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CROSS-SECTIONAL ANALYSIS

Association between Screen Time and Cardiometabolic Risk Factors and Academic Achievement among Children

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Abstract

Background: Excessive screen time has been associated with a deleterious impact on cardiometabolic health and academic achievement in children; however, the evidence supporting these effects depends on the type of electronic device.

Objective: To examine the association between the time spent watching television (TV) and using interactive electronic devices (computers, tablets, etc.) with cardiometabolic risk factors and academic achievement in school-aged children (8-11 years).

Methods/design: Cross-sectional analysis was conducted using baseline measurements from a cluster randomized trial conducted in children in the 4th and 5th grades of primary education from 10 schools in Cuenca Province, Castilla-La Mancha (Spain). Sociodemographic variables, academic achievements, cardiometabolic risk (CMR) indicators, blood pressure and biochemical determinations were measured. Additionally, screen time was measured as TV viewing, electronic device use and overall screen media use and categorized by exposure time as low (< 2 hours), medium (2-3 hours) or high (> 3 hours). Academic achievement was assessed using academic grades that could range from 0 to 10. ANCOVA analyses adjusted for age, SES and BMI, were used to assess differences in anthropometric variables, metabolic variables, and academic achievement across screen time categories by sex.

Results: A total of 560 children (51.96% girls) aged 8 to 11 years were examined. The mean total screen time (h/d) for boys was higher (3.89; 95% CI: 3.65-4.13) than that for girls (3.42; 95% CI: 3.21-3.63). For boys, those who watched TV for > 3 hours had worse mean differences than those in the lower categories of watching television in systolic blood pressure (SBP) in mmHg, (-4.09; 95% CI [-7.82, -0.37], p = 0.026), HDL-c levels in mg/dL (8.18; 95% CI [2.25, 14.11], p = 0.003), glucose levels in mg/dL (0.75; 95% CI [-0.86, 2.36], p = 0.79), metabolic syndrome indices in percentage (-3.79; 95% CI [-7.22, -0.35], p = 0.025), and glycated haemoglobin A1c levels in mg/dL (-0.09; 95% CI [-0.18,-0.00], p = 0.046). In addition, boys and girls in the highest category of TV viewing reported worse scores in mathematics (6.50 [SD 1.81] and 6.11 [SD 1.80], respectively) than their peers. When analysing these variables by use of electronic devices and total screen time, most of these relationships disappeared.

Conclusion: Our data show that watching TV is the dimension of screen time that is most consistently associated with increased cardiometabolic risk factors and lower academic performance.

Keywords

Television watching, TV viewing, Video games, Screen time, Electronic use, BMI, Children, Adiposity, Cardiovascular risk, Academic performance, Academic achievement, Mathematics and language

List of Abbreviations

BMI: Body Mass Index; CMR: Cardiometabolic Risk; HDL-c: High-Density Lipoprotein Cholesterol; LDL-c: Low-Density Lipoprotein Cholesterol; DBP: Diastolic Blood Pressure;

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DCCT: Diabetes Control and Complications Trial; IFCC: International Federation of Clinical Chemistry and Laboratory Medicine; FPG: Fasting Plasma Glucose; HbA1c: Glycated Hemoglobin A1c; HPLC: High-Performance Liquid Chromatography; MetS index: Metabolic Syndrome Index; PA: Physical Activity; SB: Sedentary Behaviors; SD: Standard Deviation; SBP: Systolic Blood Pressure; SES: Socioeconomic Status; TV: Television; WHO: World Health Organizatio

Introduction

Physical activity (PA)-related behaviours are mainly established during early childhood and tend to persist for a lifetime [1,2]. Physical activity has positive effects on cognitive function and academic outcomes and is also associated with adiposity in children and adolescents [3,4]. Despite the positive effect of PA on health [2], the World Health Organization (WHO) reports that most adolescents do not meet the PA recommendations. Furthermore, in the 2020 guidelines on PA and sedentary behaviour (SB), it is recommended that children and adolescents limit the time they spend in screen-based SB, but the cut off for limiting the use of screen media has not been clarified [4,5].

Screen-based SB has been related to poorer health outcomes and serious threats to children´s health [6-10]. In recent decades, the increased accessibility to digital media for studying and entertainment has increased opportunities for children to adopt SB by spending more time in front of screens [3]. Thus, screen time, especially television time (TV), is associated with lower fitness and worse cardiometabolic profile [11-13]. However, it has been suggested that not all screen time has the same influence on health outcomes, and distinguishing between some types of screen-based SB (such as doing homework or reading, which have been related to better academic achievement) and TV viewing has had mixed results [14]. In addition to the inherent negative effects of SB, the mechanisms behind the detrimental effect of screen-based SB and health outcomes include a reduction in time for active behaviours [15,16]. Regarding academic achievement, whereas PA has been associated with better academic performance [17], sedentary behaviours and screen time have been associated with lower cognition and academic achievement [18,19].

In recent years, cardiometabolic risk (CMR) factors in children (including increased blood pressure, obesity, hyperlipidemia, and insulin resistance) have been established essentially related to SB such as spending hours in front of screens and unhealthy diet [2]. Although cardiovascular disease does not represent a significant cause of death in children and adolescents, if it is between adults, causing an inflammatory disorder that damages and clogs arteries by formation of fatty plaques (atherosclerosis). The formation of these plaques can start during childhood and progress into adulthood [20].

The time children spend watching television, playing video games or surfing on the Internet contributes to the appearance of problems such as obesity [9,10,12-14]. These behaviors and CMR factors influence children's development [21,22] academic achievement and lifelong opportunities [12,17]. Given that CMR factors track from infancy through adolescence and into adulthood [14,21,22] and screen time is a potentially modifiable behaviour in childhood, there is a growing interest in examining the association between screen time and CMR factors [12,13,23,24] and the relationship between screen time and academic achievement in children [18,19].

Additionally, time spent using digital screens may be translated into less time performing PA, as well as worse dietary patterns and physiological health implications [2,9,12,13,25]. As a result, children who perform more SB have increased risks for overweight/obesity, cardiovascular diseases and related comorbidities than children who spend less time performing SB [24,26-29].

Therefore, the aim of this study was to examine the relationship between screen media use and cardiometabolic risk factors and academic achievement in boys and girls, using the data from a cluster randomized trial (NCT03236337) [30], distinguishing between TV viewing, electronic device use (personal computer, tablet, telephone…) and total screen media use.

Methods/Design

Study design and participants

This was a cross-sectional analysis of the baseline measurements of a cluster randomized trial aimed at assessing the effectiveness of the MOVI-daFit! intervention in CMR and cognitive function (NCT03236337) [30], approved by the Clinical Research Ethics Committee of the Hospital "Virgen de la Luz" in Cuenca. This trial involved children in the fourth and fifth grades of elementary school (8-11 years-old) at ten schools in Cuenca Province, Spain. Measurements were taken in September 2017 at the schools by evaluators who were previously trained to standardize the measurements.

Study variables and measurements

Anthropometric variables: Weight was measured using a scale (Seca 861) with each child wearing light clothing and barefoot. For height measurements, a wall stadiometer (Seca 222) was used with each child barefoot and standing upright with the sagittal midline touching the backboard. The child had to face forward, and their line of sight had to be parallel to the ground. The mean of the two weight and height estimates were used to calculate body mass index (BMI) = ((kg)/height $(m)^2$).

The waist circumference was considered the mean of three measurements using flexible tape at the midpoint between the last rib and the iliac crest at the end of normal exhalation.

Body fat percentage and fat-free mass were measured under controlled temperature and humidity conditions using an 8-electrode Tanita Segmental-418 bioimpedance analysis system (Tanita Corp., Tokyo, Japan) [31]. In addition, measurements were made before breakfast, after urination, and after a 15-minute resting period.

Cardiometabolic risk (CMR) variables:

Blood pressure: Systolic blood pressure (SBP), diastolic blood pressure (DBP) and heart rate were measured in a quiet place using an OMRON-M5-I device (Omron Healthcare UK Ltd.) [32] and the cuff size was used according to the child's arm circumference. We considered the mean of two measures separated by 5 minutes after a 5-minute resting period for the analysis.

Biochemical determinations: Blood samples were taken from the ulnar vein between 9 and 10 a.m. and after a 12-14 hour fasting period. Two aliquots of each sample were frozen for future determinations that could be of interest to the parents.

Lipid profile: Total cholesterol, high-density lipoprotein cholesterol (HDL-c), low-density lipoprotein cholesterol (LDL-c), and levels of triglycerides, glucose, insulin, glycated haemoglobin A1c (HbA1c) and C-reactive protein were determined. Lipid profile and fasting plasma glucose (FPG) measurements were performed using the Cobas 8000 Roche Diagnostics system. Insulin was measured with the Architect i2000 Abbot Diagnostic system. C-reactive protein was measured using the Cobas 6000 Roche Diagnostic system, and HbA1c was measured by high-performance liquid chromatography (HPLC) with the analyser ADAMS HA 8180V Menarini Diagnostic, which was standardized for the Diabetes Control and Complications Trial (DCCT), and the International Federation of Clinical Chemistry and Laboratory Medicine (IFCC). Finally, biochemical determinations allowed the estimation of insulin resistance using the HOMA model and the determination of the metabolic syndrome index (MetS index) [33]. The samples were refrigerated when they were extracted at a location more than 75 minutes away from the laboratory.

Academic achievement was assessed using academic grades in language and mathematics that could range from 0 to 10. Scores at the end of the 2016/17 school year, gathered from the school administration, were considered for these analyses.

Sexual maturation was reported by parents identifying their child's pubertal status on figures based on the Tanner stages [34,35].

Socioeconomic status (SES): A questionnaire to assess socioeconomic background (each parent' education and employment situation) was completed by parents.

Screen media use: Screen media use was assessed using an ad hoc questionnaire [13,14] in which parents reported the number of hours their children spent viewing TV or using electronic devices (personal computer, tablet, telephone…) on both weekdays and weekend days (no information was available on whether the computer screen time corresponded to homework or leisure activities). Eight response options were available for each item: no time, less than 1/2 h; 1/2 -1 h; 1 -2 h; 2 -3 h; 3 -4 h; 4 -5 h; and more than 5 h. The mean time of each answer was used to calculate the l daily total time for each type of screen media as follows: 1/7 × (2 × weekend day hours + 5 × weekday hours). The overall screen media use was calculated by summing the time spent viewing TV and using electronic devices.

Data analysis

Normal distribution of the variables was checked using both statistical (the Kolmogorov-Smirnov test) and graphical procedures (normal probability plots). After checking the truthfulness of the outliers and extreme values, we winsorized them using the 1st and 99th percentiles of the distribution of the variables, (winsorizing is used in statistics by limiting extreme values in the statistical data to reduce the effect of possibly spurious outliers). Before conducting the analyses and after considering the missing data at random or completely at random nature, we imputed the missing data using Markov Chain Monte Carlo equations [36].

Partial correlation coefficients were calculated to examine the relationship between anthropometric (age, BMI, body fat and waist circumference), metabolic (SBP, DBP, total cholesterol, LDL-c, HDL-c, triglycerides, glucose, C-reactive protein, and insulin), academic achievement (language and mathematics) and screen media variables.

ANCOVA was used to test differences in the mean cardiometabolic variables and academic achievement by categories (low, < 2 hours; medium, 2-3 hours; and high, > 3 hours) of screen media use, TV viewing, electronic device use and total screen media use, controlling for age, SES and BMI, by sex. The specific cut-offs to categorize screen time were chosen taking into account the recommendations of pediatric societies [10], where children aged 7-11 should not exceed 2 hours of screen time. In addition, we included the category of more than 3 hours to distinguish the association of academic achievement between those children who do not accomplish the recommendations and those exceeding screen times. Finally, the main results were checked

Table 1: Characteristics of the study sample.

Total (n = 560)	**Boys** (n = 269)	**Girls** (n = 291)	***P***
Age (years)	9.55 (0.75)	9.62 (0.70)	0.061
Tanner stage	1.60 (0.65)	1.64 (0.84)	0.600
Body mass index	18.34 (4.06)	18.19 (3.72)	0.672
Weight status			
Thinness	36; 13.4	45; 15.4	0.484
Normal weight	153; 56.9	165; 56.7	0.966
Overweight	58; 21.6	59; 20.3	0.708
Obesity	22;8.1	22; 7.6	0.786
Body fat	22.58 (7.19)	25.57 (6.50)	**< 0.001***
Waist circumference	66.77 (10.18)	65.38 (9.67)	0.048
Socio-economic status			
Very low/Low	64; 23.8	64; 29.9	0.613
Medium	136; 50.5	141; 48.5	0.619
High/Very High	69; 25.7	86; 29.6	0.302
Systolic blood pressure	99.97 (9.17)	97.84 (9.04)	**0.004***
Diastolic blood pressure	63.62 (6.42)	63.77 (6.45)	0.934
Total Cholesterol	160.11 (25.16)	161.34 (23.04)	
HDL Cholesterol	61.05 (13.82)	58.36 (12.66)	**0.018***
LDL Cholesterol	92.35 (22.00)	94.79 (20.13)	0.178
Triglycerides	66.46 (33.08)	74.68 (30.32)	**0.009***
Glucose	106.90 (3.44)	106.93 (3.31)	**0.012***
Insulin	7.61 (5.42)	8.53 (5.29)	0.105
Metabolic Syndrome Index	73.67 (8.22)	72.14 (7.44)	0.026
Glycated hemoglobin A1c	5.17 (0.21)	5.16 (0.22)	0.495
C-reactive protein	1.80 (2.50)	1.68 (2.19)	0.149
Language score	7.03 (1.76)	7.32 (1.67)	0.046
Mathematics score	6.98 (1.82)	6.82 (1.91)	0.303
TV viewing (h/w)	2.25 (1.08)	2.05 (1.09)	0.090
Electronic devices use (h/w)	1.63 (1.32)	1.38 (1.13)	**0.022***
Total screen media (h/w)	3.89 (1.98)	3.42 (1.80)	**0.008***

Notes: Data are presented as mean (SD), except for age, weight status and socioeconomic status which are shown as percentages (%) $p < 0.05$.

to observe whether they held true after modelling screen time as a continuous variable. The analyses were performed using IBM SPSS Statistics version 26.

Results

Table 1 displays the main characteristics of the study sample. A total of 560 children (291 girls, 51.96%), aged 8-11 years, were included in this study. Of them, 14.8% of the boys and 13.85% of the girls had overweight/obesity, and 13.3% of the boys and 15.4% of the girls had low weight. The mean total screen time by sex was 3.89 hours/day (h/d) (SD 1.98) for boys and 3.42 h/d (SD 1.80) for girls. For both sexes, significant differences were found in body fat, waist circumference, systolic blood pressure, HDL cholesterol, triglycerides, glucose, metabolic syndrome index, language scores, electronic devices use (h/w), and total screen media (h/w).

Table 2 shows Pearson correlation coefficients between screen time variables (TV viewing, electronic device use and total screen media use) and anthropometric variables, metabolic variables, and academic achievement by sex. In boys, total screen time was positively correlated ($p < 0.05$) with adiposity indicators (BMI, body fat and waist circumference), SBP in mmHg, MetS index and insulin levels in mg/dL and was negatively correlated with HDL-c in mg/dL and language and mathematics grades. In girls, age and insulin in mg/dL were positively correlated ($p < 0.01$, $p < 0.05$, respectively), and language grades were negatively correlated ($p < 0.05$) with total screen time. When we separately analysed TV and electronic devices, in both boys and girls, the amount of TV time was positively correlated with insulin levels in mg/dl and negatively correlated with language and mathematics grades.

Table 2: Pearson correlation coefficients (r) anthropometric variables, biochemical determinations, and academic achievement with of screen media use variables by sex.

	TV viewing (h/w)	Electronic device use (h/w)	Total screen media (h/w)
Boys	**n = 235**	**n = 244**	**n = 235**
Age (years)	-0.006	0.148*	0.102
Body mass index	0.178**	0.131*	0.183**
Body fat	0.149	0.094	0.151*
Waist circumference	0.166**	0.117	0.168*
Systolic blood pressure	0.175**	0.092	0.162*
Diastolic blood pressure	0.097	0.054	0.090
Total Cholesterol	-0.077	-0.032	-0.067
HDL Cholesterol	-0.211**	-0.077	-0.182**
LDL Cholesterol	0.011	-0.014	-0.000
Triglycerides	0.165*	0.065	0.125
Glucose	-0.026	0.003	-0.012
Insulin	0.145*	0.074	0.149*
Metabolic Syndrome Index	0.177*	0.118	0.177*
Glycated hemoglobin A1c	0.096	0.019	0.052
C-reactive protein	0.124	0.029	0.086
Language score	-0.134*	-0.095	-0.145*
Mathematics score	-0.180**	-0.106	-0.180**
Girls	**n = 264**	**n = 264**	**n = 260**
Age (years)	0.109	0.163**	0.193**
Body mass index	0.029	0.041	0.048
Body fat	0.027	0.012	0.026
Waist circumference	0.059	0.050	0.076
Systolic blood pressure	0.079	-0.033	0.027
Diastolic blood pressure	0.015	0.003	0.023
Total Cholesterol	0.018	0.040	0.034
HDL Cholesterol	-0.070	0.084	0.004
LDL Cholesterol	0.053	0.010	0.038
Triglycerides	0.037	-0.041	-0.012
Glucose	0.014	0.020	0.021
Insulin	0.137*	0.116	0.163*
Metabolic Syndrome Index	0.042	-0.058	0.004
Glycated hemoglobin A1c	-0.011	0.036	0.025
C-reactive protein	-0.104	-0.072	-0.102
Language score	-0.189**	-0.011	-0.143*
Mathematics score	-0.177*	0.003	-0.123

TV: Television; h: Hour; w: Week; Correlation is significant at the level: *p < 0.05; **p < 0.001

Moreover, time spent viewing TV was correlated with BMI, waist circumference, SBP in mmHg, HDL-cin mg/dL, triglycerides in mg/dL and MetS index in percentage in boys. The strength of the correlations was evaluated following Evans' guideline [37] where the absolute value of r is classified as "very weak" when 0.00-0.19; "weak" when 0.20-0.39; "moderate" when 0.40-0.59; "strong" when 0.60-0.79; and "very strong" when 0.80-1.0.

TV time

The mean differences in CMR factor levels and academic grades by category of time spent viewing TV by sex, controlling for age, SES and BMI, are presented in Table 3. It is worth noting that boys who viewed TV

Table 3: Mean (SD) in biochemical determinations and academic achievement by mean TV time categories h/d by sex, controlling for age, SES and BMI.

	TV time (h/d)			
	< 2	**2-3**	**> 3**	***p***
Boys	**n = 85**	**n = 90**	**n = 60**	
Systolic blood pressure	98.28[c] (8.03)	99.46 (10.36)	102.58[a] (9.74)	0.029
Diastolic blood pressure	62.94 (5.67)	63.23 (6.57)	64.44 (7.39)	0.448
Total Cholesterol	161.71 (26.47)	162.55 (27.22)	157.66 (20.51)	0.549
HDL Cholesterol	65.37[c] (14.87)	60.61 (13.31)	57.19[a] (11.75)	0.003
LDL Cholesterol	90.75 (23.79)	94.77 (23.07)	92.58 (18.54)	0.537
Triglycerides	57.47[b,c] (23.67)	70.71 (39.69)	72.50 (29.97)	0.010
Glucose	107.22 (0.00)	106.72[a] (4.31)	106.47[a] (5.28)	0.497
Insulin	6.49 (4.31)	8.25 (6.41)	8.53 (4.83)	0.049
Metabolic Syndrome Index	71.70[c] (6.59)	74.14 (8.45)	75.49[a] (8.73)	0.022
Glycated hemoglobin A1c	5.15[c] (0.20)	5.15[c] (0.21)	5.24[a,b] (0.21)	0.027
C-reactive protein	1.43 (1.48)	2.08 (3.24)	2.04 (2.95)	0.241
Language score	7.28 (1.66)	7.26 (1.77)	6.67 (1.68)	0.063
Mathematics score	7.40[c] (1.70)	7.19 (1.73)	6.50[a] (1.81)	0.008
Girls	**n = 127**	**n = 85**	**n = 52**	
Systolic blood pressure	97.15 (8.39)	98.80 (9.14)	97.90 (8.97)	0.408
Diastolic blood pressure	63.88 (6.04)	63.96 (6.88)	63.40 (6.82)	0.477
Total Cholesterol	160.33 (20.81)	162.33 (25.12)	163.72 (24.54)	0.674
HDL Cholesterol	59.44 (12.26)	57.74 (12.24)	56.83 (13.19)	0.429
LDL Cholesterol	93.01 (17.94)	95.90 (21.26)	98.47 (20.44)	0.268
Triglycerides	72.76 (28.87)	74.17 (29.71)	74.95 (31.22)	0.901
Glucose	106.87 (3.63)	106.74 (4.25)	107.22 (0.00)	0.750
Insulin	7.99 (4.43)	8.17 (5.32)	9.49 (5.08)	0.198
Metabolic Syndrome Index	71.81 (6.99)	72.09 (7.20)	72.61 (7.92)	0.847
Glycated Hemoglobin A1c	5.16 (0.23)	5.14 (0.20)	5.18 (0.22)	0.619
C-reactive protein	1.99 (2.79)	1.34 (1.46)	1.68 (1.86)	0.157
Language score	7.62[c] (1.59)	7.39[c] (1.57)	6.63[a,b] (1.83)	0.002
Mathematics score	7.15[c] (1.91)	6.90 (1.78)	6.11[a] (1.80)	0.005

SES: Socio-Economic Status; BMI: Body Mass Index; h: Hour; d: Day; n: sample size

Pairwise mean comparisons using the Bonferroni post hoc test were statistically significant except for superscript numbers: [a] = < 2 hours TV; [b] = > 2-3 hours TV; [c] = > 3 hours TV

for more than 3 h/d had significantly worse SBP in mm/Hg mean 102.58 (SD 9.74), HDL-c levels in mg/dL mean 57.19 (SD 11.75), triglycerides levels in mg/dL mean 72.50 (SD 29.97), MetS indices in percentage 75.49 (8.73) and HbA1c levels in mg/dL mean 5.24 (SD 0.21). Likewise, girls who viewed TV for more than 3 h/d had lower grades in language and mathematics (mean 6.63 (SD 1.83), mean 6.11 (SD 1.80), respectively) but did not significantly differ in CMR factor levels.

Electronic devices use

Overall, the use of electronic devices was not significantly related to the cardiometabolic profile, except for MetS index in percentage, mean 74.45 (SD 8.67) in boys and insulin mean in mg/dL 11.12 (SD 8.66) in girls. Additionally, the academic grades did not differ by categories of mean use time of these devices (Table 4).

Total screen media

In boys, significantly worse levels of MetS index were found (mean 74.98 [SD 8.62]), HDL-c (mean 59.22 [SD 13.05]), triglycerides (mean 70.99 [SD 34.48]), and insulin (mean 8.36 [SD 5.74]) in those who used screen media more than 3 h/d on average. Conversely, no significant differences were found in cardiometabolic parameters by categories of total mean use of screen media. There were no significant differences in the mean language and mathematics grades by mean time categories of screen use in either boys or girls (Table 5).

Finally, the main results remained consistent when screen time was analysed as a continuous variable.

Table 4: Mean (SD) in biochemical determinations and academic achievement by mean electronic devices use categories h/d by sex, controlling for age, SES and BMI.

	Electronic device use (h/d)			
	< 2	**2-3**	**> 3**	***p***
Boys	**n = 169**	**n = 44**	**n = 31**	
Systolic blood pressure	98.98 (9.36)	101.22 (8.37)	102.28 (8.86)	0.097
Diastolic blood pressure	63.08 (6.20)	64.49 (6.28)	64.34 (7.34)	0.312
Total Cholesterol	162.01 (26.08)	160.22 (21.62)	158.89 (23.72)	0.804
HDL Cholesterol	62.11 (13.70)	61.65 (14.55)	59.21 (13.62)	0.608
LDL Cholesterol	93.39 (22.95)	92.00 (19.55)	91.63 (20.90)	0.895
Triglycerides	64.15 (31.29)	70.75 (38.24)	68.37 (27.96)	0.491
Glucose	106.97 (3.08)	106.21 (6.14)	107.22 (0.00)	0.457
Insulin	7.20 (4.30)	8.03 (6.25)	8.06 (6.21)	0.526
Metabolic Syndrome Index	72.58[b] (7.27)	76.07[a] (9.10)	74.45 (8.67)	0.042
Glycated Hemoglobin A1c	5.16 (0.21)	5.13 (0.19)	5.21 (0.20)	0.302
C-reactive protein	1.82 (2.45)	1.44 (1.38)	2.27 (4.09)	0.442
Language score	7.18 (1.76)	7.31 (1.65)	6.38 (1.63)	0.050
Mathematics score	7.19 (1.75)	7.07 (1.90)	6.45 (1.62)	0.112
Girls	**n = 194**	**n = 43**	**n = 27**	
Systolic blood pressure	98.20 (8.71)	95.91 (8.18)	97.85 (8.94)	0.293
Diastolic blood pressure	63.87 (6.64)	63.26 (6.00)	64.46 (5.91)	0.743
Total Cholesterol	161.68 (22.23)	164.89 (22.66)	159.04 (28.75)	0.609
HDL Cholesterol	58.12 (12.66)	62.06 (12.99)	57.88 (12.95)	0.216
LDL Cholesterol	95.13 (19.44)	96.49 (18.34)	92.48 (24.30)	0.747
Triglycerides	73.54 (30.33)	72.43 (29.17)	75.22 (24.94)	0.939
Glucose	106.78 (4.05)	107.22 (0.00)	107.22 (0.00)	0.702
Insulin	8.06[c] (4.25)	7.72[c] (4.10)	11.12[a,b] (8.66)	0.014
Metabolic Syndrome Index	72.11 (7.47)	70.92 (5.85)	72.65 (7.89)	0.600
Glycated Hemoglobin A1c	5.15 (0.22)	5.14 (0.23)	5.22 (0.18)	0.331
C-reactive protein	1.74 (2.27)	1.47 (2.39)	1.73 (1.99)	0.805
Language score	7.45 (1.61)	7.21 (1.73)	7.22 (1.98)	0.612
Mathematics score	6.95 (1.83)	6.90 (2.12)	6.57 (1.93)	0.649

SES: Socio-Economic Status; BMI: Body Mass Index; h: Hour; d: Day; n: sample size

Pairwise mean comparisons using the Bonferroni post hoc test were statistically significant except for superscript numbers: [a] = < 2 hours TV; [b] = > 2-3 hours TV; [c] = > 3 hours TV

Table 5: Mean (SD) in biochemical determinations and academic achievement by mean total screens time categories h/d by sex, controlling for age, SES and BMI.

	Total screen time (h)			
	< 2	**2-3**	**> 3**	***p***
Boys	**n = 30**	**n = 52**	**n = 153**	
Systolic blood pressure	97.93 (9.10)	97.78 (9.17)	100.80 (9.23)	0.065
Diastolic blood pressure	63.10 (6.85)	62.38 (5.05)	63.81 (6.60)	0.358
Total Cholesterol	161.90 (28.25)	165.40 (26.46)	159.59 (24.22)	0.407
HDL Cholesterol	68.79[c] (15.47)	64.46 (13.36)	59.22[a] (13.05)	0.001
LDL Cholesterol	87.99 (26.09)	95.44 (23.47)	92.89 (20.97)	0.379
Triglycerides	58.75[c] (28.70)	58.91 (25.29)	70.99[a] (34.48)	0.009
Glucose	107.22 (0.00)	107.22 (0.00)	106.64 (4.63)	0.564
Insulin	5.17[c] (2.53)	6.53 (3.05)	8.36[a] (5.74)	0.003
Metabolic Syndrome Index	70.09[c] (5.74)	71.27[c] (5.85)	74.98[a,b] (8.62)	0.001

Glycated Hemoglobin A1c	5.17 (0.20)	5.18 (0.21)	5.17 (0.21)	0.981
C-reactive protein	1.86 (1.37)	1.90 (2.61)	1.69 (2.83)	0.606
Language score	7.14 (1.62)	7.17 (1.81)	7.04 (1.71)	0.515
Mathematics score	7.34 (1.59)	7.39 (1.88)	6.96 (1.75)	0.248
Girls	**n = 59**	**n = 65**	**n = 140**	
Systolic blood pressure	97.82 (9.10)	98.15 (9.04)	97.49 (8.36)	0.877
Diastolic blood pressure	64.07 (6.43)	64.68 (6.74)	63.34 (6.34)	0.370
Total Cholesterol	161.10 (21.82)	158.76 (19.90)	163.29 (24.73)	0.474
HDL Cholesterol	57.56 (12.36)	58.03 (12.89)	59.00 (12.44)	0.766
LDL Cholesterol	94.37 (19.74)	92.35 (15.75)	96.43 (21.39)	0.437
Triglycerides	77.63 (33.18)	71.48 (31.37)	73.20 (27.58)	0.567
Glucose	107.22 (0.00)	106.53 (5.08)	106.92 (3.33)	0.610
Insulin	8.92 (5.19)	7.46 (3.60)	8.54 (5.30)	0.279
Metabolic Syndrome Index	72.21 (7.72)	72.21 (7.29)	71.90 (7.14)	0.952
Glycated Hemoglobin A1c	5.17 (0.23)	5.18 (0.21)	5.14 (0.22)	0.466
C-reactive protein	2.06 (2.89)	1.82 (2.33)	1.53 (1.97)	0.370
Language score	7.64 (1.58)	7.60 (1.47)	7.15 (1.76)	0.079
Mathematics score	7.17 (2.03)	6.95 (1.79)	6.73 (1.86)	0.306

SES: Socio-Economic Status; BMI: Body Mass Index; h: Hour; n: sample size

Pairwise mean comparisons using the Bonferroni post hoc test were statistically significant except for superscript numbers: [a] = < 2 hours TV; [b] = > 2-3 hours TV; [c] = > 3 hours TV

Discussion

It has been suggested that not all screen time use by children has the same influence on health outcomes; thus, a distinction should be made between time spent viewing TV and devices that require more activity. This study aimed to examine the relationship between both types of screen media SBs and CMR and academic achievement by sex. Our data showed that boys spent more time on screen devices than girls and that children in the higher categories of TV viewing and total screen media use had worse SBP, MetS indices, and HDL-c, triglycerides, and HbA1c levels, especially among boys. Moreover, children in the higher categories of TV viewing had lower academic grades. Finally, although the cardiometabolic profile tended to be better for children who spent less time using screen media, the differences were not statistically significant.

Adiposity

In line with previous studies, the majority of children in our study exceeded the recommended screen time, with boys being more likely to exceed the mentioned recommendations [4,38-40]. Moreover, the evidence supports a positive association between screen time and adiposity [2,10,41] specifically, higher categories of TV viewing are associated with increased adiposity [42,43] although no effect on adiposity for each additional daily hour of screen time and for computer use/game time has been reported [44]. Furthermore, unhealthy dietary intake [45] has been associated with higher levels of screen time, including TV viewing; thus, it has been hypothesized that these unhealthy behaviours may explain the association between screen time and adiposity in adolescents and children [46]. In boys, our data show that total screen time and time spent viewing TV were positively correlated ($p < 0.05$) with adiposity indicators.

Lipid profile

Findings from this study were similar to those that showed that self-reported TV viewing was the screen-time variable most consistently associated with the worst cardiovascular outcomes in children [13]. Our data are in line with previously reported data on the association between screen time and lipid profiles [41,44-47] showing that children in the highest categories of TV viewing and total screen media had the worst HDL-c.

MetS index

In our study, total screen media negatively influenced cardiometabolic risk, as measured by the MetS index, with electronic devices (i.e., digital videos, video games and computers) playing the most important role, especially for boys. Fewer studies have examined the relationships of specific types of screen media use, including TV viewing, electronic devices, and total screen media use, to MetS index variables [13,19,21]. Our study reveals that TV viewing is the most influential type of media on the MetS index variables.

HbA1c levels

Higher screen time has been associated with Type 2

diabetes risk in adults, but this association is unclear in children. Our results show that boys who viewed TV for more than 3 h/d had significantly worse HbA1c levels; furthermore, electronic device use was negatively associated with insulin levels in girls, and total screen media use was negatively associated with insulin levels in boys. The impact of SB on insulin dynamics remains poorly understood in children and adolescents, but the reported association between screen time and insulin resistance suggests that reducing screen time could facilitate early insulin resistance prevention [48,49].

Academic achievement

A negative association between sedentary time, such as time in front of a screen, and cognitive function and academic performance in children has been reported [18,19]. Given the importance that SB has in a child's development, in their relationship with the environment and with academic achievement [14,16,25] it seems essential to determine the negative effects of time spent using screen media on a child's academic performance. Several mechanisms could explain the detrimental effect of TV on academic achievement. Some studies have reported that TV viewing replaces other activities such as socializing, homework, physical activity or sleeping [15], besides other hypothesis postulates that TV viewing can also reduce children's mental effort [16], which has a detrimental effect on academic performance. Although it has been suggested that the association of screen time with academic achievement depends on the type of screen analyzed [14,50] our data agree with previous studies showing a negative association of TV time with academic achievement [14,15,51] especially language and mathematics. In addition to these findings, our data show the worst academic achievement among children in the higher categories of TV viewing and total screen media use, for both sexes. By contrast, our data support that the time using other electronic devices was not directly associated with academic achievement.

Additionally, excessive screen time has been associated with higher energy intake, lower consumption of fruits and vegetables, higher consumption of saturated fat, and lower quality of nutrients, suggesting that screen time leads to higher intake caloric associated with junk food, which could be influenced by watching food advertisements during TV viewing [52,53].

These bad habits could explain lower lipid levels, elevated HbA1c levels, and increased adiposity. In addition, dietary patterns with low consumption of fruits, fish and vegetables, and high content of sweets, fast food and soft drinks, have been associated with lower academic performance [54,55]. In fact, two studies have examined the impact of diet, screen time and physical activity on academic performance, showing that adherence to diet and screen time recommendations are associated with increased academic performance [56,57]. However, the association between screen time and poor dietary choices, with a subsequent negative effect on academic achievement, remains unclarified.

This study has some limitations that should be stated. i) The screen media use data were self-reported; bias could have occurred when reporting these data. ii) We did not consider other health-related components in the analysis, such as eating and sleeping, which could have expanded the understanding of screen media use and its effects on academic achievement and CMR. iii) The cross-sectional design prevents us from making causal inferences; regardless, prospective studies should be implemented to clearly establish the temporality of these relationships and iv) No information was available on whether the computer screen time corresponded to homework or leisure activities, therefore the lack of association between computer screen time and academic achievement should cautiously be interpreted.

Conclusion

Overall, our data show that TV viewing was the dimension of screen time that most negatively influenced cardiometabolic risk in children. Moreover, our data suggest that excess TV time is associated with lower academic grades. Our data are important for their implications in terms of limiting children's non educational screen time because screen media use is a potentially modifiable factor in children that may have negative effects on both cardiometabolic risk and academic performance.

Competing Interests

None declared. All authors have completed the ICMJE uniform disclosure form at www.icmje.org/coi_disclosure.pdf and declare no support from any organization for the submitted work; no financial relationships with any organizations that might have an interest in the submitted work in the last three years; and no other relationships or activities that could appear to have influenced the submitted work.

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Contributors

CA-B and MH-L designed the study; VM-V was the principal investigator and guarantor; CA-B and MH-L were the main coordinators of the study; BN-P, CA-B, AR-T, VM-V and MEV-A conducted the study; MH-L, CA-B and VM-V provided statistical and epidemiological support; MH-L wrote the manuscript with the support of CA-B, BN-P and VM-V; All authors reviewed and approved the final version of the manuscript.

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