



## **Electronic Overload: The Impact of Excessive Screen Use on Child and Adolescent Health and Wellbeing**

Dr Karen Martin  
The University of Western Australia, August 2011



Department of  
**Sport and Recreation**



**THE UNIVERSITY OF  
WESTERN AUSTRALIA**

*Achieving International Excellence*

A report commissioned by the Department of Sport and Recreation, Government of Western Australia

**Suggested citation: Martin K<sup>\*</sup>, 2011 *Electronic Overload: The Impact of Excessive Screen Use on Child and Adolescent Health and Wellbeing*. Department of Sport and Recreation, Perth, Western Australia**

\* Karen.Martin@uwa.edu.au, School of Population of Health, The University of Western Australia. 35 Stirling Hwy  
Crawley, Western Australia, 6009.

## Summary

Electronic screen use (such as watching television/DVDs, and using computers, video games and portable devices) is the most common leisure activity of youth in Australia and many other industrialised countries. A large majority of children and adolescents in Australia exceed the recommended maximum of two hours a day of screen use for leisure and that time spent in screen activities is increasing. Corresponding with the expanding screen-use culture of youth there has been a decline in the time children and adolescents spend playing outside and in contact with nature. These trends are concerning, as research indicates that excessive time using screens is associated with health and wellbeing adversity for children and adolescents, and time outside and in contact with nature is associated with increased physical activity and enhanced mental and physical health. This review provides an update of the negative impact of excessive use of new and existing screen technologies on the health and wellbeing of youth, and contrasts this with a summary of the benefits associated with time spent outside and in contact with nature.

Research to date indicates that children and adolescents who spend excessive time watching television, playing electronic games, using the computer or using screens overall are more likely to:

1. Encounter physical health disadvantages and participate in negative health behaviours such as;
  - increased incidence of overweight and obesity
  - higher cholesterol and fasting insulin
  - increased sedentary time, reduced physical activity and lower cardiovascular fitness
  - poor sleep habits and patterns
  - increased consumption of unhealthy foods
  - increased rates of cigarette smoking
2. Experience adverse mental and social health issues such as;
  - loneliness, depression or depressive symptoms
  - higher prevalence of withdrawal and anxiety
  - Internet addiction
  - reduced time with parents or siblings
3. Experience behavioural, learning and attentional problems or disadvantages (exacerbating the above physical, mental and social health disadvantages), for example
  - attention and concentration problems
  - less reading time
  - lower academic achievement
  - reduced creative imagination and creative play
  - higher amounts of aggressive behaviour

While excessive screen use is thought to be associated with negative health and wellbeing for youth, higher time outside and contact with nature is related to positive physical, mental and social health and behaviour and learning. Research indicates that being outside or contact with nature is positively associated with childrens' and adolescents';

- physical activity participation
- likelihood of being a healthy weight
- development of motor skills
- learning and development (personality development, cognitive functioning, attitude and school behaviour
- mental health and management of stress

Contact with nature also enhances behaviour of children with learning or behavioural difficulties;

- children with attentional deficit hyperactivity disorder perform better after contact with nature, and
- children displaying delinquent behaviour benefit from nature-based programs

The findings from this review indicate that strategies which successfully limit the time children and adolescents use screens while increasing the time they spend outside and in contact with nature are likely to lead to far-reaching positive physical, mental and social health and behaviour and learning benefits.

## Background

Screen use accounts for the highest proportion of sedentary activity amongst children and adolescents in Australia<sup>1</sup>. The large majority of children and adolescents exceed the daily two hours guideline for screen use<sup>2</sup> (including watching television/DVDs and using computers, video games and portable devices for leisure), in Australia<sup>3,4</sup>, and overseas<sup>5</sup>. In concurrence with this, children and adolescents are spending less time outside<sup>6-8</sup>, participating in less physical activity<sup>9</sup> and have less contact with nature than previous generations<sup>10</sup>. This is of concern as excessive screen use is associated with distinct health, social and learning disadvantages whereas physical activity participation, time outside and in contact with nature are associated with positive health and learning outcomes<sup>11</sup>. Children who do not meet the physical activity and screen time recommendations are three to four times more likely to be overweight than those complying with both recommendations<sup>12</sup>. Evidence also indicates that television viewing tracks into adulthood<sup>13</sup> and negative health outcomes from childhood screen behaviour may be translated into adult health<sup>14</sup>. Research shows that minimal screen time is best for health, a longitudinal study found children and adolescents who watched television one hour or less a day were the healthiest at age 26. Unsurprisingly, few fit into this group; only 6% of males and 8% of females<sup>14</sup>.

Despite the low proportion of children and adolescents meeting screen guidelines, and the potential negative impact of excessive screen use, Australian research suggests that parents are not concerned about their children's screen use<sup>15</sup>. There are few current summaries available that summarise the extent to which higher total screen use impacts upon child and adolescent health and wellbeing. This review examines research evidence to describe the potential impact of excessive screen use upon children's and adolescent's physical, mental and social health and learning and behaviour (Table 1) and briefly describes the potential advantages of displacing screen time with time outside and in contact with nature.

## Screen use

Concern about the possible negative impact of television on society and health started early; a survey published in 1949<sup>16</sup> noted that other common family leisure activities (such as visiting friends, movie attendance, and reading) was much lower in households possessing a television. This survey also identified fewer teenagers with a television attended sports events (20%) than teenagers without a television (37%). Findings about the potential negative impact of excessive screen use have compounded since this time, and television use is now widely known to be associated with childhood obesity<sup>17-24</sup>, and this relationship is stronger when a child has a television in their bedroom<sup>25</sup>.

Although children's television viewing time appears to have been stable since the introduction of television<sup>26</sup>, the ever-expanding repertoire of new screen activities including video and computer games, computer use and hand-held devices introduced over the last couple of decades is contributing to total screen use<sup>27</sup>. Average total screen use far exceeds the two hours recommended in Australia<sup>2</sup> and internationally<sup>28</sup>; as evidenced in a recent Australian study which identified 11-12 year olds reported daily average screen use of around 5 hours<sup>27</sup>. Trend data suggests screen use is increasing; in the five years to 2009 young people in the US increased the time they spent using screens from a daily average of 5 hours to 7.5 hours<sup>29</sup>. The extent of excessive screen use is unsurprising given the pervasiveness, marketing, popularity and accessibility of different screen based activities. In 2008 three quarters of Australian children aged 5 to 14 owned a mobile phone<sup>30</sup>. Trend data indicates personal screen ownership by youth has increased significantly in the last five years; for example adolescent Ipod/Mp3 ownership in the US increased from 18% to 76%<sup>29</sup>. In Australia, household ownership of a computer increased in the 10 years to 2008 from 48% to 78% and Internet access quadrupled from 16% to 72%<sup>30</sup>. Personal computer ownership is also being supported by the imperative to provide the best educational opportunities and resources for youth. In Australia, the National Secondary School Computer Fund has been initiated to ensure every student in the high school year groups nine to 12 will have access to a computer at school, with many schools allowing laptops to be taken home by the children<sup>31</sup>. Indeed, considerable effort is being made to ensure screen use, known as 'information and communication technology' (ICT) in the educational setting, is promoted and encouraged in schools an educational tool<sup>32</sup>. As a learning tool, when used in

appropriate context, screen-based technologies appear to lead to small but positive learning outcomes<sup>33</sup> and can be effective in teaching basic skills<sup>34</sup>. These technologies are also thought to be particularly useful for disadvantaged youth<sup>35</sup>; for example disengaged youth have been noted to achieve better educational outcomes when using ICT<sup>36</sup>. However, while educational benefits, access to information and social connection and support are benefits for children using screens<sup>35</sup>, the potential negative impact of excessive time using screens during leisure time requires examination.

### **Excessive screen use is associated with negative physical health outcomes and health behaviours**

One of most intensely studied health effects of screen use is the impact of television viewing on body mass index (BMI) and overweight/obesity rates. Early research following the advent of television found an association between television viewing and overweight rates of children; a longitudinal analysis of nationally representative data from the National Health Examination Surveys (1967 to 1970) indicated that television viewing was strongly related to the onset of new cases of obesity and to the lack of remission among obese children<sup>17</sup>. Research in the 1990s provided stronger evidence that both the frequency<sup>17-23</sup> and duration<sup>20,24</sup> of television viewing are associated with obesity prevalence in children. This association has been identified for children as young as three years of age<sup>37</sup>. Further to this, more recent research has noted that the relationship between television viewing and obesity is not confounded by physical activity or the fitness level of the child<sup>38-41</sup>. While strong evidence is available to support the association between television use and higher BMI, evidence is starting to build suggesting that computer use<sup>42</sup> and excessive total screen use<sup>43</sup> could be contributing to the burgeoning problem of overweight in today's youth. This is supported by intervention research highlighting that reducing screen based activities, such as television viewing and computer use, has led to reductions in adiposity<sup>44-46</sup>.

There are various mechanisms proposed for the association between screen use and risk of being overweight. These include that television viewing is associated with; increased consumption of high energy foods<sup>47</sup>, eating meals while viewing television (leading to increased total energy and fat intake)<sup>48</sup>, increased exposure to food advertising<sup>49</sup> (leading to increased parental purchase of unhealthy foods), decreased metabolic rate while watching television<sup>50</sup>, lower physical activity participation<sup>51</sup> and uneven energy balance<sup>52-54</sup>.

Associations between excessive television viewing or total screen use and higher cholesterol, higher fasting insulin and lower cardiovascular fitness have also been identified. For instance, excessive television viewing (i.e. greater than two hours per day) was identified as being a better predictor of children's high cholesterol than family history, which is traditionally used for screening children for high cholesterol<sup>55</sup>. This same study noted that greater than four hours of television per day increased the risk of high cholesterol by nearly five times. Television viewing has been noted to be associated with higher fasting insulin<sup>48</sup>. Further to this, while initially the relationship between television viewing time and aerobic fitness was thought to be only low<sup>56</sup>, more recent research has detected a significant negative relationship between television viewing and aerobic fitness<sup>57</sup> and total screen use and fitness<sup>58</sup>.

Negative effects of excessive screen use during childhood and adolescence on long term physical health may be long lasting. A longitudinal study following one thousand people in New Zealand from birth to age 26<sup>14</sup> detected television viewing time in the evening during childhood and adolescence was associated with lower cardiorespiratory fitness and raised serum cholesterol at age 26. Screen reduction programs in childhood and adolescence could assist with adult health; one study found that lower screen time in adolescence was associated with a reduced risk of being an overweight or obese young adult<sup>59</sup>.

As well as impacting upon children's physical health directly, increased screen use is also thought to be associated with negative health behaviours. A longitudinal study of children aged 10-15 years observed that children who watched television for more than 4 hours a day were 5 times more likely to smoke cigarettes. In the New Zealand cohort reported earlier, higher television watching was associated with increased cigarette smoking at age 26 after adjusting for other potential confounding variables<sup>14</sup>.

There is existing debate about whether television viewing or other screen use displaces other child and adolescent activities such as physical activity. Various studies (for example Ekelund<sup>48</sup> and Robinson<sup>60</sup>) and a review<sup>61</sup> have failed to detect an association between physical activity and screen time (such as television viewing), whereas other research has identified that screen time and physical activity are inversely related<sup>51,62</sup> and a more recent review<sup>63</sup> found this negative association for adolescent screen time (television and video) and physical activity. One study suggests that the potential displacement of physical activity with screen use could be large; a South Australian study detected that every hour of screen use for 10-13 year olds was associated with a 13 minute reduction of moderate-to-vigorous physical activity, a 12 minute reduction in sport and a 10 minute reduction in sleep<sup>62</sup>.

Television viewing habits may also displace or adversely impact upon sleep. A study of New York adolescents identified that adolescents who watched three or more hours of television per day during adolescence were at a significantly elevated risk of frequent sleep problems by early adulthood<sup>64</sup>. Furthermore, adolescents who reduced their television viewing from one hour or longer to less than one hour per day experienced a significant reduction in subsequent sleep problems<sup>64</sup>. A US study explored the association between television viewing and sleep disturbance in just over a thousand children aged between four and ten<sup>65</sup>. The study found that television-viewing habits including amount of television viewed daily, the presence of a television in the child's bedroom and the bedtime television viewing were associated with the greatest number of sleep disturbances<sup>65</sup>. This study also found increased amounts of television viewing were associated most significantly with difficulty getting to and staying asleep. Unsurprisingly, the amount of television watched was positively related to daytime sleepiness<sup>65</sup>.

### **Higher screen use is associated with mental and social health issues**

More recently, research has been undertaken to explore the impact of screen use on mental and social health of children and adolescents, finding some benefits to the new technologies. Social networking using screens offers opportunities for children and adolescents to communicate with friends and family and develop social ties not offered by conventional interaction. For example, previous research has identified that screen use was positively related to quality of peer relationships<sup>66</sup> and computer use by children has been identified as being associated with enhanced self-esteem<sup>67</sup>.

However, an expanding body of research has identified that excessive screen use is associated with, and leads to, concerning negative mental and social outcomes. Low mood and sense of loneliness is indicated as being associated with online social networking and general Internet use. While there is some evidence of a null association between Internet use and loneliness and depression scores<sup>68</sup>, a longitudinal study following families during their first year of having the Internet in their homes identified that adolescents experience a lowering of mood and increased feelings of loneliness<sup>69</sup>. A study in the Netherlands of adolescents aged 12 to 15 years found instant messenger use and chatting in chat rooms after six months were positively related to compulsive Internet use and depression<sup>70</sup>. Issues of dependency could arise because of the potency of screen-based activity for addictive-type interaction<sup>71</sup>. A study in India found nearly one fifth of youth aged 16 to 18 were "Internet dependent" and that teenagers skipped work and sleep to go online and feared that life without the Internet would be dull. The impact of this on the mental health of 'Internet dependents' is likely to be important as they experience more loneliness<sup>72</sup>, depression<sup>69,70,73,74</sup> and depressive symptoms<sup>75</sup> than those who used the Internet moderately.

Screen use may also interfere with family communication and quality of family relationships. There is evidence that the constant presence of background television diminishes parent-child interaction in young children<sup>76</sup> and another study found that, regardless of age, children who spent more time watching television spent less time with their parents and with siblings<sup>77</sup>. A review of international research identified that screen behaviour was associated with poorer family relationships<sup>78</sup>.

### **The relationship between screen use and learning, attention and behaviour**

Studies have shown that computer use can impact positively upon children's alphabet recognition, language, early mathematical knowledge, cognitive development and a create a positive attitude toward

learning<sup>67</sup>. However, screen media present highly arousing, abnormal sensory input to the brain's activating system<sup>79</sup>. Excessive and inappropriate screen use has also been implicated in reduced learning and as having a negative impact upon the development of attention in children<sup>80-82</sup>. Furthermore, the use of technology needs to be used appropriately if benefits are to be gained, and even then, may have its limits<sup>83</sup>. For example, a US study examined annual change to middle school children's grade point average (GPA) in association with their overall daily computer use<sup>83</sup>. Results indicated a positive change in GPA was associated with higher computer use each day, but reached a critical point at three hours; those who exceeded this time on computers achieved no change, or even had a loss in their GPA. This study concluded that although spending some time on computers may help students increase their learning outcomes, too much time on computers can be harmful. A German study found a negative relationship between availability of a home computer and learning and no association between school computer access and learning<sup>84</sup>.

Watching television at very a young age is likely to be detrimental to development of attention, one study found that the number of hours watching television at age one was associated with an increase in the probability of having attentional problems at age seven<sup>80</sup>. Research has also indicated that television viewing impacts upon attention behaviours for adolescents. Although, a study in Denmark did not find this relationship<sup>85</sup>, and another US study found only a weak relationship<sup>86</sup>, the most recent and robust cohort study found a positive relationship between adolescent attention problems and higher television viewing in childhood after adjusting for confounders<sup>87</sup>.

Although it is important to note that youth with behavioural problems may be more inclined to participate in screen activities due to issues such as social isolation, research has pointed to a link between screen time and aggressive behaviour. Significant associations have been detected between television viewing during early adolescence and subsequent aggressive acts against other persons<sup>88</sup>. An intervention project successfully reduced peer ratings of aggression and observed aggression in children by simply reducing television viewing time<sup>89</sup>. In addition, some behavioural problems in early adolescents', such as aggression and delinquency, can be predicted by Internet communication and the amount of online gaming<sup>90</sup>.

## Time outside

While higher screen time such as television viewing is associated with total time being sedentary<sup>91</sup>, time outside is positively associated with youth physical activity<sup>63,92</sup>. An Australian study estimated that each additional hour spent outdoors during the cooler months was associated with an extra 27 minutes per week of physical activity for girls and with an extra 20 minutes per week physical activity for boys<sup>93</sup>. Evidence also indicates that time outside is associated a decreased risk of being overweight; 27–41% lower rates of overweight and obesity are evident amongst those children spending more time outdoors<sup>93</sup>. Despite these benefits, the time children and adolescents spend outside is low, and appears to be declining. A NSW study identified that 37% of 10-12 year old children spent less 30 minutes a day playing outdoors after school<sup>25</sup>. Furthermore, a Child Development Survey of data collected from three to 12 year old children the US in 1997 and 2003, identified that the biggest change in children's activities was a large reduction in the average time children spent in unstructured outside play, which reduced by nearly a third, from an average of 36 to 25 minutes per day<sup>7</sup>.

In addition to increased physical activity and increased probability of being a healthy weight, time outside provides the opportunity to be in contact with nature which supports other aspects of physical, mental and social health and learning. Evidence indicates that contact with nature assists with building children's motor skills<sup>94,95</sup> as well as supporting more intensive physical activity<sup>96</sup>. Contact with nature is also purported as being important in children's personality development<sup>97</sup> and children's emotional responsiveness and receptivity<sup>98,99</sup>. More nature in the neighbourhood has been noted to increase children's directed attention<sup>100</sup> and nature has been indicated as assisting with children's stress management<sup>101</sup>.

Contact with nature may assist children with disorders such as ADHD and delinquency. Research in the US found that concentration levels, functioning and severity of symptoms for ADHD sufferers were lower in areas with more nature or after an intervention involving immersion in nature (such as a walk in the park)<sup>102-104</sup>. Children displaying delinquent and antisocial behaviour have been observed to benefit from nature-based programs such as wilderness camps<sup>105</sup>.

## **Conclusions and recommendations**

A healthy balance between use of screens and time outside and in contact with nature appears to be missing in the lives of youth in western societies. Excessive screen use is associated with unfavourable physical, mental and social health characteristics as well as learning and behavioural disadvantages for children and adolescents, whereas time outside and in contact with nature supports health and wellbeing. While further research assessing the impact of the current high screen use culture of youth is required, programs which successfully decrease screen use while increasing time outside are likely to lead to far-reaching positive physical, mental and social health and behaviour and learning benefits.



**Table 1: Negative health outcomes associated with excessive screen use for children and adolescents**

Screen activity	Impact	Proposed or possible mechanism/s or theories
<b>Physical health and health behaviours</b>		
<ul style="list-style-type: none"> <li>• TV viewing</li> <li>• TV viewing on weekend<sup>^</sup></li> <li>• Computer use</li> <li>• Screen use</li> </ul>	Higher BMI or overweight/obesity risk in childhood <sup>17-24,42-46</sup> and adulthood <sup>^106</sup>	<ol style="list-style-type: none"> <li>1. Increased consumption of high energy foods<sup>47</sup></li> <li>2. Eating meals while viewing TV (increased total energy and fat intake<sup>48</sup>)</li> <li>3. Increased exposure to food advertising<sup>49</sup> (leading to increased parental purchase of unhealthy foods)</li> <li>4. Decreased metabolic rate<sup>50</sup></li> <li>5. Lower physical activity participation<sup>51</sup></li> <li>6. Incorrect energy balance<sup>52-54</sup></li> </ol>
<ul style="list-style-type: none"> <li>• TV viewing</li> </ul>	Higher cholesterol in childhood <sup>55</sup> and adulthood <sup>14</sup>	Lower physical activity and unhealthy dietary practices <sup>55</sup>
<ul style="list-style-type: none"> <li>• TV viewing</li> </ul>	'Clustered' metabolic risk <sup>48</sup>	Increased adiposity from increased TV viewing <sup>48</sup>
<ul style="list-style-type: none"> <li>• TV viewing</li> </ul>	Higher fasting insulin <sup>48</sup>	Reduced metabolic rate <sup>50</sup>
<ul style="list-style-type: none"> <li>• TV viewing</li> </ul>	Sedentary time <sup>91</sup> ,	TV activity is sedentary
<ul style="list-style-type: none"> <li>• Total screen time</li> </ul>	Lower cardiorespiratory fitness in childhood <sup>52,57,58</sup> and adulthood <sup>14</sup>	<ol style="list-style-type: none"> <li>1. Lower physical activity participation<sup>57</sup></li> <li>2. High screen users may have lower PA self-efficacy<sup>57</sup></li> </ol>
<ul style="list-style-type: none"> <li>• TV viewing</li> </ul>	Cigarette smoking in childhood <sup>107</sup> and adulthood <sup>14</sup>	Portrayal of smoking in prime-time TV, movies, music videos and sporting events <sup>107</sup>
<ul style="list-style-type: none"> <li>• Total screen time</li> </ul>	Lower physical activity participation <sup>51</sup> , sports and recreation (clubs and hobbies) <sup>108</sup>	Displacement of these activities with screen time <sup>51</sup>
<ul style="list-style-type: none"> <li>• TV viewing</li> </ul>	Sleep problems in childhood <sup>65,109</sup> and early adulthood <sup>64</sup> .	<ol style="list-style-type: none"> <li>1. Displace sleep time<sup>65</sup></li> <li>2. Physiological impact; suppression of release of melatonin<sup>110</sup></li> <li>3. Developmentally inappropriate content<sup>109</sup></li> <li>4. Reduced parental limit setting<sup>109</sup></li> <li>5. Reduced physical activity<sup>64</sup></li> </ol>
<b>Mental and social health</b>		
<ul style="list-style-type: none"> <li>• Instant messenger use</li> <li>• 'Chatting' in chat rooms</li> </ul>	Internet addiction <sup>69,72</sup>	Addictive-type interaction <sup>71</sup>
<ul style="list-style-type: none"> <li>• Internet use</li> <li>• Instant messenger use</li> </ul>	Loneliness <sup>70</sup>	Internet addiction <sup>69,72</sup>
<ul style="list-style-type: none"> <li>• Excessive/intensity of Internet use</li> <li>• Instant messenger use</li> <li>• Main Internet activity is emailing</li> </ul>	Clinical depression <sup>69,70,73,74</sup> or depressive symptoms <sup>75</sup>	<p>Interactive capabilities of Internet and instant messenger<sup>73</sup></p> <p>Profile of Internet addiction group<sup>74</sup></p> <p>Replacement of personal social interaction with online interaction<sup>75</sup></p>
<ul style="list-style-type: none"> <li>• TV viewing</li> </ul>	Reduced time with parents and siblings <sup>77</sup>	Displacement of this activity with TV viewing <sup>77</sup>
<b>Learning, attention and behaviour</b>		
<ul style="list-style-type: none"> <li>• TV viewing</li> </ul>	Reading <sup>108</sup> and reading at an older age <sup>111</sup>	<ol style="list-style-type: none"> <li>1. A TV-induced deterioration of attitude toward reading<sup>111</sup></li> <li>2. TV-induced deterioration of children's ability to concentrate on reading<sup>111</sup></li> </ol>
<ul style="list-style-type: none"> <li>• TV viewing</li> </ul>	Reduced homework <sup>77</sup> and academic achievement <sup>81,82</sup>	3. Displacement of homework and studying with TV viewing <sup>77</sup>
<ul style="list-style-type: none"> <li>• TV exposure<sup>#</sup>/ viewing<sup>¥</sup></li> </ul>	Attention problems in childhood <sup># 80</sup> and adolescence <sup>¥87</sup> , concentration <sup>¥111</sup>	<ol style="list-style-type: none"> <li>1. TV exposure effects synaptic development<sup>80</sup></li> <li>2. Increased distractibility<sup>80</sup>, reduced attention span<sup>112 80</sup></li> <li>3. Diminished parent-child interaction<sup>76</sup></li> <li>4. Development of attention<sup>80</sup></li> </ol>
<ul style="list-style-type: none"> <li>• TV viewing</li> </ul>	Reduced creative imagination <sup>79</sup> and creative play <sup>77</sup>	<ol style="list-style-type: none"> <li>1. Information processing habits that interfere with information processing<sup>79</sup></li> <li>2. Displaces activities likely to promote creativity (reading and radio)<sup>79</sup></li> <li>3. Displacement of this activity with TV viewing<sup>77</sup></li> </ol>
<ul style="list-style-type: none"> <li>• Direct TV exposure</li> <li>• Household TV use</li> </ul>	Aggressive behaviour <sup>113</sup>	<ol style="list-style-type: none"> <li>1. Violence through TV commercials<sup>114</sup> and movies<sup>115</sup></li> <li>2. Desensitization to violence<sup>116</sup></li> <li>3. Shorter play time and limited attention to play activities, thus negatively influencing development<sup>116</sup></li> <li>4. Unregulated TV content<sup>113</sup></li> </ol>
<ul style="list-style-type: none"> <li>• TV and video viewing</li> <li>• Video game use</li> </ul>	Peer ratings of aggression, observed aggression <sup>89</sup>	Modelling of aggressive behaviour in TV, videos and video games <sup>89</sup>
<ul style="list-style-type: none"> <li>• 'Gaming'</li> </ul>	Aggressive acts against people <sup>88</sup>	Negative 'affect' in the brain <sup>117,118</sup>
<ul style="list-style-type: none"> <li>• Online gaming</li> <li>• Internet use for communication</li> </ul>	Aggression and delinquency <sup>90</sup>	<ol style="list-style-type: none"> <li>1. Access to and participation in violent games/videos<sup>90</sup></li> <li>2. Propensity for adolescents with behavioural issues to spend more time gaming and communicating via Internet<sup>90</sup></li> </ol>

## References

1. Australian Bureau of Statistics. *Children's Participation in Cultural and Leisure Activities* Vol Cat number 1901.0. Canberra, Australia 2006
2. Commonwealth of Australia Australian Government Department of Health and Ageing. *Australia's Physical Activity Recommendations for 5-12 year Olds*. Canberra 2004.
3. Martin K, Rosenberg M, Miller M, et al. *Move and Munch Final Report: Trends in Physical Activity, Nutrition and Body Size in Western Australian Children and Adolescents: the Child and Adolescent Physical Activity and Nutrition Survey (CAPANS) 2008*.: Physical Activity Taskforce Government of Western Australia;2010.
4. Australian Government Department of Health and Ageing. *Australian National Children's Nutrition and Physical Activity Survey- Main Findings*. Barton, ACT 2008.
5. Vincent SD, Pangrazi RP. An examination of the activity patterns of elementary school children. *Ped Ex Science*. 2002;14(4):432-441.
6. Hofferth S. Changes in American children's time—1997 to 2003. *Electronic Int J Time Use Res*. 2009;6(1):26-47.
7. Great Britain Department of Health. *Choosing Health: Making Healthy Choices Easier*. Vol 6374: The Stationery Office; 2004.
8. Gill T. Space oriented Children's policy: creating child friendly communities to improve children's well-being. *Children & Society*. 2008;22(2):136-142.
9. Salmon J, Timperio A. Prevalence, trends and environmental influences on child and youth physical activity. In: Tomkinson GR, Olds T, eds. *Pediatric Fitness. Secular Trends and Geographic Variability*. *Med Sports and Sci*. Vol 50. Basel, Karger 2007:186-202.
10. Bowdon A, Band L, Grey B. *Climbing Trees: Getting Aussie Kids Back Outdoors* 2011
11. Faber - Taylor A, Kuo F. Is contact with nature important for healthy child development? State of the evidence. In: Spencer C., Blades M., eds. *Children and Their Environments: Learning, Using and Designing Spaces*. Cambridge: Cambridge University Press; 2006:124.
12. Laurson KR, Eisenmann JC, Welk GJ, Wickel EE, Gentile DA, Walsh DA. Combined influence of physical activity and screen time recommendations on childhood overweight. *J Pediatrics*. 2008;153(2):209-214.
13. Biddle SJH, Pearson N, Ross GM, Braithwaite R. Tracking of sedentary behaviors of young people: a systematic review. *Prev Med*. 2010.
14. Hancox RJ, Milne BJ, Poulton R. Association between child and adolescent television viewing and adult health: a longitudinal birth cohort study. *Lancet*. 2004;364(9430):257-262.
15. Granich J, Rosenberg M, Knuiam M, Timperio A. Understanding children's sedentary behaviour: a qualitative study of the family home environment. *Health Ed Res*. 2010;25(2):199.
16. Riley JW, Cantwell FV, Ruttiger KF. Some observations on the social effects of television. *Public Opinion Quart* 1949;13(2):223.
17. Dietz Jr WH, Gortmaker SL. Do we fatten our children at the television set? Obesity and television viewing in children and adolescents. *Pediatrics*. 1985;75(5):807.
18. Locard E, Mamelle N, Billette A, Miginiac M, Munoz F, Rey S. Risk factors of obesity in a five year old population. Parental versus environmental factors. *Int J Obes*. 1992;16(10):721-729.
19. Andersen RE, Crespo CJ, Bartlett SJ, Cheskin LJ, Pratt M. Relationship of physical activity and television watching with body weight and level of fatness among children: results from the Third National Health and Nutrition Examination Survey. *JAMA* 1998;279(12):938.
20. Obarzanek E, Schreiber GB, Crawford PB, et al. Energy intake and physical activity in relation to indexes of body fat: the National Heart, Lung, and Blood Institute Growth and Health Study. *Am Journal Clin Nutr*. 1994;60(1):15.
21. Gortmaker S, Dietz Jr W, Cheung L. Inactivity, diet, and the fattening of America. *J Am Dietetic Ass*. 1990;90(9):1247.
22. Gortmaker SL, Must A, Sobol AM, Peterson K, Colditz GA, Dietz WH. Television viewing as a cause of increasing obesity among children in the United States, 1986-1990. *Archives Pediatrics Adolesc Med*. 1996;150(4):356.
23. Guillaume M, Lapidus L. Physical activity, obesity, and cardiovascular risk factors in children. The Belgian Luxembourg Child Study II. *Obes Res*. 1997;5(6):549.
24. Dennison BA, Erb TA, Jenkins PL. Television viewing and television in bedroom associated with overweight risk among low-income preschool children. *Pediatrics*. 2002;109(6):1028.
25. Adachi-Mejia A, Longacre M, Gibson J, Beach M, Titus-Ernstoff L, Dalton M. Children with a TV in their bedroom at higher risk for being overweight. *Int J Obes*. 2006;31(4):644-651.
26. Biddle SJH, Gorely T, Marshall SJ, Murdey I, Cameron N. Physical activity and sedentary behaviours in youth: issues and controversies. *J Royal Soc Prom Health*. 2004;124(1):29.
27. Granich J, Rosenberg M, Knuiam MW, Timperio A. Individual, social, and physical environment factors associated with electronic media use among children: sedentary behavior at home. *J Phy Act Health*. 2011;8(5):613.
28. American Academy of Pediatrics. Children, adolescents and television. *Pediatrics* 2001;107:423-426.
29. Rideout VJ, Foehr UG, Roberts DF. Generation M2: Media in the lives of 8-to 18-year-olds. 2010;54(8010).
30. Pink B. *Household Use of Information Technology: Australia-2008-09*: Canberra: Australian Bureau of Statistics; 2009.

31. Commonwealth of Australia. *National Secondary School Computer Fund* Canberra, ACT Department of Education Employment and Workplace Relations; 2011
32. Department of Education Training and Workplace Relations. *Strategic Plan to Guide the Implementation the Digital Education Revolution Initiative and Related Initiatives*: Australian Government; 2008.
33. Eng TS. The impact of ICT on learning: A review of research. *Int Educ J* 2005;6(5):635-650.
34. Ringstaff C, Kelley L. *The Learning Return on Our Educational Technology Investment; A review of Findings From Research*. San Francisco: WestEd; 2002:94107-91242.
35. Stephens-Reicher J, Metcalf A, Blanchard M, Mangan C, Burns J. *Reaching the Hard-to-Reach: How Information Communication Technologies (ICT) Can Reach Young People at Greater Risk of Mental Difficulties*. Sydney and Melbourne: Inspire Foundation and Oxygen Youth Health Research Centre 2010.
36. Walsh L, Lemon B, Black R, C M, P C. *The Role of Technology in Engaging Disengaged Youth: Final Report*. Canberra, Australia: Australian Flexible Learning Framework, Commonwealth of Australia; 2011.
37. Jago R, Baranowski T, Baranowski J, Thompson D, Greaves K. BMI from 3–6 y of age is predicted by TV viewing and physical activity, not diet. *Int J Obes*. 2005;29(6):557-564.
38. Grund A, Krause H, Siewers M, Rieckert H, Müller M. Is TV viewing an index of physical activity and fitness in overweight and normal weight children? *Pub Health Nutr*. 2001;4(06):1245-1251.
39. Hanley AJG, Harris SB, Gittelsohn J, Wolever T, Saksvig B, Zinman B. Overweight among children and adolescents in a Native Canadian community: prevalence and associated factors. *Am J Clinical Nutr*. 2000;71(3):693.
40. Hernandez B, Gortmaker S, Colditz G, Peterson K, Laird N, Parra-Cabrera S. Association of obesity with physical activity, television programs and other forms of video viewing among children in Mexico City. *Int J Obes*. 1999;23(8):845-854.
41. Salmon J, Bauman A, Crawford D, Timperio A, Owen N. The association between television viewing and overweight among Australian adults participating in varying levels of leisure-time physical activity. *Int J Obes Related Metabolic Dis*. 2000;24(5):600.
42. Arluk SL, Branch JD, Swain DP, Dowling EA. Childhood obesity's relationship to time spent in sedentary behavior. *Military Med* 2003;168(7):583.
43. Spinks AB, Macpherson AK, Bain C, McClure RJ. Compliance with the Australian national physical activity guidelines for children: relationship to overweight status. *J Sci Med Sport*. 2007;10(3):156-163.
44. Epstein LH, Roemmich JN, Robinson JL, et al. A randomized trial of the effects of reducing television viewing and computer use on body mass index in young children. *Archives Pediatric Adolesc Med*. 2008;162(3):239.
45. Gortmaker SL, Peterson K, Wiecha J, et al. Reducing obesity via a school-based interdisciplinary intervention among youth: Planet Health. *Archives Pediatrics Adolesc Med*. 1999;153(4):409.
46. Robinson TN. Reducing children's television viewing to prevent obesity: a randomized controlled trial. *JAMA*. 1999;282(16):1561.
47. French SA, Story M, Jeffery RW. Environmental influences on eating and physical activity. *Ann Rev Public Health*. 2001;22(1):309-335.
48. Ekelund U, Brage S, Froberg K, et al. TV viewing and physical activity are independently associated with metabolic risk in children: the European Youth Heart Study. *PLoS Med*. 2006;3(12):e488.
49. Borzekowski DLG, Robinson TN. The 30-Second Effect: an experiment revealing the impact of television commercials on food preferences of preschoolers. *J Am Dietetic Ass*. 2001;101(1):42-46.
50. Klesges RC, Shelton ML, Klesges LM. Effects of television on metabolic rate: potential implications for childhood obesity. *Pediatrics*. 1993;91(2):281.
51. Carlson SA, Fulton JE, Lee SM, Foley JT, Heitzler C, Huhman M. Influence of limit-setting and participation in physical activity on youth screen time. *Pediatrics*. 2010;126(1):e89.
52. Epstein LH, Roemmich JN. Reducing sedentary behavior: role in modifying physical activity. *Exerc Sports Sciences Rev*. 2001.
53. Blair SN, Kohl HW, Gordon N, Paffenbarger Jr RS. How much physical activity is good for health? *Ann Rev Pub Health*. 1992;13(1):99-126.
54. Epstein LH, Valoski AM, Vara LS, et al. Effects of decreasing sedentary behavior and increasing activity on weight change in obese children. *Health Psych* 1995;14(2):109.
55. Wong ND, Hei TK, Qaqundah PY, Davidson DM, Bassin SL, Gold KV. Television viewing and pediatric hypercholesterolemia. *Pediatrics*. 1992;90(1):75.
56. Katzmarzyk PT, Malina RM, Song TMK, Bouchard C. Television viewing, physical activity, and health-related fitness of youth in the Québec Family Study. *J Adolesc Health*. 1998;23(5):318-325.
57. Harrison M, Burns CF, McGuinness M, Heslin J, Murphy NM. Influence of a health education intervention on physical activity and screen time in primary school children: Switch Off-Get Active'. *J Science Med Sport*. 2006;9(5):388-394.
58. Aires L, Andersen LB, Mendonça D, Martins C, Silva G, Mota J. A 3 year longitudinal analysis of changes in fitness, physical activity, fatness and screen time. *Acta Pædiatrica*. 2010;99(1):140-144.
59. Boone JE, Gordon-Larsen P, Adair LS, Popkin BM. Screen time and physical activity during adolescence: longitudinal effects on obesity in young adulthood. *Int J Behav Nutr Phys Act*. 2007;4(1):26.
60. Robinson TN, Hammer LD, Killen JD, et al. Does television viewing increase obesity and reduce physical activity? A cross-sectional and longitudinal analysis among adolescent girls. *Pediatrics*. 1993;91(2):273-280.

61. Taylor W, Sallis J. Determinants of physical activity in children. *World Rev Nutr Dietetics*. 1997;82:159.
62. Olds T, Ridley K, Dollman J. Screenieboppers and extreme screenies: the place of screen time in the time budgets of 10–13 year-old Australian children. *Aust NZ J Public Health*. 2006;30(2):137-142.
63. Sallis J, Prochaska J, Taylor W. A review of correlates of physical activity of children and adolescents. *Med Sci Sports Exerc*. 2000;32:963 - 975.
64. Johnson JG, Cohen P, Kasen S. Association between television viewing and sleep problems during adolescence and early adulthood. *Archives Pediatrics Adolesc Med*. 2004;158(6):562.
65. Owens J, Maxim R, McGuinn M, Nobile C, Msall M, Alario A. Television-viewing habits and sleep disturbance in school children. *Pediatrics*. 1999;104:e27.
66. Iannotti RJ, Kogan MD, Janssen I, Boyce WF. Patterns of adolescent physical activity, screen-based media use, and positive and negative health indicators in the US and Canada. *J Adolescent Health*. 2009;44(5):493-499.
67. Haugland SW. The effect of computer software on preschool children. *J Computing Childhood Ed*. 1992;3(1):15-30.
68. Gross EF, Juvonen J, Gable SL. Internet use and well being in adolescence. *J Social Issues*. 2002;58(1):75-90.
69. Kraut R, Patterson M, Lundmark V, Kiesler S, Mukopadhyay T, Scherlis W. Internet paradox: a social technology that reduces social involvement and psychological well-being? *Am Psych*. 1998;53(9):1017-1031.
70. van den Eijnden RJM, Meerkerk GJ, Vermulst AA, Spijkerman R, Engels RCME. Online communication, compulsive internet use, and psychosocial well-being among adolescents: a longitudinal study. *Develop Psych*. 2008;44(3):655.
71. Griffiths MD, Hunt N. Dependence on computer games by adolescents. *Psych Reports*. 1998.
72. Nalwa K, Anand AP. Internet addiction in students: a cause of concern. *CyberPsych Behav*. 2003;6(6):653-656.
73. Young KS, Rogers RC. The relationship between depression and Internet addiction. *CyberPsychology Behav*. 1998;1(1):25-28.
74. Ha JH, Kim SY, Bae SC, et al. Depression and Internet addiction in adolescents. *Psychopathology*. 2007;40(6):424-430.
75. Ybarra ML, Alexander C, Mitchell KJ. Depressive symptomatology, youth Internet use, and online interactions: a national survey. *J Adolesc Health*. 2005;36(1):9-18.
76. Courage ML, Setliff AE. When babies watch television: attention-getting, attention-holding, and the implications for learning from video material. *Develop Rev*. 2010;30(2):220-238.
77. Vandewater EA, Bickham DS, Lee JH. Time well spent? Relating television use to children's free-time activities. *Pediatrics*. 2006;117(2):e181.
78. Iannotti RJ, Kogan MD, Janssen I, Boyce WF. Patterns of adolescent physical activity, screen-based media use, and positive and negative health indicators in the U.S. and Canada. *J Adoles Health*. 2009;44(5):493-499.
79. Valkenburg PM, Van der Voort THA. Influence of TV on daydreaming and creative imagination: a review of research. *Psych Bulletin*. 1994;116(2):316-339.
80. Christakis DA, Zimmerman FJ, DiGiuseppe DL, McCarty CA. Early television exposure and subsequent attentional problems in children. *Pediatrics*. 2004;113(708-713).
81. Nelson MC, Gordon-Larsen P. Physical activity and sedentary behavior patterns are associated with selected adolescent health risk behaviors. *Pediatrics*. 2006;117(4):1281.
82. Hornik R. Out-of-school television and schooling: Hypotheses and methods. *Rev Educational Res*. 1981;51(2):193.
83. Lei J, Zhao Y. Technology uses and student achievement: a longitudinal study. *Computers Educ*. 2007;49(2):284-296.
84. Fuchs T, Wößmann L. *Computers and Student learning: Bivariate and Multivariate Evidence on the Availability and Use of Computers at Home and at School*. Vol IFO working paper 8: Institute of Economic Research at the University of Munich; 2004.
85. Obel C, Henriksen TB, Dalsgaard S, et al. Does children's watching of television cause attention problems? Retesting the hypothesis in a Danish cohort. *Pediatrics*. 2004;114(5):1372.
86. Stevens T, Mulsow M. There is no meaningful relationship between television exposure and symptoms of attention-deficit/hyperactivity disorder. *Pediatrics*. 2006;117(3):665.
87. Landhuis CE, Poulton R, Welch D, Hancox RJ. Does childhood television viewing lead to attention problems in adolescence? Results from a prospective longitudinal study. *Pediatrics*. 2007;120(3):532.
88. Johnson JG, Cohen P, Smailes EM, Kasen S, Brook JS. Television viewing and aggressive behavior during adolescence and adulthood. *Science(Washington)*. 2002;295(5564):2468-2471.
89. Robinson TN, Wilde ML, Navracruz LC, Haydel KF, Varady A. Effects of reducing children's television and video game use on aggressive behavior: a randomized controlled trial. *Archives Pediatr Adolesc Med*. 2001;155(1):17.
90. Holtz P, Appel M. Internet use and video gaming predict problem behavior in early adolescence. *J Adolesc*. 2011;34:49-58.

91. Lowry R, Wechsler H, Galuska DA, Fulton JE, Kann L. Television viewing and its associations with overweight, sedentary lifestyle, and insufficient consumption of fruits and vegetables among US high school students: differences by race, ethnicity, and gender. *J School Health*. 2002;72(10):413-421.
92. Biddle SJH, Marshall SJ, Gorely T, Cameron N. Temporal and environmental patterns of sedentary and active behaviors during adolescents' leisure time. *Int J Behav Med*. 2009;16(3):278-286.
93. Cleland V, Crawford D, Baur L, Hume C, Timperio A, Salmon J. A prospective examination of children's time spent outdoors, objectively measured physical activity and overweight. *Int J Obes*. 2008;32(11):1685-1693.
94. Fjørtoft I. The natural environment as a playground for children: The impact of outdoor play activities in pre-primary school children. *Early Childhood Educ J*. 2001;29(2):111-117.
95. Fjørtoft I. Landscape as Playscape: the effects of natural environments on children's play and motor development. *Children Youth Environments*. 2004;14(2):21-44.
96. Wheeler B, Cooper A, Page A, Jago R. Greenspace and children's physical activity: A GPS/GIS analysis of the PEACH project. *Prev Med*. 2010.
97. Sobel D. *Children's Special Places: Exploring the Role of Forts, Dens, and Bush Houses in Middle Childhood*: Wayne State University Press; 1993.
98. Derr V. *Voices from the Mountains: Children's Sense of Place in Three Communities of Northern New Mexico*: Ann Arbor, MI: Bell Howell Learning Company; 2001.
99. Ratanapojnard S. Community-Oriented Biodiversity Environmental education: Its Effect on Knowledge, Values, and Behavior Among Rural Fifth-and Sixth-Grade Students in Northeastern Thailand. 2001; PhD Thesis.
100. Wells N. At home with nature: effects of "greenness" on children's cognitive functioning. *Environ Behav*. 2000;32(6):775.
101. Wells N, Evans G. Nearby nature: A buffer of life stress among rural children. *Environ Behav*. 2003;35(3):311.
102. Faber Taylor A, Kuo F. Children with attention deficits concentrate better after walk in the park. *J Attention Dis*. 2009;12(5):402.
103. Taylor A, Kuo F, Sullivan W. Coping with ADD: The surprising connection to green play settings. *Environ Behav*. 2001;33(1):54.
104. Kuo F, Faber Taylor A. A potential natural treatment for attention-deficit/hyperactivity disorder: evidence from a national study. *Am J Public Health*. 2004;94(9):1580.
105. Wilson SJ, Lipsey MW. Wilderness challenge programs for delinquent youth: A meta-analysis of outcome evaluations. *Evaluation Program Planning*. 2000;23(1):1-12.
106. Viner RM, Cole TJ. Television viewing in early childhood predicts adult body mass index. *J Pediatrics*. 2005;147(4):429-435.
107. Gidwani PP, Sobol A, DeJong W, Perrin JM, Gortmaker SL. Television viewing and initiation of smoking among youth. *Pediatrics*. 2002;110(3):505.
108. Mutz DC, Roberts DF, Vuuren DP. Reconsidering the displacement hypothesis. *Communication Res*. 1993;20(1):51.
109. Thompson DA, Christakis DA. The association between television viewing and irregular sleep schedules among children less than 3 years of age. *Pediatrics*. 2005;116(4):851.
110. Higuchi S, Motohashi Y, Liu Y, Ahara M, Kaneko Y. Effects of VDT tasks with a bright display at night on melatonin, core temperature, heart rate, and sleepiness. *J Applied Physiol*. 2003;94(5):1773.
111. Koolstra CM, Van der Voort T. Longitudinal Effects of Television on Children's Leisure Time Reading A Test of Three Explanatory Models. *Human Comm Res*. 1996;23(1):4-35.
112. Singer JL. *The Power and Limitations of Television: A Cognitive-Affective Analysis. The Entertainment Functions of Television* 1980:31-65.
113. Manganello JA, Taylor CA. Television exposure as a risk factor for aggressive behavior among 3-year-old children. *Archives Pediatr Adolesc Med*. 2009;163(11):1037.
114. Rajcecki D, McTavish DG, Rasmussen JL, Schreuders M, Byers DC, Jessup KS. Violence, conflict, trickery, and other story themes in TV ads for food for children. *J Applied Social Psych*. 1994;24(19):1685-1699.
115. Yokota F, Thompson KM. Violence in G-rated animated films. *JAMA*. 2000;283(20):2716.
116. Schmidt ME, Pempek TA, Kirkorian HL, Lund AF, Anderson DR. The effects of background television on the toy play behavior of very young children. *Child Develop*. 2008;79(4):1137-1151.
117. Mathiak K, Weber R. Toward brain correlates of natural behavior: fMRI during violent video games. *Human Brain Mapping*. 2006;27(12):948-956.
118. Murray JP, Liotti M, Ingmundson PT, et al. Children's brain activations while viewing televised violence revealed by fMRI. *Media Psych*. 2006;8(1):25-37.