shown mixed results with exposure at home versus school, with some studies indicating that young people are typically exposed to computers more in the school environment (Olds et al 2006). The current findings have clarified that whilst the proportion of children with access is similar at home and school, total exposure is greater at home, with increased frequency, duration and mean weekly hours of computer use. When educators, parents and health professionals are assisting young people with health and development issues associated with computer use, it is now clear that the home environment must also be considered in assessment and intervention.

NSES was shown to influence young people's computer exposure in a variety of ways including time spent on computers in both home and school environments. Additionally the nature of the computer use in both school and home environments was found to differ according to NSES.

Within the school environment, young people from advantaged neighbourhoods (high NSES) were found to use school computers more frequently, for longer durations and have higher frequencies of using computer learning programs and other academic related computer activities at school. They were also found to interact more with teachers during computer use. Therefore the increased use of school computers reported by high NSES young people is likely to provide an opportunity for extended educational attainment and improved academic skills.

Within the home environment young people from disadvantaged neighbourhoods (low NSES) had increased use of home computers with greater mean weekly hours of use, usual duration and longest durations. While an increased use of home computers could be viewed as compensatory for reduced school computer use, a closer examination of the nature of their home computer use indicated different issues. Young people from low NSES were found to not be using home computers for learning program /academic related activities, but for multimedia and chat room activities. This social aspect of computer use was also seen with young people from low NSES neighbourhoods usually talking with friends during computer use. These social aspects of these young people's computer use could be viewed as not being conducive to educational attainment associated with some computer use.

CONCLUSION

This study demonstrated that, whilst access was nearly universal, young people's home, school and neighbourhood influenced their frequency, duration and nature of computer use. A better understanding of computer exposure is seen as critical to developing appropriate policies to ensure safe use of information technology thereby ensuring adequate health and development of young people.

Table 1. Sample demographics

	Sample	Mean age (years)	SD (years)
Year 1	146	6.8	0.7
Year 6	350	11.3	1.0
Year 9	563	14.2	1.2
Year 11	292	16.3	1.2

Table 2. Percentage of participants with access to computers and internet at home and school

NSES Percentile	NSES Values	School		Home	
		computer	internet	computer	internet
<10th	<924.5	100.0	100.0	96.8	92.0
10th	924.6 – 929.5	100.0	100.0	98.7	93.5
20th	929.6 – 973.5	100.0	100.0	100.0	93.4
30th	973.6 – 995	100.0	100.0	100.0	94.3
40th	995.1 – 1034.5	100.0	100.0	97.0	97.0
50th	1034.6 – 1062.2	100.0	100.0	100.0	97.1
60th	1062.3 – 1111.7	100.0	100.0	98.6	97.9
70th	1111.8 – 1129.7	100.0	100.0	100.0	100.0
80th	1129.8 – 1164.9	100.0	100.0	100.0	98.2
90th	1165<	100.0	100.0	99.4	98.9
	Mean	100.0%	100.0%	98.9%	95.9%

Table 3. Correlations (Spearman's rho) of NSES and school and home computer frequency and durations

	School Computer Use				Home Computer Use			
	monthly frequency	monthly duration	monthly longest duration	weekly hours	monthly frequency	monthly duration	monthly longest duration	weekly hours
NSES	.148(**)	-.033	.088(**)	.086(**)	-.036	-.220(**)	-.138(**)	-.157(**)

** Correlation is significant at the 0.01 level (2-tailed).

Table 4 Correlations (Spearman's rho) of NSES with school and home computer activities

	School Computer Activities							
	games	multimedia	write letters	learning programs	internet	emails	chat rooms	other
NSES	.126(**)	-.010	.029	.094(**)	.033	.257(**)	.017	.012

	Home Computer Activities							
	games	multimedia	write letters	learning programs	internet	emails	chat rooms	other
NSES	.020	-.079(**)	.009	.042	-.062(*)	-.056(*)	-.117(**)	-.032

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

Figure 1. Percentage of boys and girls reporting longest duration greater than 2 hours for home and school computer use across school year levels

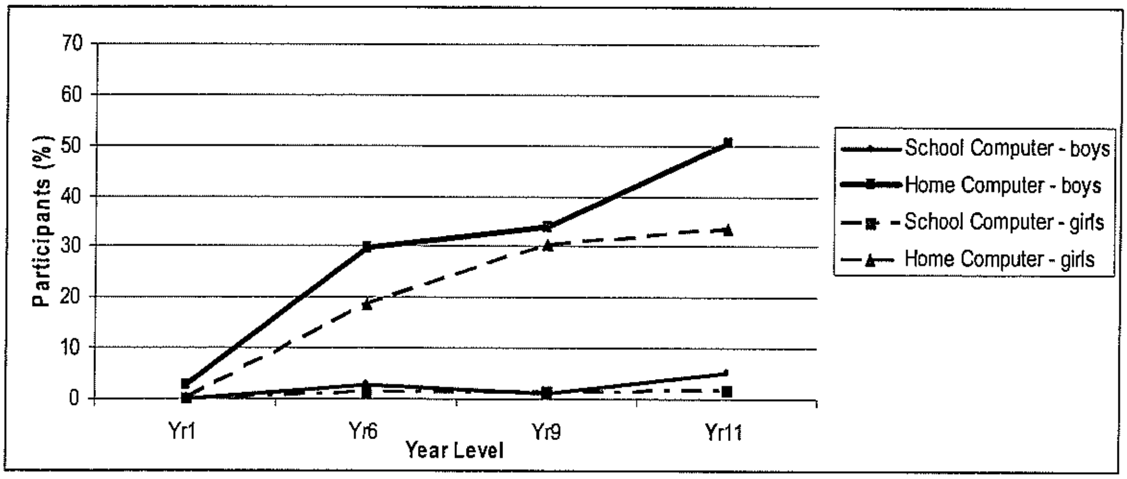


Figure 2. Percentage of computer postures used at school and home

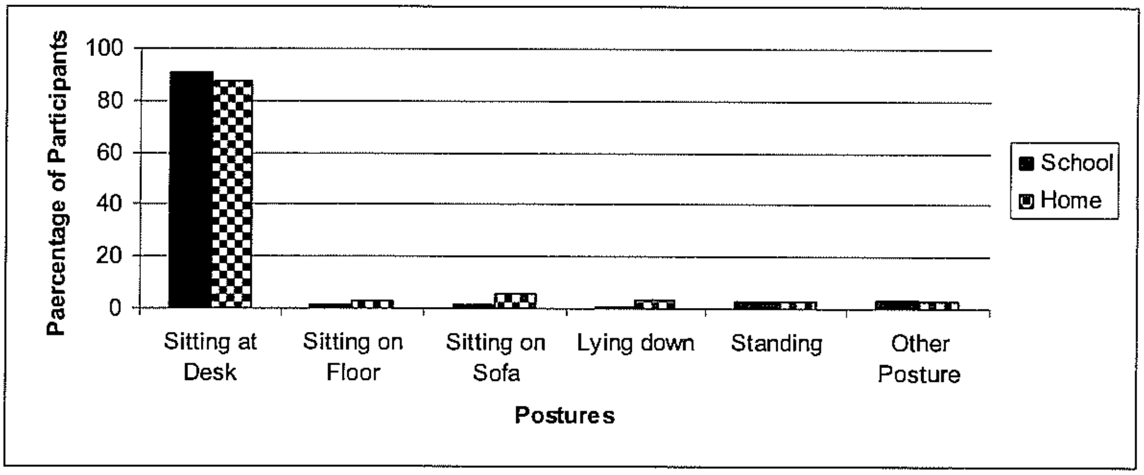


Figure 3. How often able to choose computer activity

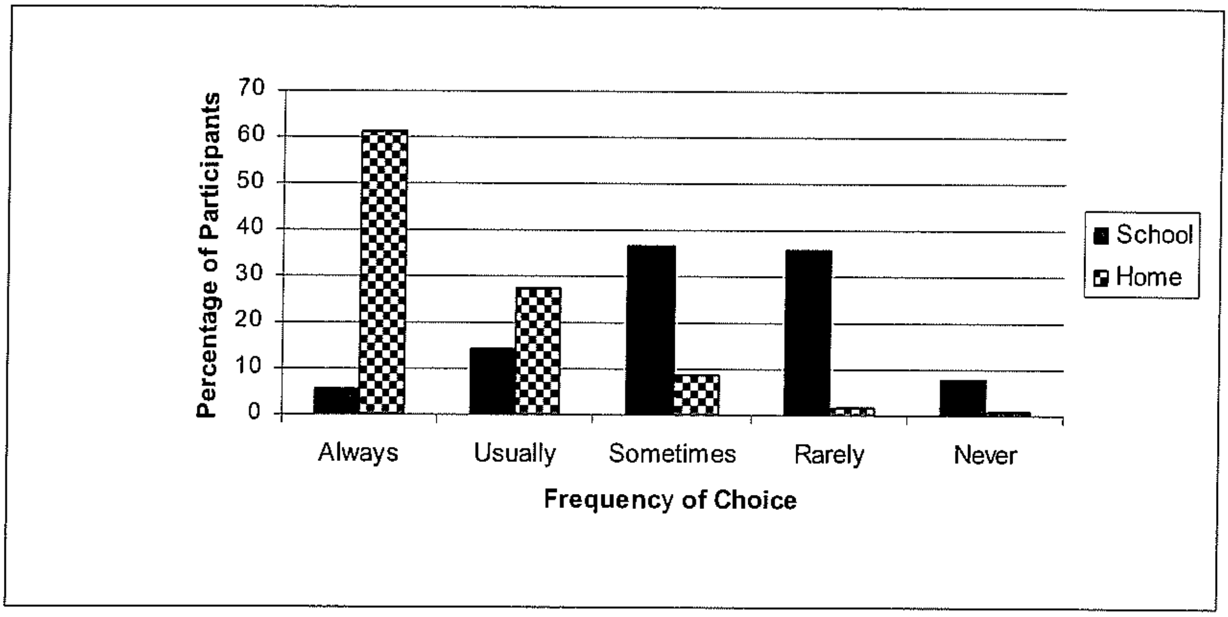


Figure 4. Who usually decides computer activity

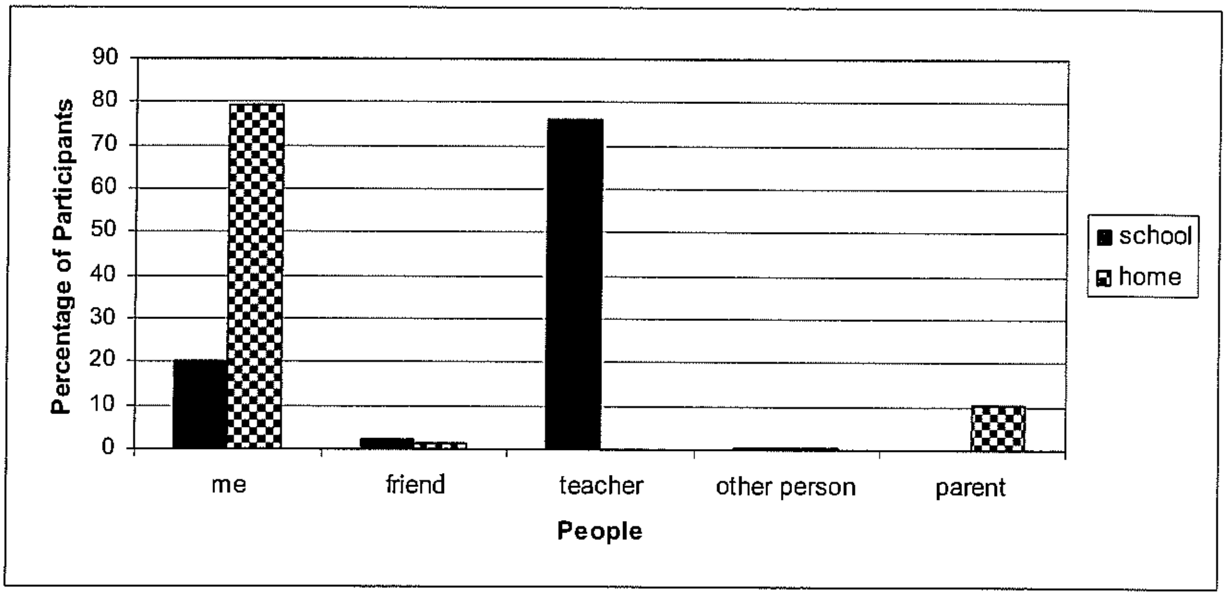


Figure 5. Who usually with when using computer

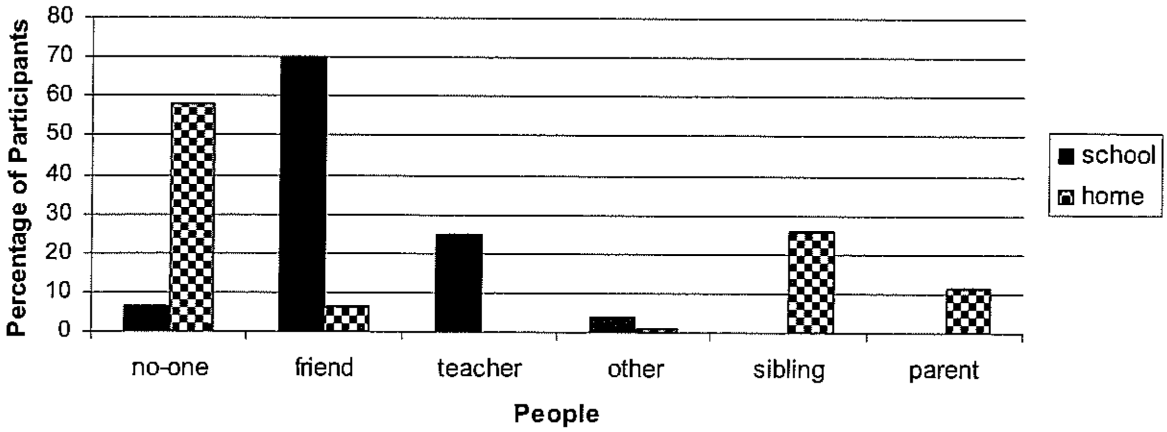
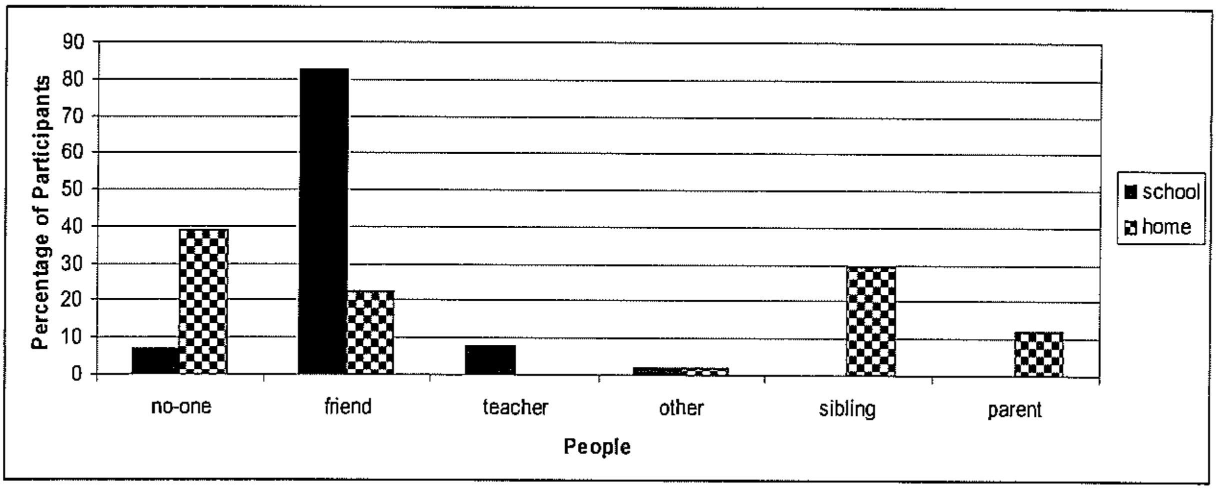


Figure 6. Who usually talk with when using the computer



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Appendix I

Harris, C., Straker, L., & Pollock, C. (2010). Musculoskeletal outcomes in children using home computers – A proposed model. *Proceedings of the International Conference on Prevention of Work-Related Musculoskeletal Disorders (PREMUS),* Angers, France, August 2010.

MUSCULO-SKELETAL OUTCOMES IN CHILDREN USING COMPUTERS – A MODEL OF THE RELATIONSHIPS BETWEEN USER VARIABLES, COMPUTER EXPOSURE AND MUSCULOSKELETAL OUTCOMES

Courtenay Harris

Aims

The etiology of musculoskeletal outcomes associated with the use of information technology (IT) has predominately been defined by studies of adults in their work environments. Theories explaining the causation of work related musculoskeletal disorders have identified individual (biomechanical, physiological and psychosocial), task demand, work organization and environmental risk factors. Models based on these theories have subsequently been developed to investigate the causal relationship between IT exposure and outcomes experienced by the user.

As IT use by children is rapidly growing in both home and school environments, current literature demonstrates an increase in musculoskeletal outcomes related to children's IT use. Children's use of IT appears to be very different to adult's use of IT in work environments. Although many potential risk factors may be similar, due to the nature of children and their different occupational roles and environments, it is proposed that risk factors and models of causal relationships between computer use and musculoskeletal outcomes would vary for children.

The aim of this study was therefore to investigate children's computer exposure to develop and test a model that would assist in understanding the relationships between potential risk factors of user variables and computer exposure with musculoskeletal outcomes.

Methods

1351 children in school Years 1, 6, 9 and 11 (ages ~ 6,11,14,16, years) from eight primary and five secondary schools (10 schools in total as some schools had both primary and secondary) in Perth Australia were surveyed. The study design was cross sectional involving the completion of a questionnaire survey by participants, and for younger participants their parents. Both questionnaires contained questions relating to the participant and their activity exposure as an individual, within a family context, and within their neighbourhood. A survey tool, rather than observations and time diaries, were used within this study to allow for a large sample of data to be collected given the power requirement for statistical path analysis to the test the study's model. Convenience sampling was undertaken to ensure the sample had a required range of participants from different SES backgrounds, an even gender mix and even age range from school years 1, 6, 9 and 11 (approximate ages of 6, 9, 14 and 16 years).

Descriptive statistics were used to describe the sample, and Spearman rank correlation coefficients (r_s) and logistical regression analysis were used to examine direction and relationships of independent and dependent variables. MPlus statistical modelling program version 5 was used to estimate the proposed relationships between variables, with dependent variables of home computer exposure and outcomes.

Results

Risk factors found to have a significant direct effect on participant's reports of MSS included; gender, age, somatic complaints (headache and stomach ache) and computer exposure. Risk factors found to have a direct effect on computer exposure (and indirect effect on musculoskeletal outcomes) included age, television exposure, computer anxiety, sustained attention (flow), socio-economic status, somatic complaints (headache).

Discussion/Conclusion

The proposed child-specific model t will assist academics, teachers and parents to understand the risk factors for MSS associated with children's home computer use, and therefore assist in targeting interventions that would encourage the use of this valuable technology in a safe and productive manner.

Keywords: Computer work, mechanism of pain and injury, personal risk factors for MSD

Musculoskeletal outcomes in children using home computers – a proposed model

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BACKGROUND

- Multi-factorial models of musculoskeletal etiology have been developed.
- Based on adults, in work environments. (Figure 1)
- Children's computer use is rapidly growing. (Rideout et al. 2010)
- Children reporting musculoskeletal outcomes with computer use. (Burke & Peper, 2002; Ramos et al. 2005; Hakala et al. 2006)
- Children's use of computers is different, mind and bodies different, environments of use are different.
- Suggests need for a child specific model.

AIM

To develop and test a model of the relationships between user variables, home computer exposure and musculoskeletal outcomes.

METHODOLOGY

Subjects:

- 1351 children aged 6 – 16 years, from 10 metropolitan Western Australian schools.
- Subjects selected to represent a range of socioeconomic status, even gender mix and range of ages.

Measures:

- Survey questionnaire.
- Physical measures for height and weight.

Data analysis:

- Spearman rank correlation (r_s), regression analysis and path analysis (Mplus).

EXPOSURE RESULTS

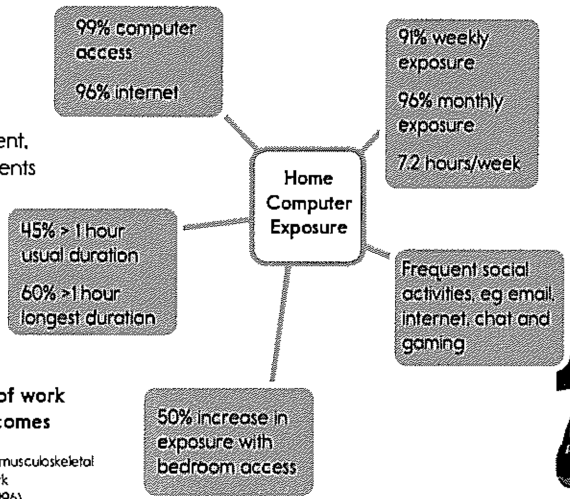
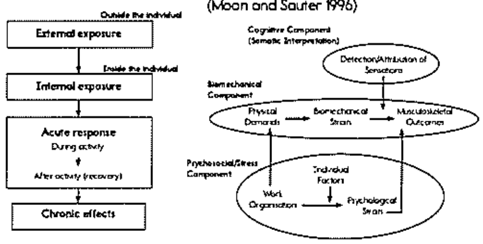


Figure 1. **Adult models on causation of work related musculoskeletal outcomes**

Exposure-effect model (Mathiassen, 1993)

Ecological model of musculoskeletal disorders in VDT work (Moon and Sauter 1996)



Proposed Children's Home Computer Exposure Model

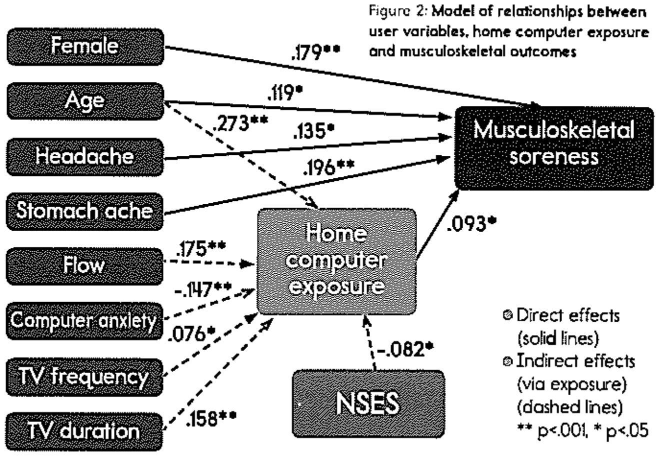
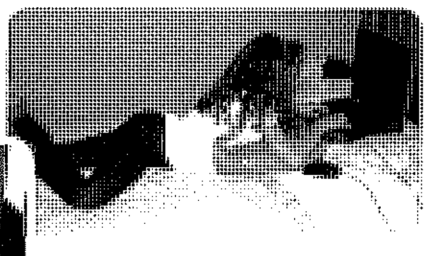
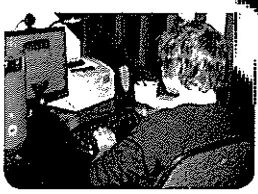


Figure 2: **Model of relationships between user variables, home computer exposure and musculoskeletal outcomes**





CONCLUSION

Path analysis showed predictive relationships between children's user variables, home computer use and musculoskeletal outcomes.

This model can be used as a guide for encouraging safe and productive use of computers by children.

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Appendix J

Harris, C., Straker, L., Smith, A. & Pollock, C. (Accepted subject to minor review 6 November 2010). The influence of age, gender and other information technology use on young people's computer use at school and home. *Work.*

The influence of age, gender and other information technology use on young people's computer use at school and home.

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Young people are exposed to a range of information technologies (IT) in different environments, including home and school, however the factors influencing IT use at home and school are poorly understood. **Objective:** The aim of this study was to investigate young people's computer exposure patterns at home and school, and the factors impacting on their computer use such as age, gender and the types of IT used. **Method:** 1351 children in years 1, 6, 9 and 11 from 10 schools in metropolitan Western Australia were surveyed. **Results:** Most children had access to computers at home and school, with computer exposures comparable to TV, reading and writing. Total computer exposure was greater at home than school, and increased with age. Computer activities varied with age and gender and became more social with increased age, at the same time parental involvement reduced. Bedroom computer use was found to result in higher exposure patterns. High use of home and school computers was associated with each other. Associations varied depending on the type of IT exposure measure (frequency, weekly, usual and longest duration) **Conclusion:** The frequency and duration of children's computer exposure were associated with a complex interplay of the environment of use (school and home), the participant's age and gender and other IT activities.

Keywords: ergonomics; human – machine interface; exposure; children; school; home

1.0 INTRODUCTION

Young people today are reported to live "media saturated lives" (Ramos et al. 2005), with a recent review of ninety studies, across 539 independent samples, finding that youths are likely to use TV, computer and electronic games for 25%

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of their waking hours (Marshall et al., 2006). Information technology (IT) use by young people includes reading and writing with paper based media, and interacting with electronic based media such as computers, television (TV), electronic game devices and mobile (cell) phones.

Computer use is an important type of IT with young people using desktop and laptop computers to play games, write documents, complete learning programs, work with pictures and music in multimedia programs, surf the internet and communicate by email and chat rooms. The range of computer activities is expanding, with Roberts et al. (2005) reporting that 50% of the types of computer activities surveyed in 2004 which were not even surveyed in 1999 (instant messaging, graphics and online gaming), are now used daily by many young people. Computer use is growing rapidly, both in the proportion of children using computers and in their daily exposures. For example, Roberts et al. (2005) found that computer exposure had doubled from 27 mins/day in 1999 to 62 mins/day in 2004.

Young people use computers in a variety of environments, with school and home the most common. Nearly all children in affluent communities use computers at school and the majority use computers at home. The USA Census Bureau found that in 92% of children enrolled in school used a computer at school (UCB, 2008) and in Australia 90% of school aged children used a computer at school (ABS, 2007). Within the home environment, 70% of Australian households had access

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to a computer, with 60% also having internet access. The USA Census Board reported that, in 2003, 76% of households with school children had computer access and 67% had internet access (UCB, 2008).

As previous studies have identified a potential impact on young people's health and development with exposure to computers, consideration of exposure patterns in both home and school environments is required to understand the impact of computer use.

Computer use has been reported to impact on children's health and development in a number of areas. Cognitive functions, such as visual attention and spatial representation skills, have been reported to be enhanced by playing computer games and home computer use has been related to improved academic performance (Borzekowski and Robinson 2005, Li et al. 2006, Subrahmanyam et al. 2000, 2001). Conversely, Fuchs and Wößmann (2005) analysed data from 15 year olds in 32 countries (n= 174000 for literacy and n= 96855 for mathematics) and found that when they controlled for family and school characteristics, the use of computers at home was negatively related to student performance in literacy and mathematics, and there was no significant relationship between performance and school computer access. However the nature of computer exposure was found to be important as there were positive relationships between student performance at school and communication and education related tasks at home and frequency of computer use at school.

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Psychosocial function is reportedly influenced by computer use. Some research suggests increased aggressive behaviour with violent game playing (Olson et al. 20, 2007), and issues with social relationships, loneliness and psychosocial well being with videogames and internet use (Subrahmanyam et al. 2000). Conversely, Orleans and Laney (2000) suggested that home computer use provided an opportunity for positive socialization. This is particularly important for those who may usually lack social skills or opportunity due to geography or physical limitations (Straker and Pollock, 2005).

Musculoskeletal discomfort has been reported with children using and carrying laptop and tablet computers (Harris and Straker 2000, Sommerich et al, 2007) and with home computer use (Jacobs and Baker 2002). Additionally, it has been suggested that children's screen time activities may reduce physical activity participation and contribute to increased childhood obesity rates (Olds et al. 2006, Wake et al. 2003). The evidence for these links is mixed, and it appears that while screen time activities may displace physical activity for some children, this is not necessarily associated with increased obesity.

Few studies have investigated the impact of both home *and* school computer exposure on young people's health and development. Kent and Facer (2004) surveyed 1800 students in England in 2001 and 2003 to explore the differences in young people's IT use at home and school. The influence on exposure (as

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measured by frequency of specific computer tasks), due to age, gender and socio-economic status (SES) was reported, however the interplay of age and gender on exposure patterns in each environment was not. Computer use was found to be more frequent in older boys, with gender also influencing the types of computer activities performed. SES influenced access to home computers. More recently, Li et al (2006) conducted a randomised control study with 122 American children. Positive associations with both home and school computer use for school readiness, and some aspects of cognitive development were found, although measures of exposure were limited to frequency only. Duration of computer use at home and school was investigated in a study of 476 young Americans to examine potential musculoskeletal outcomes (Ramos et al. 2005) however associations with the use of other IT types were not clear.

Exposure measures used in past studies have often been limited to a single aspect of exposure, potentially resulting in inadequate characterisation of exposure. The importance of investigating more than one aspect of exposure was demonstrated in Fuchs & Wößmann (2005) where different results were found when comparing access to computers versus frequency of computer use. Further, duration of use rather than frequency of use has been related to physical discomfort (Harris and Straker 2000, Jacobs and Baker 2002).

Age and gender are reported to influence young people's IT exposure patterns, including IT types, computer activities and duration of use in different

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environments (Kent and Facer 2004, Olds et al. 2006, Roberts et al. 2007). However, research exploring the interplay of age and gender on computer exposure patterns at home and school, across school ages is limited. For example, Kent & Facer (2004) report the impact of age and gender on home and computer tasks separately. Additionally, as IT exposure patterns have been shown to impact the health and development of children as young as 5 years (Straker et al. 2006), the inclusion of the whole range of school aged children in exposure studies is warranted.

Computer use is just one, albeit important, component of IT use by children. Recent studies investigating young people's exposure to a variety of IT have shown some associations between IT activities. For example, Cummings et al (2007) found that adolescent video game players spent less time with paper based IT such as reading and homework, whereas Borzekowski et al (2005) found that younger students (mean= 8.5years) using a range of electronic media (including computers) reported more time doing paper based IT and homework. These studies however have not considered the association of young people's home and school computer use with other IT activities.

Computer use is clearly a rapidly growing activity for many children. Current evidence suggests it may have important influences on child physical, mental and social health and development. However our current understanding of these influences is limited due to: inadequate characterisation of exposure patterns,

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inadequate assessment of the interaction effect of age and gender and inadequate consideration of the impact of exposure to other IT. As technology continues to develop and young people increase their use of computers, a sound understanding of the exposure of children to computers is a prerequisite to understanding and managing the influences of computers on child health and development. The aim of this study was therefore to provide a detailed analysis of the computer exposure patterns of young people at school and home including exposure measures of frequency and duration, interplay of age and gender and other IT activities.

2. 0 METHODS

2.1 Sample

1351 students (792 boys and 559 girls) from eight primary and five secondary schools (10 schools in total as some schools had both primary and secondary) in Perth, Australia, participated in the study. Schools from local government, Catholic education and independent private education systems were approached to participate with the aim of an even gender mix, broad socioeconomic range and Year 1 to 11 coverage. 150 Year 1 children, and 350 children from each of Years 6, 9 and 11 were organized to be surveyed during 4th term of 2005. Participating children numbers and mean (SD) ages is shown in Table 1. Discrepancies between proposed and actual numbers were due to some parental questionnaires not being returned, some children being absent on the day of testing and one school requesting all Year 9 children be surveyed.

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Table 1. Sample demographics

	Proposed sample	Sample	Mean age (years)	SD (years)
Year 1	150	146	6.8	0.7
Year 6	350	350	11.3	1.0
Year 9	350	563	14.2	1.2
Year 11	350	292	16.3	1.2

Informed consent was gained prior to commencement with ethics approval provided by the Curtin University of Technology Human Research Ethics Committee.

2.2. Survey Tool

The survey tool was based on the Young People's Activity Questionnaire (YAQ) (Harris and Straker 2000), with the addition of extra questions regarding IT types and activities at home and school. This YAQ-IT was completed by children in Years 6, 9 and 11, with a simplified version (Year One's Activity Questionnaire-YOAQ), being completed by Year 1 parents. Both questionnaires were divided into 3 sections. Section One related to questions about the participant, their school, general activity levels, and pre-existing musculoskeletal conditions. Section Two asked participants about their use of a range of activities, including monthly frequency, usual duration and longest duration of watching TV, writing / drawing, reading, using mobile phones, playing electronic games, using computers at home and school, playing musical instruments and physical activities. In Section Three each participant's teacher completed questions about the children's academic performance, and each child was then weighed and

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measured by the researcher. As the aim of this paper relates to exposure of computers at home and school, results relating to SES, physical, psychological variables and musculoskeletal disorders and outcomes will be made available in subsequent papers.

2.3 Survey Procedures

The parents of participants in Year 1 completed their questionnaire at home and returned the questionnaires to their teachers for collection. The researcher attended the class on a different day to collect the measurements and teacher assessment information. For all other participants the questionnaire was completed at school during class time with the researcher and relevant teacher present. For these children measurements and teacher assessments were collected at the time of questionnaire completion.

2.4 Data Analysis

Descriptive statistics were used to demonstrate the relationships with children's IT exposure and patterns of IT use in different environments. Independent *t*-tests (*t*), Wilcoxon Signed Rank test *(W),* Kruskal-Wallis (*H*), McNemar Tests (x^2), Mann-Whitney U-tests (U), Spearman Rank Correlation Coefficients (r_s) and Chi squared (x^2) analysis were used to examine the influence of gender and Year level on IT exposure. SPSS v15 was used for all analyses, with a critical alpha level of .01 used to balance type 1 and type 2 errors.

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3. 0 RESULTS

3.1 Computer Use at School

All schools surveyed had computers and internet access. 97.8% of participants reported computer use at school in the last month. Computers were reported to be used for 2.4(sd=3.3) hours per week at school by participants (Years 6, 9 and 11 only as durations of computer use at school was not reported by parents for Year 1 participants). Computers were used in laboratories by 82.2% and in normal classrooms by 62.7%. Both laptop and desktop computers were used at school by 24.5%, with 74.2% using only desktops and 1.3% using only laptops. None of the participating schools issued their students with their own computers, or required students to supply a laptop.

Hours of computer use at school increased with Year level from 1.5(1.8) hours/week in Year 6 to 2.4(3.5) in Year 9 and 3.3(4.1) in Year 11($H(2) = 71.4$, $p<.001$),and this was true for both boys ($H(2) = 52.0$, $p<.001$) and girls ($H(2) = 21.6$, $p<.001$). Over Years 6, 9 and 11, boys had greater weekly hours of school computer use (2.6 [3.9] hrs) compared to girls (2.1[2.2] hrs) and whilst the pattern was consistent across all years the difference was only significant at Year 9 (Yr6 $U= 13761$, $p= .854$; Yr9 $U=28510$, $p=.012$; Yr11 $U=7983$, $p=.252$). Weekly hours of computers use at school was positively correlated with frequency ($r_s = .555$,

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p<.001) and duration (usual duration, r_s = .218, p<.001, and longest duration, r_s = .214, p<.001) of computer use at school.

Table 2 demonstrates the percentage of participants performing different computer activities at school at different frequencies. Year level was associated with frequency of all computer activities (x^2(12)>91.0, p<.001). The frequency of all computer activities at school increased with higher Year levels, except using learning programs where Year 6 participants had the highest frequency of use. More boys had a increased frequency of playing computer games (x^2(4)>54.6, p<.001), using multimedia (x^2(4)=9.7, p=.046), learning programs (x^2(4)=10.3, p=.035), surfing the internet (x^2(4)=10.2, p=.037) and other computer activities (x^2(4)=10.6, p=.032) at school.

Table 2. Percentage of participants using different activities: School and home.

Frequency of Use	Play games	Multimedia	Write Letters	Learning Programs	Surf Net	Email	Chat rooms	Other
			School					
Not at all	43.2	34.9	35.2	42.6	14.7	43.4	75.3	37.8
1 x month	22.5	25.7	34.7	22.5	20.8	21.7	12.8	20.7
1 x week	20.5	22.5	21.8	22.1	30.4	18.3	5.9	25.2
2-3 x week	9.7	12.8	6.9	11.0	24.2	11.7	2.9	11.5
Daily	4.1	4.2	1.5	1.8	10.0	5.0	3.2	4.9
			Home					
Not at all	29.4	29.1	43.3	65.0	9.2	19.3	34.9	11.1
1 x month	16.1	21.1	29.2	18.1	15.9	18.4	16.3	18.2
1 x week	19.3	20.0	17.1	10.4	16.7	15.8	9.1	21.6
2-3 x week	22.4	17.2	7.9	4.9	28.8	22.1	17.1	29.9
Daily	12.7	12.6	2.4	1.6	29.4	24.3	22.6	19.2

In the school environment 69.7% reported usually being with friends and 82.8% reported usually talking with friends when using a computer. Additionally, 25.9%

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reported usually being with teachers and 7.5% reported usually talking with teachers while using a computer at school. 5.7% of participants reported usually having no-one with them when they used a computer at school. Using a computer alone was associated with Year level, with Year 6 participants more likely to be alone ($x^2(3)=16.7$ $p<.001$), but was not associated with gender (although a trend for more boys to be on their own at school was evident $x^2(1)=2.8$, $p=.096$). There were no associations between frequency of school computer activities and being alone, however trends for increased frequency for email ($x^2(4)=8.6$ $p=.073$) and multimedia ($x^2(4)=7.9$ $p=.096$) activities were evident.

3.2 Computer Use at Home

98.9% of participants reported having access to a computer at home with 95.9% reporting internet/email at home. 95.7% of participants used a computer at home in the last month. Computers were reported to be used for 7.2 (sd =9.6) hours per week at home by participants in Years 6, 9 and 11. At home the most common location for computer use (53.7%) was a shared room (eg living room, shared study). 26.3% reported using a computer in their own bedroom or study area, and other areas were reported by 4.7 – 10.3%. A desktop computer was used at home by 82.5% of participants, a laptop computer by 33.8% and 2.1% reported using other types of computers.

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Hours of computer use at home increased with Year level from 1.8 (2.1) hours/week in Year 1 to 4.1 (6.1) in Year 6 to 8.0 (9.0) in Year 9 and 11.8 (13.1) in Year 11 ($H(3)=278$, $p<.001$) and this was true for both boys ($H(3)= 153$, $p<.001$) and girls ($H(3)= 128$, $p<.001$). Across all Years boys had greater weekly hours of home computer use (8.2 [10.9]hrs) compared to girls (5.6[7.0] hrs) and this pattern was consistent at all Year levels (Yr 1 $U= 1665$, p=.054 Yr6 $U=10734$, p=.036; Yr9 $U=25418$, p=.014; Yr11 $U=6880$, p=.002). Weekly hours of computer use at home was positively correlated with frequency ($r_s = .704$, $p<.001$) and duration (usual, $r_s =.632$, $p<.001$, and longest, $r_s =.589$, $p<.001$) of computer use at home.

Table 2 demonstrates the percentage of participants performing different computer activities at home at different frequencies. All computer activities at home were associated with an increased frequency of activity with higher Year levels ($x^2(12)>66.0$, $p<.001$), except playing games and using learning programs which Year 6 participants used most frequently. Boys had a higher frequency of playing computer games ($x^2 (4) = 113.6$, $p<.001$) and surfing the internet ($x^2 (3) = 9.6$, p=.049) than girls; girls had a higher frequency of using email ($x^2 (3) = 23.4$, $p<.001$) than boys. Computer activities of playing games and chat room showed a bi-modal distribution.

32.3% reported usually being with a sibling or friend when using a computer at home. Sibling/ friend presence was associated with Year level, with younger

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participants more likely to be with friends or siblings (x^2 (3) = 81.6 p<.001), but was not associated with gender. Email, writing stories, chat room, surfing the net and multimedia activities were less frequent when with others (x^2 (3) > 10.5, p=.033). There was no association between the frequency of playing computer games or using learning games and the presence of siblings or friends.

11.3% reported that their parents were usually with them when using a computer at home. Parent presence was associated with Year level, with younger participants more likely to report parents with them (x^2 (3) = 253.9 p<.001), but was not associated with gender. Less parental presence was associated with increased frequency of playing games, surfing the net, email, use of chat rooms, writing stories and use of multimedia (x^2 (4) > 28.1 p<.001). There was no association between learning activities and parent presence.

58.0% of participants reported usually having no-one with them when they used a computer at home. Using a computer alone was associated with Year level, with older participants more likely to be alone (x^2 (3) = 205.7 p<.001), but was not associated with gender. There was an increased frequency of using multimedia, writing stories, surfing the net, emailing and using chat rooms and a decreased frequency of playing computer games when participants were on their own.

Participants who used a computer in their own bedroom (26.3%) had an increased frequency and duration of home computer use (x^2 (4) > 44.7, p<.010),

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and an increased frequency of all home computer activities except writing letters and learning programs. Weekly hours of home computer use was higher for those participants with a computer in their bedroom (10.8[sd 13.0] hours) than those without (5.8[sd7.4] hours) (t(411) =6.6 p< .001). This difference was found to be significant for both boys (12.4 [sd14.6] hours vs 6.4[sd8.1] hours t(276) =5.7 p< .001,) and girls (7.8 [sd 8.8] hours vs 5.0 [sd 6.3] hours, t(148) =3.2 p< .001). Whilst increased use was related to age, and age was related to having a computer in their bedroom, access to a bedroom computer was found to be an additional effect on increased hours of use (x^2 (3) = 50.2 p<.001).

At home participants report talking with no-one (39.2%), talking to friends (22.7%), siblings (29.4%), and parents (12.1%) when using computers.

3.3 Comparison of Computer Use in School and Home Environments

Mean hours of home computer use was greater than school use (W= -21.23, p<.001). This was true for Year 6 (W= -8.17, p<.001), Year 9 (W= -15.75, p<.001) and Year 11 (W= -11.36, p<.001) and for both genders at each Year level (W > -12.1, p<.001).

Spearman's rho correlations between measures of monthly frequency, duration (usual and longest) and weekly hours of computer use at school and at home ranged from .704 (frequency of home computer use and total weekly duration of home computer use) to .081 (frequency of home computer use and longest

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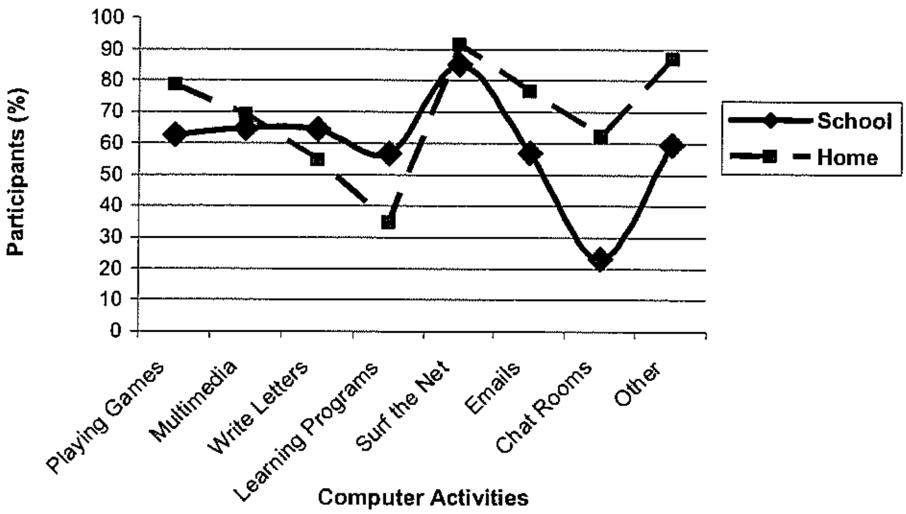
duration use at school). All correlations were positive and significant at the 0.01 level and tended to be larger within each environment (home/school) and within the same exposure measure (frequency/duration/hours).

Figures 1a & 1b: Percentage of Boys and Girls Performing Computer Activities at Least Monthly at Home and School.

Figure 1a: Boys



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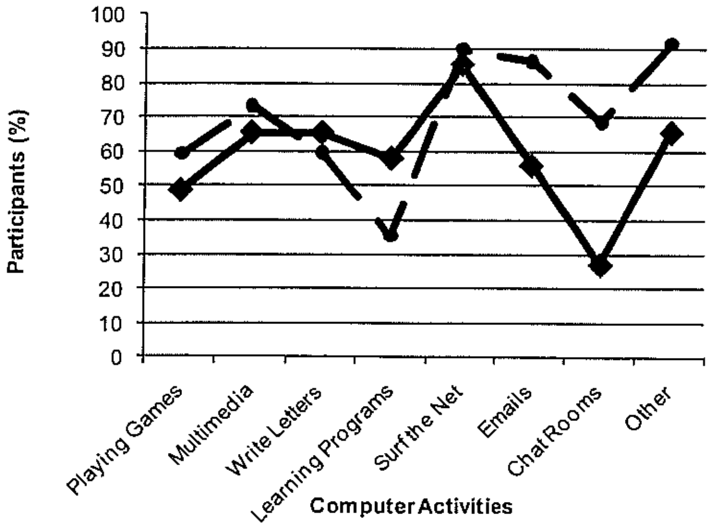

Figure 1b: Girls

As illustrated in Figures 1a and 1b, computer activities that could be deemed less structured and more social (surfing the internet, emailing, playing games, using multimedia and chat rooms) were performed at least monthly by more boys and girls at home compared with at school (x^2 >7.8, p<.010 except multimedia for boys p=.072 and surf net for girls p=.015). Learning programs and writing stories and letters were used at least monthly by more boys and girls in the school environment ($x^2_{(4)}$>10.33, p<.035).

60% of participants reported always being able to choose their computer activities at home, compared to 5% in the school environment. At school 75% of participants reported that the teacher usually decided the computer activities, whilst at home 10% reported that their parents usually choose the computer activities. In both environments approximately 2% reported friends or others usually choose the computer activities. There was an association with frequency of own choice of IT activity and Year level in both home and school environments, with an increased frequency of choice with increased Year level. Gender was not associated with frequency of choice.

90% of participants reported sitting at a desk for computer work at home and school. Although minimal, more variation of postures occurred in the home, with an increase of participants using postures of lying down (3.2 % vs 1.0%) and sitting on the floor (2.6% vs 1.3%) and sofa (5.6% vs 1.2%).

3.4 Computer use related to other IT types

Participants reported using a range of IT other than computers, including screen based activities of TV, electronic games and mobile (cell) phone and paper-based activities of reading books and magazines and writing with pen and paper.

3.4.1 Frequency of IT Tasks. IT use varied from 99.6% of all participants for watching TV at least monthly, to 68.4% of all participants playing electronic games at least monthly (see Table 3). 97.8% of participants used computers at least monthly at school and 87.1% at least weekly. At home 95.7% of participants used computers at least monthly, and 91.2% used computers at least weekly. 70.0% of all participants used mobile phones at least monthly, with half using them daily.

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Table 3. Percentage of participants using different IT types: Frequency and usual duration.

Frequency of Use	Watching TV/DVDs	Writing drawing	Reading	Mobile phones	Electronic games	Computer at school	Computer at home
			Frequency of Use				
Not at all	0.4	4.1	4.6	30.0	32.6	2.2	4.3
1 x month	1.6	5.1	8.4	8.6	19.1	10.6	4.5
1 x week	7.7	7.0	15.1	9.6	18.2	32.3	14.2
2-3 x week	24.7	15.4	27.1	18.4	21.0	42.6	33.9
Daily	65.5	68.4	44.8	33.4	9.2	12.2	43.1
			Usual Duration of Use				
< 30 minutes	9.4	27.2	41.1	62.2	35.2	30.3	20.1
30-60 minutes	28.7	20.5	27.3	13.0	32.0	58.3	34.9
1-2 hours	33.3	15.9	16.3	9.0	21.5	9.4	24.4
2-5 hours	17.4	15.8	9.1	8.0	8.0	1.1	14.6
> 5 hours	11.2	20.6	6.2	7.8	3.3	0.8	6.0

Frequency of home and school computer use were positively correlated to frequency of use of mobile phones and watching television (see Table 4). Frequency of home computer use was negatively correlated to frequency of reading. There was no correlation between frequency of home or school computer use and frequency of electronic game playing or writing tasks. Usual and longest duration of all tasks are positively correlated to each other. Weekly hours of home computer use was positively correlated to all electronic IT, negatively correlated to reading frequency and not correlated with writing frequency.

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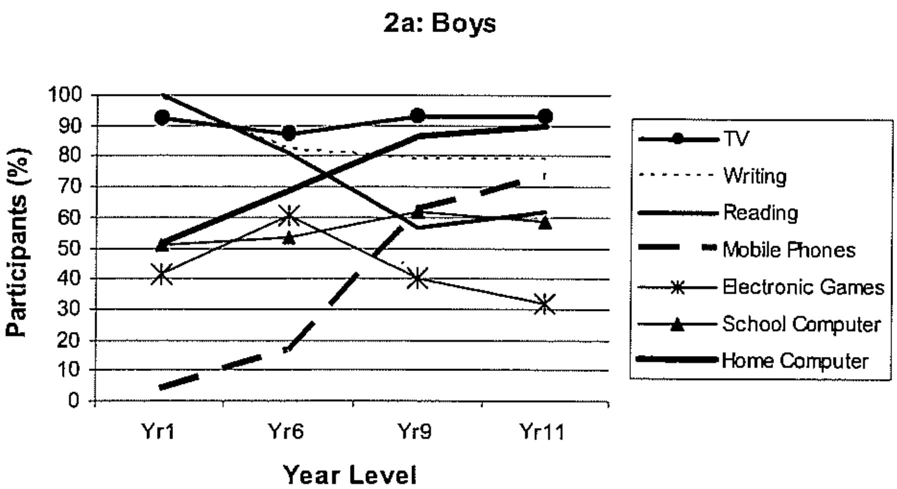
Frequency of IT type was associated with Year level for all IT types (see Figures 2a and 2b). Computer use at home, (x^2 (12) = 261.4, p<.001) and school (x^2 (12) = 91.3, p<.001) and mobile phone use (x^2 (12) = 635.0, p<.001) increased with Year whereas reading frequency decreased with Year (x^2 (12) = 171.0, p<.001). When examined separately for boys and girls, the same pattern of frequency (increasing or decreasing for different year levels / IT types) was reflected for both boys and girls, except for boys watching TV, where there was no association with Year level (x^2 (12) = 15.3, p=.223).

Table 4. Correlations (Spearman's rho) between Home and School computer use and other IT types in the last month.

	School computer use				Home computer use			
	Frequency	Usual duration	Longest duration	Weekly hours	Frequency	Usual duration	Longest duration	Weekly hours
TV / DVD frequency	.079(**)	.048	.058	.014	.166(**)	.122(**)	.089(**)	.124(**)
TV / DVD usual duration	.071(*)	.131(**)	.035	.101(**)	.231(**)	.334(**)	.219(**)	.251(**)
TV / DVD longest duration	.051	.048	.195(**)	.017	.191(**)	.246(**)	.399(**)	.239(**)
Writing and drawing frequency	.046	.046	.059(*)	.034	.038	-.023	-.010	-.008
Writing and drawing usual duration	.035	.138(**)	.112(**)	.066(*)	.092(**)	.129(**)	.084(**)	.071(*)
Writing and drawing longest duration	.069(*)	.119(**)	.213(**)	.053	.066(*)	.084(**)	.188(**)	.060(*)
Reading frequency	.040	-.030	.001	-.055	-.117(**)	-.160(**)	-.142(**)	-.186(**)
Reading usual duration	.107(**)	.128(**)	.078(**)	.031	.033	.097(**)	.033	.041
Reading longest duration	.087(**)	.061(*)	.168(**)	.013	.032	.070(*)	.159(**)	.063(*)
Mobile phone frequency	.118(**)	.229(**)	.112(**)	.172(**)	.351(**)	.264(**)	.241(**)	.339(**)
Mobile phone usual duration	.115(**)	.251(**)	.134(**)	.179(**)	.338(**)	.316(**)	.267(**)	.359(**)
Mobile phone longest duration	.107(**)	.207(**)	.164(**)	.143(**)	.311(**)	.298(**)	.319(**)	.347(**)
Electronic games frequency	.050	-.009	.012	-.020	.046	.088(**)	.127(**)	.067(*)
Electronic games usual duration	.098(**)	.143(**)	.119(**)	.097(**)	.203(**)	.402(**)	.371(**)	.326(**)
Electronic longest duration	.093(**)	.090(*)	.187(**)	.055	.181(**)	.367(**)	.462(**)	.282(**)

Frequency of IT types use was also associated with gender for all IT types except watching TV / DVDs (see Figures 2a and 2b). A greater percentage of boys used computers at home and school and electronic games more frequently than girls, and a greater percentage of girls used mobile phones, read books and wrote more frequently than boys. There was a trend for younger boys to use computers at school more frequently than girls ($x^2(4) = 12.5$, p=.014). Frequency of computer use at home was similar for both genders in older participants, however more boys in Years 1 and 6 used computers frequently at home.

Figure 2a & 2b: Percentage of boys and girls performing IT types at least 2-3 x weekly



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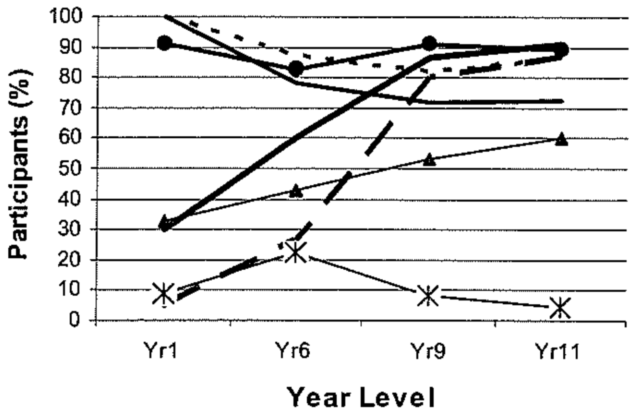
2b: Girls



3.4.2. Duration of IT Type. 61.2% of participants usually watched more than 1 hour of TV each day, compared with only 32.8% playing electronic games for this duration. School use of computers rarely exceeded 1 hour, whereas 45.0% of participants used a computer at home for more that 1 hour each day. See Table 3.

Correlations between usual duration of home or school computer use and other IT activities were all significant and positive. Correlations between longest duration of home or school computer use were also significant, and positive for all IT types.

Usual duration of use was associated with Year level for all IT types. When examined separately for boys and girls, increasing usual duration of IT use was significantly associated with higher Year level for both genders for all IT tasks

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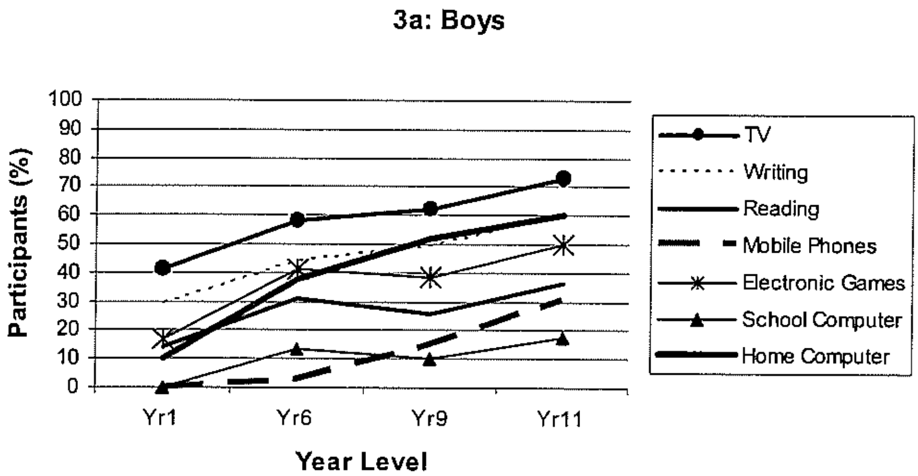
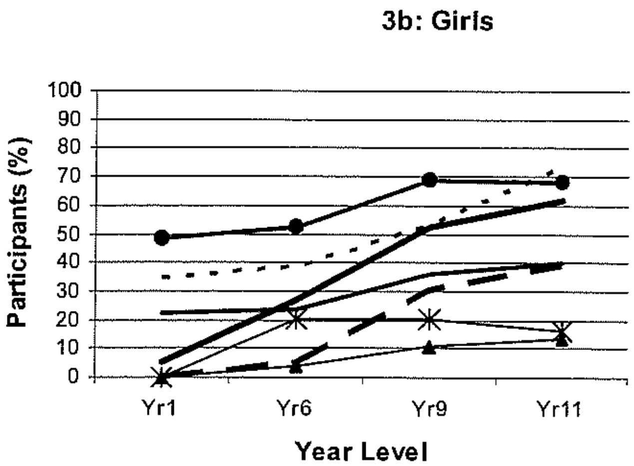
except girls and playing electronic games ($X^2(12)=24.8$, $p=.019$) (see Figures 3a and 3b).

Figure 3a & 3b: Percentage of boys and girls IT types usual duration.





Usual duration of IT use was associated with gender for reading, writing and drawing, use of mobile phones, using electronic games and computer use at home. More girls reported reading for more than 1 hour a day at all Years except

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Year 6 ($X^2(5)=6.9$, $p=.225$). More girls reported using mobile phones for more than 1 hour a day at all Years except Year 1 ($X^2(2)=1.2$, $p=.500$). Boys at all Years reported longer usual duration of playing electronic games ($X^2(12)=36.6$, $p<.001$). More boys in Years 1 and 6 reported using a computer at home for more than 1 hour a day ($X^2(12)=85.8$, $p<.001$). There was no association overall between gender and usual duration of watching television / DVD's and using computers at school ($X^2(4)=4.7$ $p=.032$). Boys reported longer durations overall for all IT types than girls.

4. 0 DISCUSSION

Weekly computer use was found to be comparable to young people's exposure to reading, writing or television, reinforcing the importance of computers in young people's daily life. However, this study's more detailed exposure analysis has identified that exposure patterns vary with home versus school location, gender and age.

Previous studies have shown mixed results with exposure at home versus school, with some studies indicating that young people are typically exposed to computers more in the school environment (Olds et al 2006). The current findings have clarified that whilst the proportion of children with access is similar at home and school, total exposure is greater at home, with increased frequency, duration and mean weekly hours of computer use across Years and genders. When

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educators, parents and health professionals are assisting young people with health and development issues associated with computer use, it is now clear that the home environment must also be considered in assessment and intervention.

It has previously been reported that boys use computers at home more than girls. This study confirmed this in terms of overall exposure, but also identified that whilst this is true across all Year levels, both genders increased their use with age. Additionally, in terms of frequency of use this study confirmed that older (Yr 9 &11) girls and boys had a similar frequency of home computer use. Different computer activities were found to be used by different genders, with boys performing more gaming and surfing the net, and girls more email. Additionally, bi-modal distributions of home computers activities suggest that there may also be sub-groups of children using computers with different computer patterns.

Home computer use has previously been found to include a range of educational and recreational activities and involve parents, siblings, friends or students on their own. This study confirmed a range of activities were used at home, particularly social activities. It also clarified that the nature of computer use was influenced by age and gender. Exposure to computer activities increased with age, except gaming and learning programs which peaked at age 10 years of age. Younger students were more likely to involve others including parents, and older students were more likely to use computers on their own. Orleans & Laney (2000) reported that adolescents whose parents were less involved in their

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children's computing were more likely to socialize using the computer. The use of email, more often by girls and surfing the internet, more often by boys, were found to be the most frequently used home computer activities that increased with age. Kent & Facer (2004) also found more frequent use of social IT activities at home with older children, suggesting this occurs to allow students to continue their social networks.

Increased access to personal media has previously been reported to increase TV and electronic game exposure and have effects on young people's health and development (Borzekowski and Robinson 2005, Marshall et al. 2006, Olson et al. 2007, Roberts et al. 2005). Current findings show that increased access to computers, in this case a bedroom computer, was associated with increased home computer use in terms of frequency, duration and types of most social activities being performed for both genders for older (Year 9 and 11) students. Increased exposure, in addition to risks associated with less supervision and potentially more sustained and awkward postures, mean special attention should be given to bedroom computer use.

Previously it was understood that school environment constraints such as curriculum, resources, timetables and teacher direction would impact on young people's computer use, but detailed exposure patterns were not clear. Our findings show all students were exposed to computers at school, and that school computer use had an educational focus, with an increased frequency of learning

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programs and writing activities. School computer time constraints were reflected in reduced computer durations (11.3% > one hour in a usual sitting at school, 47. 7% > one hour at home) and frequencies (55% 2-3 x week at school vs 77% 2-3 week at home) compared to home use. This study did however demonstrate that despite these constraints young people's characteristics, as depicted by the interaction of their Year and gender, influenced their school computer exposure (including mean hours, frequency and duration) for some activities. For example the Year 9 and 11 boys had an association with school computers use for gaming activities. Given the increased use of school computers, understanding exposure patterns in this environment is also important for children's health and development.

Some aspects of computer exposure were similar at school and home, for example for boys and girls exposure increased with age in conjunction with their ability to choose how they spend their time on computers. Similarly boys had greater frequency and longest duration of computer use and exposure to gaming, multimedia, learning programs, and surfing the internet at home and school. Therefore some health and education concerns and interventions may apply across both environments.

Prior evidence suggested that heavy users of one type of IT are often heavy users of other types (Borzekowski and Robinson 2005, Roberts et al, 2005). This study confirmed that home and school computer use were positively associated

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with each other for all exposure measures, and this was true for both genders. However the more detailed analysis also showed a more complex interplay of age and gender. For example, older students demonstrated an association with school and home use only within the same measure, for example school and home frequencies, but not school duration and home frequency. Similarly, while older students may not have the highest frequency of an IT type, when they do participate they have longer durations, for example boys using electronic games. The relationships between home and school computer use and other IT types demonstrate the importance of using a range of exposure measures. Whilst duration measures (usual and longest) of IT use (TV, writing, reading, mobile phone and electronic game) were positively correlated with each other, frequency of IT types were not always positively correlated (electronic games and home computer were associated with **decreased** frequency of reading). Strategies to manage exposure to IT should therefore be age and gender specific, targeting exposure practices in home and school environments.

5.0. LIMITATIONS and FUTURE RESEARCH DIRECTIONS

Whilst different numbers of boys and girls were sampled at different Year levels, the analysis by gender and Year level ensured this did not bias the results. An examination of the sample Index of Relative Socioeconomic Advantage Disadvantage (IRSAD) (ABS, 2007) showed a good range of SES in the sample. SES is likely to have an influence on IT exposure and this is currently being examined with data from this study. Given the sampling frame, the pattern of computer exposure reported here is likely to be representative of contemporary children in an Australian metropolitan context. Further research should explore these patterns in samples from other cultures and rural and remote locations. Whilst a parent / child report of IT exposure was suited to gaining the large data set required, future research should attempt cross validation of exposure measures using electronic computer activity monitoring.

6.0 CONCLUSION

The current findings show that young people's computer exposure is influenced by the environment of use, their age and gender. Their computer exposure is also related to other IT exposure. A greater understanding of young people's computer exposure will assist in understanding and managing the impact of computer use on young people's health and development.

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