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Screen Smart: Evaluation of a Brief School Facilitated and Family Focused Intervention to Encourage Children to Manage Their Screen-Time

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Abstract

Background: Screen-time (ST) has been associated with child health. We designed a brief intervention (Screen Smart) based on social cognitive theory that targeted children and their parents to raise awareness of and support management of recreational screen-time. Key components were: 3 brief school lessons, a 10-day 'homework' passport, a one day turn-it-off challenge and two weeks of follow-up tracking. Our purpose was to examine the impact of Screen Smart on children's knowledge, self-efficacy, and outcome expectancies, ST goals, ST, Physical Activity (PA) and sedentary time.

Methods: We used mixed methods and randomly assigned 12 schools to Screen Smart or Usual Practice and recruited Grade 4 and 5 children. We used The Physical Activity Questionnaire for Older Children (PAQ-C) and accelerometers to measure PA and sedentary time and questionnaires assessed demographics, household environment (access and limits), knowledge, self-efficacy, outcome expectancies, ST and PA. We used Repeated Measures ANOVA to assess differences between groups over time and analyzed Passport entries qualitatively.

Results: 368 children (mean age 9.8 years, S.D.=.585; 167 boys, 201 girls) consented. Screen-time knowledge and awareness of guidelines increased significantly (F=9.14, p=.002) and self-reported TV time decreased (F=4.07, p=.05) in the intervention condition. Screen Smart children absorbed key messages. Self-efficacy, outcome expectancies, ST goals didn't change and both self-reported and measured PA decreased significantly in both groups over time. Home screen access increased significantly while ST limits didn't change. Conversely, accelerometry showed that the intervention group became less physically active on weekends (F=9.51, p=.002). Seasonal reductions in organized sport and outdoor activity participation may have contributed.

Conclusion: A brief school-facilitated ST intervention focused on students and families to enhance ST management had a modest impact on knowledge and self-reported TV time but not on computer use, gaming or physical activity. Enhanced dose may be required to change these behaviors.

Keywords: Sedentary Behavior; Screen-Time; Child Obesity; School-Based Intervention

Introduction

Canadian youth are increasingly inactive, 50% of male and 68% of females (12-19 years of age) are considered inactive (expending less than the equivalent of 60 minutes of brisk walking per day) based on self-report data [1]. Critically, time spent on screen-based behaviors is significantly associated with inactivity even when controlling for socio-demographic and other variables [1]. The Canadian Society for Exercise Physiology (CESP) recommends that children over 2 years of age spend less than two hours per day using screens [2], yet on average Canadian youth spend 7.8 hours with screens per day [3].

This high rate of inactivity and time spent using screens is problematic because increased screen-time is associated with increased BMI and more unhealthful dietary profiles in youth [4,5]. Research has shown that overweight and obesity were lowest in children that watched less than one hour of television per day and highest among those that watched four or more hours per day [6]. In fact, during youth, overweight and obesity is more strongly correlated to time spent with screens than to physical activity levels [7,8]. Considering that nearly a third of Canadian youth are overweight or obese [8] effective interventions to reduce sedentary time, including screen-time, are a public health priority.

Although the literature on screen-time interventions was limited, school-based interventions were successful at reducing screen-time and BMI in youth [9-14]. Further, research on school-based comprehensive PA interventions highlighted the importance of engaging the family [15,16]. To the best of our knowledge there were no published studies on family-focused screen time interventions and thus the Coalition for Action on Childhood Obesity (CACO) developed Screen Smart, a family-based intervention that was facilitated through the school and targeted children aged 5-12 years.

The purpose of this study was to assess the efficacy of the newly developed Screen Smart intervention. Specifically the aim was to examine the effect of Screen Smart on: knowledge about and awareness of screens, self-efficacy and outcome expectancy beliefs, goals and the amount of screen-time, physical activity and sedentary time accumulated weekly by older elementary school children (Grades 4-5/children 8-11 years of age).

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Methods

We used a mixed methods concurrent triangulation design and prioritized the quantitative data to address the primary aim of the study and related research questions. We collected qualitative information from the children to support the findings of the quantitative data [17]. Within this mixed methods design our quantitative data was collected using a randomized comparison design with baseline and follow-up measurement in Screen Smart and Usual Practice schools.

Recruitment

We obtained ethical approval for the study from the University of Victoria Ethics Review Board and from five school districts on Vancouver Island and the Lower Mainland of BC where we were approved to recruit schools and students. Based on a small to moderate effect 0.3 and 80% power we needed 175 children per group (intervention and comparison condition). Based on previous school studies we estimated a 50% response rate and class sizes of approximately 30 [16]. To achieve this we needed a minimum of 24 classes to agree to participate.

Recruitment of schools was carried out by email, fax and phone follow-up to Principals and orientation visits with teachers. Following the orientation visits twelve schools (n=25 Grade 4/5 classes) agreed to participate and were randomized to intervention or usual practice using a randomization website www.random.org. Teachers handed out consent forms to children to take home for parents to read and sign and collected them for the research team prior to data collection. One school dropped out leaving 6 intervention and 5 usual practice schools.

Sample

Three hundred and sixty-eight students consented to complete questionnaires (RR=61%). Two hundred and seventeen children were in intervention schools and 151 in usual practice schools. Parents of intervention and control groups had similar education (82.9% intervention and 85.4% control parents had some post-secondary education; χ^2=6.106, p=.296) and income levels (mean income category of \$50,000-\$74,999 for both groups; χ^2=2.841, p=.585).The mean age of students was 9.8 years (S.D=59; Range=8-11); 201 girls and 167 boys, representing 68.3% of eligible girls and 58.9% of eligible boys in the consented classrooms. Three hundred and fifty-two students were measured at baseline (7 found the questionnaires too difficult to complete, 8 were absent and 1 withdrew) and 314 were measured at follow-up (6 found the questionnaires too difficult to complete, 25 were absent, 5 additional students withdrew (n=6) and one intervention school (n=17) could not be booked for follow-up).

All three hundred and sixty-eight children were invited to wear accelerometers, with 2 declining and one withdrawing during baseline measurement. Of the three hundred and sixty-five children who agreed to wear an accelerometer, 295 (intervention n=174, control n=121) had 3 or more valid days of wear time at baseline (7 were absent, 57 had less than 3 monitored days and 6 accelerometers malfunctioned). At follow-up, two hundred and fifteen children (intervention n=110, control n=105) had 3 or more valid days of wear time (3 participants declined, 33 were absent, 98 had less than 3 monitored days, 2 accelerometers malfunctioned and one intervention school (n=17) could not be booked for follow-up).

Intervention

Screen Smart is a school facilitated, family focused intervention for Canadian elementary school aged children (children in grades K-7) developed by the Coalition for Action on Childhood Obesity (CACO) through funding from the Canadian Partnership Against Cancer. The aims of the intervention were to: a) raise children's awareness of screen-time and knowledge about the associated risks of, and guidelines for screen-time, b) to increase children's self-efficacy, outcome expectancies, and change screen-use goals, and c) to decrease the amount of recreational screen-time and increase the amount of physical activity outside of school.

Screen Smart (SS) is based on social cognitive theory (SCT [18];) and targeted children, schools and parents to address the reciprocal relationship between person and environmental determinants of health behavior. Personal and environmental determinants include among others: knowledge, incentives, self-regulatory capabilities and socio-structural supports [18]. SCT involves preparing children with the skills and self-efficacy so that they can self-regulate and manage the pressures they face in their different interpersonal relationships [18]. Based on a systematic review by Bruvold [19] Bandura suggested that practicing self-regulation was related to successful health behavior change [18]. Specifically, school and homework activities targeted: i) awareness (exploring the role of screens, frequency of screen use and their home screen environment), ii) knowledge of screen-time guidelines, iii) outcome expectancies - the impact of screens on them personally (e.g. students discussed the good things and bad things about both screens and the good things about alternative choices), iv) self-efficacy (students set goals to trade 30 minutes of screens for other activities and tracked their success as well as participating in a one day turn it off day and reflecting on their experience) and v) family support (by engaging the parents in the homework activities). The key components of the two week intervention included a) a 10 day take-home passport that engaged children and their families in screen-time homework activities (e.g. students assessed their home screen environment, designed their own Trade 30 cards, set small goals for trading screen-time with other activities, parents initialed each activity), b) classroom activities to support the passport (teachers asked for the passport to be turned in each day, introduced/prepared the students for the home-based activities and checked on how it went, provided stickers for completion and implemented three classroom lessons), c) a turn-it off 'awareness' day, where students tried going without screens to raise their awareness of their own use and to experience reducing screen-time, and d) two weeks of tracking screen-time goals set by the children at the end of the passport phase (teachers asked for the tracking sheets which were designed to be displayed on refrigerators at home to be returned each week).

Instruments

Parents (84.5% female and 15.5% male parents or guardians) completed a survey asking them for general demographic information and about the screen limits they imposed on their children. No differences in weekly or weekday screen limits were found between male and female parent/guardian reports (p>.05). Children completed Screen Smart Passports during school time and as take-home exercises. Children completed all other questionnaires during school hours in small groups with the assistance of a team of research assistants.

Passports: Quantitative information about the intervention dose and qualitative information about student goals and knowledge was collected from the passports. The number of passports turned in and passport homework activities completed and signed by the parents were tracked and summarized to assess dose. The proportion of their day spent with screens on Day 1 and Day 10 of the passport and number of goals set and achieved were also analyzed. Finally, the response to the Day 10 question asking "The most important thing I learned in Screen Smart was…?" was reviewed, coded and categorized.

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Knowledge: We measured knowledge using a series of true and false (n=4) and multiple choice questions (n=2) developed specifically to test the key messages in the Screen Smart lessons and passport. One of the key questions asked students to identify the Canadian guideline for screen-time. Correct answers were summed to obtain a total knowledge score (0=low knowledge, 6=highest knowledge score).In addition, we used an open-ended question at the end of the Passport that asked students to indicate the most important thing they had learned. We conducted content analysis and categorized the responses.

Attitudes and motivations: We measured self-efficacy for limiting screen-time using a modified questionnaire validated with a similar age group (Grade 6 children) by Jago et al. [20]. We combined all types of screens used using the term screen-time rather than having items that addressed each individually. (E.g. TV and computer). The self-efficacy score was calculated with values ranging from 1 (low self-efficacy) to 8 (high self-efficacy) Jago et al. [20] reported that each of the items discriminated between screen-time self-efficacy using item response theory and the uni-dimensionality of the scales was supported. However, the full scales were more valid in explaining sedentary behavior and light activity in boys than girls. The averaged Flesch-Kincaid reading grade level (Microsoft Corporation, Redmond, VA) was 3.8 for items in this instrument.

In addition, we measured outcome expectancies and goals (wanting and planning to use screens) related to screen-time behaviors ('TV' included watching TV, videos and DVDs, 'Computer' included using the computer in general and for internet and video games) and physical activity ('PA') using modified (simplified language) sub-scales of an instrument developed for adults and validated by Rhodes and Blanchard [21]. We measured their outcome expectancy beliefs about how fun, enjoyable, good for you and smart to do TV, computer/video games and PA. The Flesch-Kincaid (Microsoft Corporation, Redmond, VA) average reading level for the outcome expectancy belief items was Grade 5.7 and for goals items was Grade 5.8. Scale reliabilities for outcome expectancies and goals are presented in Table 1.

Screen-time: We measured screen-time using a validated screen-time 7-day recall developed by He et al. [22] to determine self-reported screen time (television time, game time, computer time and total screen time) among children in Grades 5 and 6.

Environment: access to and limits on screens: We measured access to screens as an environmental measure. We asked the students four questions about number of household TVs (0-5+), game systems and (0-5+) computers (0-5+) and presence of TV or computer in bedroom (0=no, 1=yes). The scores on the four questions were summed to create a total access score with the highest access score of 12.

	Baseline			Follow-up
Variable	**n**	**Cronbach's Alpha**	**n**	**Cronbach's Alpha**
Affective OE - TV	341	.816	312	.836
Affective OE - Computer	342	.851	314	.834
Affective OE - PA	340	.840	313	.823
Instrumental OE - TV	340	.718	313	.771
Instrumental OE - Computer	340	.697	313	.764
Instrumental OE - PA	342	.771	313	.829
Goals - TV	340	.714	314	.753
Goals - Computer	341	.747	313	.778
Goals - PA	341	.794	312	.791

OE = Outcome expectancy

Table 1: Scale Reliabilities.

We measured limits on screen-time by asking children about how much total TV/ computer/ game time their parents or guardians limited them to on weekdays and weekends using ordinal scales (1=30 minutes or less/day, 2=1 hour, 3=2 hours, 4 hours and 5=No limits). Concurrent validity was assessed comparing to parent reports of limits. Correlations with parent reported weekday limits were r^s=.417, p<.0001 and with parent weekend limits were r^s=329, p<.0001. Furthermore, when access and rules were entered into a regression model to examine predictive validity, the model significantly predicted weekly screen-use levels (R=.392, F=27.01, p<.0001); explaining 15% of the variance. Limits/rules were the significant predictor (β=.377, t=6.886, p<.0001) in that model.

Physical activity and sedentary time: We measured physical activity and sedentary time using GT1M ActiGraph activity monitors (ActiGraph LLC, Florida) and a 15 second epoch length that was then converted to 60 second bouts. A research assistant distributed accelerometers to children at their schools and provided instructions on how to wear it correctly. Accelerometers were on an elastic belt and worn at the hip. Participants were asked to wear the accelerometer during waking hours for 6 consecutive days both before and after the intervention period, and to take it off only when they slept, bathed, showered or swam. Children were also given a log sheet so that they, or their parents, could record the time the accelerometer was put on and taken off each day.

We downloaded the data from the accelerometers and screened each file for spurious data points (e.g. extremely high values representing monitor saturation) and patterns (e.g. extended periods of the same count value). We included all accelerometer files with at least 3 monitored days of 10 or more hours/day in our analysis.We used age-specific cut points to classify the PA into the intensity categories of interest (sedentary and MVPA) for daily (overall, weekday, weekend and for the 3 pm to 8 pm window of time after school) wear [23]. We used Kinesoft software version 3.3.63 (Saskatoon, Canada) to extract the minutes for each category. PA was categorized as MVPA if it was equal to or greater than 3.0 METs and sedentary behavior if it was less than 1.5 METS. (<1.5 METs).

We also measured physical activity using the Physical Activity Questionnaire for Older Children and included a question about organized sport. A physical activity summary score (PA score) was calculated with values ranging from 1 (low activity) to 5 (very active). This instrument was validated for children in this age group [24].

Analysis

We used Predictive Analytics Software (PASW; v20.0, Chicago, IL) to conduct the quantitative analyses. We generated descriptives for all variables and used one-way analysis of variance to determine if there were baseline differences between groups on interval measures. We used chi-square test of association to determine if ordinal measures such as gender and education were significantly associated with group at baseline. To assess differences in outcomes between baseline and follow-up we used Generalized Linear Model repeated measures that adjust for baseline differences. We established the significance level at p <0.05 and when significant time-by-group effects were found, we conducted related samples t-tests to identify where significant changes occurred. In the case of ordinal and categorical data we used Chi-square test of association to determine if the proportion of responses was associated with group membership. We entered qualitative data from the Passport verbatim into Excel V. 14.3.8 and then coded text units grouping them into like categories and generating relevant category labels.

Results

At baseline the sample of children was achieving more than 2 hours per day of directly measured MVPA (Table 2). Conversely the accelerometers also showed that they spent just over 8 hours/day sedentary. Self-reported screen-time was also just below the Canadian maximum guideline of 2 hours per day and 69.1% of the children reported household screen-time limits of 2 hours or less per day (28.7% reported 30 minutes or less) while another 25.2% reported having no limits.

There were significant differences between intervention and controls at baseline for a number of variables depicted in Table 2. The control group had lower self-efficacy, higher knowledge; and higher outcome expectancies and goals for both TV and computer. As well, the control group accumulated less accelerometer measured MVPA and more sedentary time. However, the self-reported time spent doing sedentary activities and the PA score were similar between groups at baseline and a similar proportion of children reported participation in organized sport (67.5% of the intervention group and 76.6% of the control group; χ^2=3.286, p=.070. Data not shown).

	Intervention	Control	F	p
	Mean (SD)	Mean (SD)		
Attitudes, Motivation, Knowledge (score range)				
Self-efficacy (1-8)	5.31 (2.29)	4.62 (2.25)	7.70	.006
Knowledge (0-6)	3.87 (1.24)	4.20 (1.25)	5.53	.019
Affective OE – TV (2-10)	6.56 (1.88)	7.52 (1.75)	22.50	.000
Affective OE – Computer (2-10)	6.60 (2.18)	7.53 (1.79)	16.97	.000
Affective OE – PA (2-10)	8.91 (1.69)	8.81 (1.59)	.30	.587
Instrumental OE – TV (2-10)	3.82 (1.67)	3.91 (1.61)	.22	.642
Instrumental OE – Computer (2-10)	4.05 (1.80)	4.25 (1.61)	1.12	.291
Instrumental OE – PA (2-10)	9.29 (1.55)	9.36 (1.25)	.21	.644
Goals – TV (2-10)	5.03 (1.98)	5.77 (1.90)	11.83	.001
Goals – Computer (2-10)	5.20 (2.18)	6.12 (1.90)	16.02	.000
Goals – PA (2-10)	8.75 (1.81)	8.47 (1.81)	1.96	.163
Access (0-12)	4.93 (2.09)	4.63 (2.03)	1.83	.177
Physical Activity (units)				
Self-reported (PAQ)				
PA score	3.20 (.69)	3.21 (.69)	.02	.897
Accelerometer:				
Overall MVPA (min/d)	136.19 (34.57)	126.81 (42.80)	4.10	.044
Weekday MVPA (min/d)	137.52 (34.31)	131.85 (42.44)	1.52	.218
Weekend MVPA (min/d)	132.31 (52.25)	119.41 (52.18)	3.59	.059
After school MVPA (min/d)	53.42 (19.12)	54.13 (23.80)	.08	.785
Sedentary activity (units)				
Self-reported				
Television time (hrs/wk)	7.34 (7.26)	6.70 (5.65)	.71	.400
Game time (hrs/wk)	2.77 (4.00)	3.34 (4.56)	1.39	.240
Computer time (hrs/wk)	3.35 (4.67)	3.26 (4.26)	.03	.864
Total screen (hrs/wk)	13.61 (11.30)	13.20 (9.71)	.11	.739
Accelerometer				
Overall Sedentary time (min/d)	504.90 (57.20)	530.54 (71.13)	8.91	.003
Weekday Sedentary time (min/d)	515.91 (62.27)	538.33 (76.77)	7.25	.008
Weekend Sedentary time (min/d)	476.22 (84.17)	508.63 (78.68)	9.25	.003
After school Sedentary time (min/d)	188.17 (37.61)	189.08 (29.79)	.05	.827
Accelerometer wear time (hrs/d)	12.74 (.80)	12.84 (.81)	.98	.324

Total screen time = TV + Game + Computer
OE = Outcome expectancy

Table 2: Differences in variables between intervention and usual practice groups at baseline.

Changes in outcome variables over time

Knowledge: Knowledge increased significantly over time (F=10.483, p<.002) and there was a significant group by time interaction (Table 3); with the intervention condition increasing significantly (t (172)=-5.02, p<.0001) while the controls stayed the same (t(116)=-.068, p=.946).

In addition, when the qualitative data from the knowledge question in the passport was analyzed it was evident that the core concepts of the intervention were learned: trading thirty minutes for something active, the benefits and costs of screen-time and the guidelines for healthy screen-use. There was also evidence that the 'experience' of trying to change had an impact on self-efficacy (both positive and negative). The following categories (ordered most related comments to least) and illustrate the key messages:

- Do more – physical activity (n=45 comments)
- sub-theme: PA is fun, more important, better for you
- Do less of screens and more PA (trade/balance) (n=39 comments)
- Do less - screen time (n=29 comments)
- sub-theme: Screens are bad for you, not as fun
- Awareness (n=17 comments)
- sub-theme: Health
- sub-theme: Self (habits)
- I know the 'limits' now (n=8 comments)
- Change is hard (n=4 comments)
- Change is easy (n=1 comments)

Attitudes and motivation: Self-efficacy (confidence in their ability to go without screens) did not change significantly over time nor was there a significant group effect. Similarly, no significant effects were seen for outcome expectancies or goal orientation for TV, Computer or PA between groups over time. As illustrated by the qualitative data the efficacy response to the intervention wasn't consistently positive.

Environment: The students reported significantly greater access to screens over time in both groups (F=16.83 p<.0001) but this did not differ by group. There were no significant differences in reported screen-time limits over time or by group (data not shown).

Screen-time: There was a significant interaction effect for weekly hours of TV time reported (Table 3) with the intervention group significantly decreasing self-reported screen time by just over 1 hour per week (t (172)=2.64 p=.009). No significant time or group effects for weekly hours of video game or computer time were found.

Analysis of their 'time charts' in the passport at the beginning and end of the intervention showed that children reported: 83.7(51.1) minutes/day of screen time at baseline and 68.3(52.1) minutes/day at follow-up (t (122)=2.90 p=.004). Fifty-one percent of the children decreased their screen time while another forty-nine percent didn't change or increased.

Physical activity and sedentary levels – directly measured: Sixty-nine percent of the children (range 41%-89% across schools) had usable data with 74% returning their logs filled in properly. Overall MVPA was significantly higher in the Screen Smart group at baseline (Table 2) and all MVPA measures decreased between baseline and follow-up in both

Variable	Baseline	Follow-up	F	p
	Mean (SD)	Mean (SD)		
Attitudes, Motivation, Knowledge (score range)				
Self-efficacy (1-8)	I – 5.45 (2.24) C – 4.59 (2.25)	I – 5.11 (2.45) C – 4.52 (2.30)	1.08	.301
Knowledge (0-6)	I - 3.90 (1.24) C - 4.19 (1.20)	I - 4.42 (1.27) C - 4.20 (1.39)	9.14	.002
Affective OE – TV (2-10)	I – 6.57 (1.88) C – 7.57 (1.63)	I – 6.31 (1.92) C – 7.08 (1.98)	.95	.331
Affective OE – Computer (2-10)	I – 6.50 (2.17) C – 7.56 (1.71)	I – 6.25 (2.01) C - 7.11 (2.03)	.81	.368
Affective OE – PA (2-10)	I – 8.98 (1.54) C – 8.80 (1.59)	I – 9.01 (1.53) C – 8.65 (1.76)	1.14	.287
Instrumental OE – TV (2-10)	I – 3.83 (1.69) C - 3.96 (1.63)	I – 3.62 (1.61) C - 3.76 (1.53)	.00	.947
Instrumental OE – Computer (2-10)	I – 4.02 (1.76) C – 4.29 (1.62)	I - 3.71 (1.66) C – 3.96 (1.61)	.00	.924
Instrumental OE – PA (2-10)	I – 9.42 (1.32) C – 9.39 (1.22)	I – 9.39 (1.57) C – 9.38 (1.18)	.00	.918
Goals – TV (2-10)	I – 5.02 (2.01) C – 5.78 (1.86	I – 5.21 (2.04) C – 5.58 (2.15)	2.50	.115
Goals – Computer (2-10)	I – 5.19 (2.21) C – 6.13 (1.92)	I - 5.38 (2.26) C - 5.91 (2.08)	2.54	.112
Goals – PA (2-10)	I – 8.87 (1.66) C - 8.42 (1.81)	I – 8.77 (1.64) C - 8.37 (1.86)	.08	.779
Access (0-12)	I – 4.87 (2.11) C – 4.63 (2.04)	I – 5.08 (2.23) C - 5.05 (2.10)	2.17	.142
Limits-Child (weekday plus weekend)	I - 3.85 (2.69) C – 3.97 (2.62)	I – 4.10 (2.53) C – 4.02 (2.62)	1.42	.233
Physical Activity (units)				
PA score	I - 3.17 (.70) C - 3.19 (.68)	I - 3.05 (.64) C - 3.10 (.71)	.33	.567
Accelerometer:				
Overall MVPA (min/d)	I- 137.6 (36.2) C- 127.6 (43.6)	I- 128.2 (34.2) C- 125.7 (38.7)	3.22	.074
Weekday MVPA (min/d)	I- 139.1 (35.7) C- 131.7 (43.2)	I- 134.6 (36.7) C- 127.4 (39.8)	.00	.967
Weekend MVPA (min/d)	I- 137.2 (57.6) C- 122.2 (57.0)	I- 115.0 (45.9) C- 119.2 (46.6)	5.75	.018
After school MVPA (min/d)	I- 55.3 (20.0) C- 53.3 (23.1)	I- 49.9 (19.55) C- 47.1 (18.1)	.10	.750
Sedentary activity (units)				
Self-reported:				
Television time (hrs/wk)	I - 7.48 (7.49) C – 6.90 (5.72)	I - 6.32 (5.84) C- 7.11 (6.41)	4.07	.05
Game time (hrs/wk)	I - 2.83 (4.15) C - 3.42 (4.71)	I - 2.61 (4.47) C - 3.17 (4.39)	.00	.954
Computer time (hrs/wk)	I - 3.52 (4.84) C - 3.25 (4.32)	I - 2.90 (4.39) C - 3.02 (3.92)	.67	.413
Total screen time (hrs/wk)	I – 14.00 (11.61) C - 13.35 (9.92)	I - 11.90 (9.67) C - 13.23 (9.20)	3.20	.075
Accelerometer				
Overall Sedentary time (min/d)	I- 506.8 (56.0) C- 528.4 (66.2)	I- 510.6 (57.4) C- 522.4 (64.3)	1.83	.177
Weekday Sedentary time (min/d)	I- 517.4 (56.1) C- 541.5 (75.2)	I- 515.2 (59.0) C- 534.9 (68.4)	.32	.571
Weekend Sedentary time (min/d)	I- 480.3 (90.8) C- 507.4 (76.6)	I- 508.6 (81.3) C- 492.0 (79.4)	9.51	.002
After school Sedentary time (min/d)	I- 187.6 (31.2) C- 191.8 (29.9)	I- 191.3 (31.4) C- 196.6 (29.5)	.07	.794
Accelerometer wear time (hrs/d)	I – 12.73 (.74) C – 12.88 (.78)	I – 12.61 (.85) C – 12.79 (.89)	.10	.754

Total screen time=TV+Game+Computer, OE: Outcome Expectancy

Table 3: Group effects for key outcome variables over time (baseline to follow-up).

groups. The only group difference at follow-up was for weekend MVPA (Table 3), which decreased in the intervention students (*t* (71)=4.44, p <.001) but remained unchanged in the control students (*t* (69)=.469, p=.641).

Overall, weekday and weekend sedentary times were significantly lower in the SS group at baseline (Table 2) and no changes were seen across time for either group. At follow-up, however the intervention group saw an increase in weekend sedentary time (*t* (79)=-2.66, p=.010) and the control group no change (*t* (69)=1.68, p=.102). After school sedentary time increased in both groups between baseline and follow-up but no group differences were seen.

Weekend accelerometer wear time was higher in the control group at baseline (12.4 (1.1) versus 12.1 (1.1) hrs/d; F=4.02, p=.046) and did not change over time but was different by group (F(140)=3.90, p=.050). Post hoc analysis showed that weekend wear time did not change for the intervention group (from 12.2 (1.0) to 12.2 (.8) hours/d; *t* (71)=-.52, p=.605)) but the control group decreased from baseline to follow-up (from 12.5 (1.0) to 12.1 (1.1) hours/day; *t* (69)=2.29, p=.025). (Data not shown.)

Physical activity levels - self-reported: PA scores in both groups decreased significantly over time (F (307)=11.56, p=.001) but this was not significantly different by condition. More of the control students participated in organized sport at baseline (Table 2). As well, change in participation in organized sport was significantly associated with condition (X^2=10.63, p=.005). 11% of the Screen Smart students decreased their participation in organized sport over time versus 2% of the control students. Further analysis revealed that while the total number of self-reported active outdoors session per week decreased in both groups (Outdoor activity sessions per week: intervention 18.9 to 13.8, control 21.0 to 18.4, F(278)=36.5, p <.001:), the decline was significantly more in the intervention group (F(278)=3.83, p=.05) (Table 3).

Dose: One hundred and forty Passports were handed in from 223 children (63% response rate). Of those passports returned, 61% had 90% of their passport days initialled by parents and 30% had no parent initials. As well, 74% had 90% of their Screen Smart stamps from the teacher (11% didn't collect any stamps). Seventy-seven percent of students reported on the screen-time management goals they set with 44% reporting meeting three goals, 26% meeting two goals and 7% reporting meeting one goal.

Discussion

The purpose of the project was to evaluate the short-term impact of a school-facilitated but family focused intervention to help children manage their screen-time (Screen Smart). The intervention approach and measurement were theory-based, designed to involve parents and the home environment and to enhance implementation feasibility in the schools (focused on families, reduced time commitment by schools). The impact of the intervention varied across outcome measures. Screen Smart had an impact on knowledge and self-reported TV time but no impact on computer or gaming time, self-efficacy, outcome expectancies, goals, screen-time limits or on self-reported or directly measured physical activity and sedentary time. We discuss the results in the context of the literature and study limitations following.

Knowledge, awareness and beliefs

Screen Smart was a relatively brief single-focus intervention compared to other school interventions that had an impact on screen-time or BMI. Planet Health [25], Just Do It [26] and Kiel Obesity prevention trials [12] all embedded screen-time reduction goals and educational strategies within broader more comprehensive interventions. The most comparable interventions were SMART [10,13] and Planet Health [25], both of which were based on social cognitive theory. These interventions were more comprehensive and delivered a greater intervention dose than Screen Smart. They were implemented over extended time periods; with Planet Health teachers implementing 33 lessons over 2 years and SMART teachers implementing 18 lessons over 6 months. The Planet Health intervention included one lesson where students planned a 2-week "Power Down" event which could be considered comparable in dose.

We showed that a brief intervention could have a short-term impact on knowledge and awareness. This finding is positive and likely reflects the orientation of the three classroom lessons and Passport content. Several activities; a) assessment of personal screen-time and the home screen environment; b) discussions of the positive and negative impacts of screen-time; and c) discussions of goals and reflections on facilitators and barriers to change, all target knowledge and awareness. Most of the interventions we found in the literature [9-12,26]; incorporated information and activities to enhance knowledge and motivation and used SCT concepts, but none reported on changes in knowledge and awareness of screen use and screen-time guidelines as an outcome. Nor did they measure some of the theoretically derived (SCT) mediators of behavior change (self-efficacy, outcome expectancies, goals, etc.). Our brief intervention did not shift self-efficacy, outcome expectancies or goal orientation to screen use. This may once again reflect the minimal dose of intervention. It may be that there were too few activities that provided authentic mastery experiences. In fact our qualitative data showed that some students reported learning that it was hard to change.

Environment

A majority of children in our study reported having household screen-time rules. This differed from a US national survey that showed 61% of all children over 8 years of age didn't have rules about TV time [27]. Our intervention targeted parents through the homework in the Passport but the only measure that could reflect changes in the family/household environment was child-reported screen access and screen-time limits. Interestingly, both the intervention and comparison children reported increases in screen access at follow-up. It may be that the baseline measurement sensitized the children to the presence of screens in their house or, in the case of the intervention condition, that the children became more aware of the screens through the intervention activities. If parental awareness went up you might expect some changes in limits for their children but we didn't see this. Although, over 70% of our sample reported having limits and most limits met the Canadian guidelines for healthy screen use at baseline.

The SMART intervention in contrast focused substantially on changing the environment in the home. Their intervention included budgeting screen time, reducing physical access to screen equipment, a TV monitoring device and four newsletters. They also provided a 'guideline' or 'goal' for participants of 7 hours or less per week. Theirs was the first intervention to measure and show an impact on other members of the family.

Screen-time

The average screen-use in our study was just under 2 hours per day (approximately 13.5 hours/week not including screens used in schools). This is a quarter of the average found in a representative sample of Canadian youth but that data addressed screen use across the whole day [3]. Interestingly about 51% of youth in the Canadian study spent more than the current guideline of 2 hours while less than half (46%) of our cohort failed to meet the guideline at baseline. Self-reported time spent watching TV decreased after the Screen Smart intervention. This finding is similar to other school-based research [9,13]. Conversely gaming and computer use did not change in our study while in the SMART intervention study, Robinson and Borzekowski found significant differences in weekday and weekend gaming [13]. There were some important differences between the two studies however. Although both were based on social cognitive theory, incorporated mastery experiences and motivating lesson activities, Robinson and Borzekowski's intervention was a) longer and more intense (18 lessons, 6 months, involved TV monitoring devices in the home and other strategies), b) the target cohort was younger, c) displacing screen-time with other activities like PA was not included and d) parental reports of screen time were used to measure screen-time. They also didn't include computer use in their approach suggesting that reducing computer use may be even more complex than addressing TV, videos and video games because of the cross-over with educational uses. As well, the opportunity for mastery experiences during the Screen Smart intervention was limited (goal setting and tracking and 1 day power down) whereas in the SMART study the turn-it-off event was much longer and supported by home-based monitoring, incentives and follow-up.

Physical Activity and Sedentary Time

The level of MVPA was comparable to other studies of children where similar cut points were used [28-30] but considerably higher when compared to studies employing stricter cut-points [31,32]. This is to be expected as the choice of cut-points dramatically affects MVPA [33].

The PAQ-C score and directly measured overall, weekday, weekend and after school MVPA all decreased in both intervention and control groups. With baseline measures in September/October and follow up measures in November/December, it is likely that seasonality contributed to these decreases. At baseline the weather was both warmer (8.9 ± 1.7°C versus 4.0 ± 3.8°C; $p=.004$) and drier (2.1± 2.0 versus 7.8 ± 6.5 mm precipitation; $p=.014$) [34], with more daylight hours (10.4 versus 8.8 hrs; $p <.001$) [35] compared to follow-up. This could have resulted in more time spent outdoors which has been positively related to children's physical activity [36]. Furthermore work by several researchers has shown that MVPA was lowest in winter when compared to other seasons [37]; that youth were more physically active on warmer days and on days with no rain and that day length was also associated with PA [38,39].

The only group difference observed in directly measured PA was the significant decrease in weekend MVPA (and concomitant increase in sedentary time) in the intervention group. This is hard to explain as accelerometers do not provide the information needed to assess type and context [40]. Screen-time didn't increase so this may not make a substantial difference to sedentary time. This finding may also relate to seasonal changes in organized sport participation as a greater proportion of the children in Screen Smart reduced their activities and research has shown children enrolled in organized sport have higher PA levels [41].

Overall, weekday and weekend sedentary time did not change from baseline to follow-up and after school sedentary time increased in both groups overtime. This may also be a function of seasonality. Concomitant with the decrease in MVPA levels, weekend sedentary time did increase significantly in the Screen Smart group. Sedentary time has been shown to be affected by monitor wear time [42]. In our analysis weekend wear time was significantly different by group and showed more variability than weekday wear time, especially in the intervention group. With accelerometer it can be difficult to accurately estimate sedentary time when wear time does not precisely reflect awake time. With 10 hours of wear time considered the minimum for a valid day and most children awake considerably longer than that, numerous hours of wear time may not be captured. With most of the non-wear time in the evenings, a time that many children spend in more sedentary pursuits, sedentary behavior may also be under represented.

With an average difference of an hour in television viewing time, it was hoped that this would be captured in the directly measured sedentary time. However, since screen time is only one of many possible sedentary activities and accelerometer wear time does not always reflect awake time, this was not the case.

Limitations

Our results need to be viewed in the context of a number of limitations. Some of which were outlined previously. First, it appeared that we had a biased sample. The number of children achieving both the physical activity and screen-time guideline and reporting screen-time limits was substantive. This may have lead to a ceiling effect where we couldn't effect change. In fact our teachers reported having to adjust their approach for those students that had very low daily screen use and limits and didn't need to 'Trade 30' (a key message in the materials).

In terms of measurement, three days of accelerometer monitoring may have been insufficient to capture habitual physical activity patterns with four considered a more acceptable minimum when assessing habitual physical and sedentary activity [43]. However, some researchers consider three days to be adequate in intervention studies and since our results were very similar when comparing 3 days versus four, we accepted the three-day minimum to maintain a better sample size (n=183 versus 144).We also utilized self-report and although the instruments had been validated with age groups similar to the children in our study others have cautioned that young children (under 10) are not able to reliably recall their behavior which may lead to over or underestimation [40,44,45].The averaged item by item reading level of most of our instruments (5/7) ranged from Grades 3.8 to 6.4 on the Flesch-Kincaid readability scale (Microsoft Corporation, Redmond, VA). We attempted to mitigate readability and comprehension issues by a) having at least two research staff and the teacher present to assist children with questionnaires and b) by testing the oldest children in the schools (study schools went up to Grade 5 and Grade 4/5 splits were common). As children's birthdays varied across the school year (some later, some earlier) some children were younger than 10 at the time of testing. Interestingly, the instrument with the lowest average item by item reading level (grade 3.8) was reported by our research staff as being the most difficult for the children to understand and required additional explanation. This may be because the Flesch-Kincaid score represents verbal content but not other factors that are known to influence comprehension like layout and presentation format [46].

Summary

Screen Smart children absorbed key messages about managing screen-time and decreased their TV viewing time. In light of the low levels of physical activity and high levels of screen-time in Canadian children a brief school facilitated family-focused intervention can be seen as an important piece of an overall strategy to decrease screen-time in children. It is likely that this type of intervention is more feasible to implement in the context of schools but more intensive interventions of longer duration appear necessary to facilitate greater change. In general, more research on screen-time interventions is needed. Future interventions and measurement tools need to address video gaming, computer use and other hand held screens.

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