Sedentariness, Small-Screen Recreation, and Fitness in Youth

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Background: There are concerns that sedentariness among young people has increased and that this may be detrimental to their health. The purpose of this study was to examine the association between sedentary activities, including small-screen recreation (SSR: watching TV/DVDs/videos, recreational computer use) and cardiorespiratory endurance (CRE) in children aged 11–15 years.

Methods: A cross-sectional representative population survey was taken of New South Wales (Australia) school students in Grades 6, 8, and 10 (N=2750) in 2004. Sedentary activities and SSR were measured by a self-report questionnaire. CRE was determined by the 20-meter multi-stage shuttle run test. The optimal cut point for time spent on SSR was determined by receiver operating characteristic analysis.

Results: Time spent in sedentary activities was inversely associated with CRE among Grade 8 students (p=0.01) and Grade 10 girls (p=0.03). CRE was lower among Grade 8 students (p<0.001) and Grade 10 girls (p<0.001) who spent ≥2 hours/day on SSR compared with students who spent <2 hours/day. The 2-hour/day cut point for SSR had high sensitivity (boys: 84%, [95% CI=79%, 87%]; girls: 79% [95% CI=74%, 84%]) and low specificity (boys: 28% [95% CI=24%, 32%]; girls: 42% [95% CI=38%, 46%]).

Conclusions: Cardiorespiratory endurance did not differ consistently across quintiles of sedentariness and SSR among boys; however, among girls there was a consistent inverse association. If confirmed in prospective studies, these findings have important implications for risk of chronic disease.

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Introduction

Societal changes in the past 20 years have resulted in greater availability of sedentary activities. As a result, there are concerns that young people are spending excessive amounts of time doing sedentary behaviors, and today's children are perceived to be more sedentary than previous generations. These issues are of concern because sedentary lifestyles are associated with the development of a number of chronic diseases in adulthood,[1] and there is strong evidence that sedentary behaviors adopted during childhood track into adult life.[2,3]

Much of the research on sedentariness has focused on TV viewing and, more recently, on other small-screen recreation (SSR) technologies (e.g., DVDs, videos, computers), yet young people engage in many other sedentary activities (homework, reading, chatting with friends).[4,5] The health-related effects of prolonged sedentariness have been examined extensively among adults,[1] but not among children.

Consistent evidence indicates that physical activity and TV viewing are separate constructs,[6] but only limited evidence is available on the association between sedentary activities and fitness.[7–9] Cardiorespiratory endurance (CRE), or aerobic fitness, is an outcome of physical activity and an important component of metabolic health.[10] It therefore provides a useful and objective endpoint to examine the health-related effects of sedentariness.

To our knowledge, no other studies have examined the nature of the association between total sedentariness and CRE in a representative sample of young people. Nor have any studies examined the sensitivity and specificity of the SSR guidelines, which recommend that children aged 2–18 years spend less than 2 hours per day on SSR.[11,12] The purpose of this study, therefore, was to examine the associations between

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Table 1. Categories and components of adolescent sedentary activity questionnaire

Sedentary category	Sedentary activity
Small-screen recreation	Watching TV
	Watching videos/DVDs; playing video games
	Using a computer for fun, including e-communications, e-games, surfing the net
Education	Using a computer for homework
	Doing homework not on a computer
	Out-of-school-hours tutoring
Travel	Motorized travel (car/bus/train/boat)
Cultural activities	Reading for fun
	Doing hobbies or crafts, including board or card games
	Playing/practicing a musical instrument
Social activities	Sitting around chatting with friends, using the telephone, hanging out, listening to music
	Religious activities

sedentary behavior, including SSR, and fitness among a representative sample of children aged 11–15 years.

Methods

Design

The New South Wales (NSW) Schools Physical Activity and Nutrition Survey 2004 was a representative survey of primary and high school students in NSW, Australia, conducted between February and April 2004 (late summer to early autumn in the southern hemisphere). A detailed description of the survey method has been published elsewhere.[13]

Informed consent by students and their care providers was a requirement for participation. The University of Sydney Human Research Ethics Committee, the NSW Department of Education and Training, and the NSW Catholic Education Commission approved each study. Data for Grades 6, 8, and 10 (mean ages 11.3, 13.3, and 15.3 years, respectively) are presented here because students in only these grades completed survey questionnaires.

Measures

Students reported their gender, date of birth, postcode of residence, and language spoken most at home. Postcode of residence was used as a proxy for SES, based on the Australian Bureau of Statistics' Index of Relative Socioeconomic Disadvantage (IRSD),[14] and was used to rank students in tertiles of SES (low, medium, or high). The IRSD describes the socioeconomic aspects of geographic areas and includes indices on income, educational attainment, unemployment, and proportion of people in unskilled occupations. Language spoken most at home was used to categorize students into English-speaking and non-English-speaking backgrounds.[15] Height and weight were measured and BMI (kg/m^2) calculated, and students' weight status was categorized according to international guidelines.[16]

Cardiorespiratory endurance. CRE was assessed by the 20-meter multi-stage shuttle run test (20mMST).[17] Students were divided into groups of 15–20 to complete the test, and field staff instructed students regarding the test and pacing. The test was terminated when a student could no longer follow the set pace within the given time period on two successive shuttles, or when they withdrew voluntarily. Scores were recorded as the level and shuttle reached in the test and then converted to the number of laps completed to provide a continuous variable for analysis.[18]

Physical activity. Information about physical activity was collected using the Adolescent Physical Activity Recall Questionnaire.[19] Students reported participation in all organized and informal physical activity during a normal week separately for summer and winter school terms. Students reported each activity and the frequency and duration of participation. All activities were assigned a MET value,[20] and time spent in moderate to vigorous physical activity (i.e., MVPA >3 METs) was calculated. Only summer physical activities were included in the analysis because the survey and CRE were conducted during summer months.

Self-reported sedentary behavior. Time spent in sedentary behaviors was measured using the Adolescent Sedentary Activity Questionnaire,[21] which has good reliability and face

Table 2. Descriptive characteristics of sample

	Grade 6		Grade 8		Grade 10	
	Boys Mean (±SE)	Girls Mean (±SE)	Boys Mean (±SE)	Girls Mean (±SE)	Boys Mean (±SE)	Girls Mean (±SE)
Participants (*n*)	483	496	408	393	555	415
Age (years)	11.4 (0.01)	11.3 (0.01)	13.5 (0.02)	13.4 (0.02)	15.4 (0.02)	15.4 (0.02)
Overweight/obese (%)	30.8	23.5	26.2	22.3	26.0	17.4
English-speaking (%)	87.0	87.0	85.0	89.0	85.0	83.0
Sedentary behavior (hours/day)	4.9 (0.1)	4.7 (0.1)	6.0 (0.12)	5.8 (0.12)	6.5 (0.1)	6.4 (0.1)
SSR (hours/day)	2.8 (0.1)	2.2 (0.1)	3.2 (0.1)	2.8 (0.1)	3.4 (0.1)	2.8 (0.1)
CRE (laps)	35 (1)	26 (1)	50 (1)	35 (1)	64 (1)	35 (1)
Adequate fitness (%)[a]	59.6	75.1	65.0	75.2	66.5	62.9
MVPA (minutes/day)	124.3 (3.2)	99.2 (2.3)	132.8 (4.0)	104.1 (3.2)	119.1 (3.2)	90.9 (3.4)

[a]Age- and gender-adjusted criterion-referenced standards, FITNESSGRAM, Cooper Institute for Aerobic Research, 1999
CRE, cardiorespiratory endurance; MVPA, moderate-to-vigorous physical activity; SSR, small-screen recreation

validity. Students reported the time they usually spent engaged in a range of sedentary activities, before and after school, separately for each day of the week and each weekend day (Table 1). Hours per day were calculated separately for total sedentary behavior and SSR.

Analysis

For the analysis, time spent in sedentary behavior and SSR were categorized into quintiles based on hours per day. Analyses were conducted separately for boys and girls in each grade, using SAS version 9.1 during 2008. As distributions of the outcome variable (CRE) were skewed, summaries are presented as unadjusted medians and interquartile ranges. Inferential analyses were conducted on log-transformed data because the log transformation resulted in approximately symmetric distributions of CRE. Analyses were adjusted for BMI status (not overweight/obese and overweight/obese); SES (low, medium, and high); language background (English-speaking background and non-English-speaking background); and time spent in MVPA (summarized by quintiles). Analyses were conducted using the SURVEYREG procedure to allow for stratification by education sector and for clustering within

Table 3. Median laps (interquartile range: IQR) by quintiles of sedentary behavior (hours/day) and small-screen recreation (hours/day)

	Quintiles (hours/day)					*p* value for trend[a]
	1 (lowest)	2	3	4	5 (highest)	
BOYS						
Sedentary behavior (hours/day)						
Grade 6						
Quintile range	0.0–2.6	2.7–3.7	3.8–5.1	5.2–7.11	7.2–11.4	
Median laps (IQR)	33.0 (20.5–48.0)	33.0 (22.0–45.0)	27.0 (18.0–51.0)	31.0 (20.0–49.0)	27.5 (20.0–43.0)	0.1
Grade 8						
Quintile range	0.7–3.7	3.8–5.1	5.2–6.4	6.5–8.0	8.1–11.4	
Median laps (IQR)	57.0 (42.0–70.0)	52.0 (35.0–64.0)	50.0 (34.0–62.0)	48.0 (30.0–62.0)	42.0 (25.5–62.5)	0.03
Grade 10						
Quintile range	0.9–4.4	4.5–5.7	5.8–6.9	7.0–8.5	8.6–11.4	
Median laps (IQR)	73.0 (52.0–85.0)	63.5 (52.0–81.0)	61.0 (46.0–76.0)	58.0 (44.0–72.0)	62.0 (45.0–76.0)	0.1
Small-screen recreation (hours/day)						
Grade 6						
Quintile range	0.0–1.1	1.2–2.0	2.1–2.9	3.0–4.4	4.5–9.6	
Median laps (IQR)	30.0 (19.0–48.5)	33.0 (22.0–50.0)	33.0 (22.0–48.0)	29.0 (20.0–48.0)	26.0 (16.5–42.0)	0.05
Grade 8						
Quintile range	0.2–1.7	1.8–2.5	2.6–3.3	3.4–4.5	4.6–8.8	
Median laps (IQR)	58.0 (41.5–72.0)	52.0 (36.0–70.0)	44.0 (33.0–62.0)	50.5 (27.0–62.0)	42.0 (26.0–62.0)	0.009
Grade 10						
Quintile range	0.3–1.8	1.9–2.7	2.8–3.7	3.8–4.7	4.8–9.9	
Median laps (IQR)	72.0 (53.0–84.0)	66.0 (52.0–85.0)	62.0 (38.0–74.0)	61.5 (46.0–74.5)	58.5 (46.0–76.0)	0.4
GIRLS						
Sedentary behavior (hours/day)						
Grade 6						
Quintile range	0.7–2.6	2.7–3.7	3.8–5.0	5.1–6.6	6.7–11.1	
Median laps (IQR)	24.0 (17.0–34.0)	24.0 (16.0–31.0)	24.0 (16.0–33.0)	24.0 (17.0–31.0)	20.5 (16.0–26.5)	0.1
Grade 8						
Quintile range	0.9–3.7	3.8–4.9	5.0–6.3	6.4–7.8	7.9–11.4	
Median laps (IQR)	38.0 (24.5–50.5)	33.5 (24.0–45.0)	38.5 (24.0–51.0)	27.0 (22.0–40.0)	26.0 (18.5–39.0)	0.005
Grade 10						
Quintile range	1.0–4.2	4.3–5.4	5.5–6.8	6.9–8.4	8.5–11.4	
Median laps (IQR)	40.0 (27.0–52.0)	33.0 (22.0–47.0)	33.0 (20.0–45.0)	33.0 (23.0–40.0)	24.0 (16.0–37.0)	0.03
Small-screen recreation (hours/day)						
Grade 6						
Quintile range	0.0–0.9	1.0–1.4	1.5–2.2	2.3–3.4	3.5–8.1	
Median laps (IQR)	25.0 (17.0–34.0)	24.0 (17.0–33.0)	23.0 (17.0–33.0)	22.5 (12.0–28.0)	20.5 (16.0–26.5)	0.05
Grade 8						
Quintile range	0.0–1.4	1.5–2.1	2.2–2.9	3.0–4.0	4.1–8.4	
Median laps (IQR)	41.0 (25.0–52.0)	39.5 (27.0–50.5)	33.0 (24.0–42.0)	26.0 (19.0–42.0)	24.0 (18.0–34.5)	0.002
Grade 10						
Quintile range	0.3–1.3	1.4–2.1	2.2–2.9	3.0–4.1	4.2–8.9	
Median laps (IQR)	42.0 (28.0–55.0)	36.0 (27.0–45.0)	31.5 (20.0–47.0)	33.0 (22.0–42.0)	21.0 (16.0–34.0)	<0.0001

[a]Adjusted for physical activity, BMI, language background, and SES

school class. Pearson correlation coefficients were calculated separately for gender and grade.

Receiver operating characteristic (ROC) curves were developed to determine the SSR cut point indicative of risk of low CRE. ROC curves are a graphic means of estimating a cut point for a screening test that maximizes the rate of true positives (sensitivity) while minimizing the rate of false positives (1 − specificity).[22] The area under the curve is used to measure whether the values of the curve are significantly better than chance at predicting the presence of disease.

Results

The sample consisted of 2750 students (Grade 6, n=979; Grade 8, n=801; and Grade 10, n=970). The participation levels for Grades 6, 8, and 10 were 72%, 63%, and 50%, respectively. Descriptive characteristics of the students are summarized in Table 2. Students in Grades 6, 8, and 10, respectively, spent approximately 4.8, 5.9, and 6.5 hours per day engaged in sedentary behavior and 2.5, 3.0, and 3.2 hours per day engaged in SSR. Partial correlations between sedentary behavior, SSR, and CRE were low (−0.23, −0.06).

Associations Among CRE, Sedentary Behaviors, and SSR

Table 3 shows the median number of laps completed by students for quintiles of time spent engaged in sedentary behavior (hours/day) and SSR (hours/day) adjusted for physical activity, BMI status, SES, and language background and stratified by grade, for boys and girls separately.

Boys

All sedentary behaviors. Among Grade 6 and 10 boys, there was no evidence that the median number of laps completed differed across quintiles of sedentary behavior (p=0.1 for both grades). Among Grade 8 boys, there was moderate evidence that fewer laps were completed across consecutive quintiles (p=0.03), with boys in the highest quintile completing 26% fewer laps than boys in the lowest quintile.

Small-screen recreation. There was some evidence that Grade 6 boys completed fewer laps across quintiles (p=0.05). Among Grade 8 boys, there was strong evidence that fewer laps were completed across quintiles of SSR. Boys in the highest quintile completed 28% fewer laps than boys in the lowest quintile (p=0.009). Although Grade 10 boys completed fewer laps for each consecutive quintile of SSR, there was no evidence of a difference between groups (p=0.4).

Girls

All sedentary behaviors. The median number of laps completed by Grade 6 girls did not differ across quintiles of sedentary behavior (p=0.3). There was moderate evidence that Grade 8 (p=0.005) and 10 girls (p=0.03) in the highest quintiles of sedentary behavior completed fewer (32% and 40%, respectively) laps than girls in the lowest quintiles.

Small-screen recreation. There was some evidence that Grade 6 girls completed fewer laps across quintiles of SSR (p=0.05). Among Grade 8 and 10 girls, there was strong evidence that fewer laps were completed across consecutive quintiles (p=0.002 and <0.0001, respectively) Girls in the highest quintiles of SSR completed 42% and 50% fewer laps than girls in the lowest quintiles.

Associations Between CRE and SSR Guidelines

The median number of laps completed by SSR guidelines (i.e., <2 hours/day vs ≥2 hours/day) are shown in Table 4. Among Grade 6 and 10 boys and Grade 6 girls, there was no evidence that the number of laps completed differed according to the SSR category (p=0.1 and 0.07, respectively). Boys in Grade 8 who spent ≥2 hours/day on SSR completed 16% fewer laps than boys who spent <2 hours/day on SSR (p=0.003). Among Grade 8 and 10 girls, there was strong evidence that girls who spent ≥2 hours/day on SSR completed fewer laps (34% and 26%, respectively) than girls who spent <2 hours/day on SSR (p<0.0004 and p=0.007, respectively).

The ROC curves in Figure 1 show that curves for boys and girls lie to the left of the chance line (p<0.001). For boys and girls, the areas under the curve were 59% (SE=0.02 [95% CI=0.54%, 0.63%]) and 66% (SE=0.02 [95% CI=0.62%, 0.71%]), respectively. The 2-hour/day cut point for SSR had high sensitivity (boys: 84% [95% CI=79%, 87%]; girls: 79% [95% CI=74%, 84%]) and low specificity (boys: 28% [95% CI=24%, 32%]; girls: 42% [95% CI=38%, 46%]).

Table 4. Median laps (interquartile range) by small-screen recreation guideline

	Small-screen recreation		
	<2 hours/day	≥2 hours/day	p value[a]
Boys			
Grade 6	33.0 (19.0–48.0)	29.0 (20.0–45.0)	0.1
Grade 8	55.0 (41.0–71.0)	46.0 (32.0–62.0)	0.003
Grade 10	72.5 (54.0–84.0)	62.0 (46.0–62.0)	0.2
Girls			
Grade 6	24.0 (17.0–33.0)	22.0 (15.0–28.0)	0.07
Grade 8	41.5 (27.5–52.0)	27.0 (20.0–41.0)	0.0004
Grade 10	39.0 (27.0–51.0)	29.0 (19.0–42.0)	0.007

[a]Adjusted for physical activity, BMI, language background, and SES

Discussion

The findings from this study indicate that health-related fitness did not differ consistently across quintiles of sedentariness and SSR among boys. However, among girls there was a consistent inverse association between total sedentary behavior and SSR in each grade. Although there was a significant association between SSR and fitness in Grade 6 and 8 boys, the association was not significant among older boys in this study. Boys experience an adolescent growth spurt in peak VO_2, which maximizes near the time of peak height velocity (PHV).[23] Therefore, it is plausible that by Grade 10 boys have experienced their PHV and may have developed sufficient muscle mass to enable them to maintain fitness in parallel with large amounts of sedentary behaviors: they can "sit but be fit."

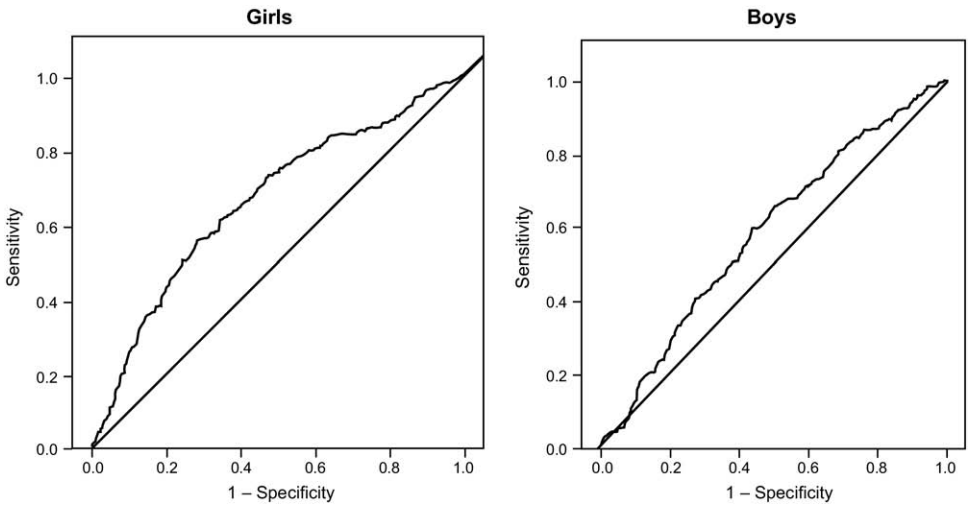

Figure 1. ROC curves for time spent in small-screen recreation (SSR) among girls and boys
Note: Diagonal segments are produced by ties.

These findings differ from previous research,[8,9,24,25] which shows no association between fitness and TV viewing. In contrast to these studies, this study was based on a large representative sample of students who reported on a range of SSR (not only TV viewing) for each day of the week. Different methods for assessing CRE may also have influenced findings.

The association between fitness and total sedentariness, not only SSR, was also examined in this study, and the results suggest a significant inverse association between sedentariness and CRE, particularly among adolescent girls. Unfortunately, the current study design prevents determining whether less-fit girls are more sedentary, or whether sedentariness leads to low fitness. Longitudinal studies are required to determine the direction of the association.

This study was the first to use ROC curves to examine the SSR guideline against a component of health-related fitness. The results showed that 2 hours/day of SSR has high sensitivity, indicating it was the optimal cut point to identify when young people are at risk of low CRE. This finding is important for two reasons. First, low CRE is strongly associated with the clustering of CVD risk factors among young people.[26] Second, the guideline was based on concerns about the ability of media programs to influence children's perceptions and behaviors (i.e., violence, aggression, sexuality, body image, nutrition, and obesity)[11,12] rather than on evidence of a direct health-related outcome.

The main strengths of this study were to examine the associations among a range of sedentary behaviors, in addition to SSR and CRE, among young people and to use ROC analysis to assess the efficacy of the 2-hour/day cut point for SSR. Further, this study was conducted among a large sample of randomly selected adolescents using a reliable questionnaire. The cross-sectional study design is limited in its ability to explain causal associations, and although the 20 mMST is an objective measure, it may be affected by factors such as maturation, which was not assessed in this study, temperature, time of day, and motivation.[27]

This study provides health-related evidence to support the recommended guideline that young people spend less than 2 hours/day on SSR. The findings suggest CRE was lower among the more sedentary adolescents and those who are high SSR users. However, further research, particularly longitudinal studies, is needed to understand the health-related effects of sedentariness among young people.

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