



Original Contribution

Teens and Screens: The Influence of Screen Time on Adiposity in Adolescents

Tracie A. Barnett*, Jennifer O'Loughlin, Catherine M. Sabiston, Igor Karp, Mathieu Bélanger, Andraea Van Hulst, and Marie Lambert

* Correspondence to Dr. Tracie A. Barnett, Centre de Recherche du CHU Sainte-Justine, Bureau A830, 3175 Ch. de la Côte-Sainte-Catherine, Montréal, Québec, Canada H3T 1C5 (e-mail: ta.barnett@umontreal.ca).

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The effect of screen time during secondary school on percent body fat was examined in a cohort of 744 Canadian adolescents aged 12–13 years at baseline. Participants completed self-reported questionnaires on television viewing and computer use in 19 survey cycles over 57 months from 1999 to 2005. Triceps skinfold thickness and subscapular skinfold thickness were measured in survey cycles 1 and 19. Four screen-time trajectory groups identified in growth mixture modeling included steady-low screen time (73% of the sample), steady-high (10%), increasers (9%), and decreasers (8%). The effect of screen-time trajectory on percent body fat at survey cycle 19 was modeled in boys and girls separately by using linear regression, adjusting for baseline percent body fat and physical activity. Relative to that of steady-low screen-time trajectory group boys, percent body fat was 2.9 (95% confidence interval: 0.7, 5.0) and 2.4 (95% confidence interval: 0.5, 4.2) percentage units higher on average among “increasers” and “steady-high” trajectory group boys, respectively. There was no evidence that screen time has an effect on percent body fat in girls overall, although physical activity modified the association between screen time and percent body fat in both sexes. Efforts to prevent obesity in youth should emphasize reducing screen time.

adiposity; adolescent; body composition; body mass index; exercise; longitudinal studies; sedentary lifestyle; television

Abbreviations: CI, confidence interval; MVPA, moderate-to-vigorous physical activity; Sum2SF, sum of the 2 skinfolds.

Overweight and obesity have become overwhelming public health and economic concerns. According to the 2005 Behavioral Risk Factor Surveillance System, 1 in 4 North American adults is obese with a body mass index in excess of 30 kg/m² (1). Given lack of evidence on the long-term efficacy of treatment programs (2), early prevention remains the most promising strategy to reduce the burden of overweight and obesity. However, the evidence base for developing effective prevention programs is limited by incomplete understanding of the natural course and determinants of overweight and obesity originating in youth (3). Although the causes are multifactorial and include environmental, biologic, and behavioral factors (4, 5), the surge in prevalence over the last 2 decades (6) suggests that the underpinnings of the current epidemic are likely not genetic (7). Given almost universal unlimited access to television, computers, the Internet, and video/digital video disk (DVD) technology, a highly

plausible determinant of overweight and obesity is sedentary behavior associated with screen time (8).

The association between television viewing and cardio-metabolic risk factors including abdominal obesity, diabetes, and metabolic syndrome is well established in adults (9–13). Similarly in youth, television viewing and, more generally, screen time have been linked to adiposity (14, 15), fitness (16), adverse lifestyle behaviors, and poor physical health status (17), as well as with adverse cardiometabolic risk (18–21). Nevertheless, reported associations between television viewing and body mass index in youth are weak (22, 23). Some researchers using percent body fat rather than body mass index as an indicator of adiposity report stronger associations with television viewing (24, 25).

Little is known about patterns of screen time in adolescents during secondary school. Furthermore, there is limited evidence of a causal link between screen time and the

development of overweight and obesity, since most studies are cross-sectional or limited to short (i.e., less than 2 years) follow-up periods that may not capture delayed or cumulative effects of screen-time on adiposity (26, 27). Increased understanding of screen-time patterns in adolescence and how specific screen-time patterns relate to adiposity may contribute to better informed prevention efforts. In this analysis, we describe screen-time trajectories of television viewing and computer use in a cohort of adolescents followed through secondary school. We then examine the effect of screen-time trajectory on percent body fat.

MATERIALS AND METHODS

Study population

Data were available in the Nicotine Dependence in Teens Study, a longitudinal cohort investigation of the natural course of nicotine dependence in youth (28). Students were recruited from all grade 7 classes in a convenience sample of 10 secondary schools in or near Montreal, Canada. Schools were selected to include a mix of French and English schools, urban, suburban, and rural schools, and schools located in high, medium, and low socioeconomic neighborhoods. All 13 schools approached agreed to participate; 3 schools were excluded, 2 because of a low return of consent forms and 1 because school administrators could not guarantee collaboration over the entire study period. All participants provided consent, and parents/guardians provided written informed consent. The institutional review boards at McGill University and the Centre de Recherche du Centre Hospitalier de l'Université de Montréal approved the study protocol.

Data were first collected in the fall of 1999 (i.e., survey cycle 1) in self-reported questionnaires administered in English or French according to the language of instruction in the school, either classroom by classroom or in the school cafeteria to groups of classes. Follow-up data were collected every 3 months each year during the 10-month school year for a total of 20 survey cycles. Over half (55.4%) of eligible students participated in the first survey cycle; approximately 94% of participants eligible for follow-up in each survey cycle completed questionnaires. Measures of height, weight, and triceps and subscapular skinfold thicknesses in survey cycles 1 and 19 were used in this analysis. A detailed description of the study design and data collection methods is available (28, 29). For the analyses reported here, we used data from the first 19 survey cycles, which covered 57 months of follow-up.

Study variables

Sociodemographic data included date of birth, sex, family status (i.e., 2 parents, other), number of siblings (0, ≥ 1), parents' level of education (1 or both parents university educated, neither parent university educated, missing).

Anthropometric measurements were taken by technicians trained according to a standardized protocol (30). Two measures of height to the nearest 0.1 cm, weight to the nearest 0.2 kg, and triceps and subscapular skinfold thicknesses to

the nearest 0.5 mm were obtained for each participant. If discrepancies greater than 0.5 cm for height, 0.2 kg for weight, or 1.0 mm for each skinfold thickness were observed between the 2 measures, a third measure was obtained. The average of the 2 closest measures was recorded. To assess interrater reliability, we obtained repeat measures for a systematic 1 in 10 subsample of students. Interrater reliabilities (split half coefficients) of 0.99, 0.99, 0.97, and 0.97 were observed for height, weight, triceps skinfold thickness, and subscapular skinfold thickness, respectively. Body mass index was computed as weight (kg)/height (m)². Participants were categorized as "overweight" if their body mass index exceeded 24 kg/m², which approximates the 85th percentile cutoff value for defining overweight in both boys and girls aged 16.5 years according to standard definition (31).

The dependent variable (percent body fat at survey cycle 19) was computed according to the method of Slaughter et al. (32): When the sum of the 2 skinfolds (Sum2SF) was 35 mm or less, percent body fat = 1.21 (Sum2SF) – 0.008 (Sum2SF)² – 1.7 in boys and 1.33 (Sum2SF) – 0.013 (Sum2SF)² – 2.5 in girls. When Sum2SF exceeded 35 mm, then percent body fat = 0.783 (Sum2SF) – 1.7 in boys and 0.546 (Sum2SF) + 9.7 in girls. Slaughter's equations have shown excellent reliability and very high validity in criterion validation studies (33) and are recommended for use in clinical settings (34).

Screen time was measured in survey cycles 1–19 in 4 items. For each of a "usual" weekday (Monday–Friday) and a "usual" weekend day (Saturday–Sunday), participants were asked to report the number of hours usually spent 1) watching television or video movies and 2) playing computer games or using the Internet. These were multiplied by 5 and 2, respectively, and then summed to obtain an estimate of the usual number of hours of screen time per 7-day week. Estimates of 1-week test-retest reliabilities for similar measures of self-reported hours of television viewing and computer use for week days and weekends range from 0.40 to 0.50 (35).

Physical activity was measured in each survey cycle in a 7-day recall based on the Weekly Activity Checklist (36) but adapted to reflect physical activities engaged in by Montreal youth. Specifically, participants reported, for each day of the preceding week, each activity that they had engaged in for at least 5 minutes outside of regular school gym class. The original instrument correlated with accelerometer data at $r = 0.34$, and the 2-week test-retest reliability of the adapted checklist was 0.73 (37). The adapted checklist also showed evidence of convergent-construct validity with energy intake (38). For this current analysis, only moderate and vigorous intensity activities were retained, defined as activities with an estimated energy cost of over 4 metabolic equivalent values (39); 26 of the 29 activities satisfied this criterion and were retained. For each of the 26 activities listed, the number of days in the 7-day period checked by participants were summed to create an indicator of weekly moderate-to-vigorous physical activity (MVPA). MVPA measured in survey cycles 1–19 was used to describe the average weekly MVPA over the 5-year study period for each participant. The median of overall MVPA was 12.9

(interquartile range, 7.7–18.3) activities per week in boys and 7.4 (interquartile range, 3.7–12.6) activities per week in girls. Participants were categorized as either “active” (at or above the sex-specific median value) or “inactive” (below the sex-specific median value).

Statistical analysis

Growth mixture modeling was applied to identify screen-time trajectory groups in boys and girls combined on the basis of the 19 measures of average weekly screen time through secondary school (40, 41). Growth mixture modeling estimates separate intercepts and slopes (i.e., “growth factors”) for groups of individuals with distinct patterns of the variable under study (42). Parameter estimates were obtained with maximum likelihood estimation by using the expectation-maximization algorithm. We began modeling with a 2-group unconditional linear growth model against which models with additional groups were tested. Although no limit was set on either the number of groups or growth factors, model fit indicators did not warrant considering more than 6 groups. Models with higher-order (i.e., quadratic, cubic) growth terms did not produce reliable solutions. Thus, candidate models were restricted to those with linear growth, allowing random effects on both the mean and variance of growth factors. Model selection was guided by indices of model fit and by model interpretability (43). Statistical criteria for model selection included the average posterior probabilities for each group, the entropy (range, 0–1), the Bayesian Information Criterion, the sample size-adjusted Bayesian Information Criterion, and the Vuong-Lo-Mendell-Rubin likelihood ratio test (44). We also set the minimum group prevalence at 5% because of the poor replicability of small groups. Participants were assigned to the group for which they had the highest estimated posterior probability. All models were estimated by using MPlus, version 4.1, software (45).

Linear regression was used to model the effect of screen-time trajectory on percent body fat at survey cycle 19 while adjusting for baseline percent body fat (and thereby implicitly also adjusting for prebaseline factors that influence percent body fat) and average MVPA over the study period, in sex-specific analyses. Furthermore, because there is evidence that the level of physical activity modifies the association between screen time and adiposity (46–50), the analyses were also stratified by physical activity status (i.e., physically active or physically inactive).

In secondary analyses, percent body fat at survey cycle 19 was dichotomized such that an identical number of participants were categorized as “overweight” (i.e., based on body mass index and where overweight includes obese) and “overfat” (i.e., based on percent body fat) within sex-specific strata. This was done to allow for the possibility of perfect agreement between overweight and overfat, since, unlike body mass index, there are no standardized cutpoints for categorizing adolescents according to excess percent body fat. Thus, if exactly one-quarter of boys were overweight on the basis of standardized body mass index cutpoints, then the percent body fat cutpoint was selected such that exactly one-quarter of boys would be in the “overfat

category.” These percent body fat cutpoints were 28% and 34% in boys and girls, respectively. Using polytomous logistic regression controlling for baseline percent body fat, we examined the effect of screen-time trajectory on the likelihood of being overweight only, overfat only, or both, at survey cycle 19. “Neither overweight nor overfat” was the reference category in these analyses.

Linear and logistic regression analyses were carried out in SAS, version 9.1, software (51).

RESULTS

Of 1,293 participants in the Nicotine Dependence in Teens Study, anthropometric data were available for 1,192 participants in survey cycle 1 (575 boys and 617 girls) and 801 participants in survey cycle 19 (389 boys and 412 girls). Anthropometric data were available for 756 participants in both survey cycles 1 and 19. The reasons for missing data included the following: absent on the day of measurement (11%); moved to a nonparticipating school (71%); dropped out of the study (17%); and other (1%). Twelve of the 756 participants were excluded because data on screen time were available for only 1 of the 5 study years, so that the analytical sample comprised 744 participants including 358 boys and 386 girls. Of these 744 participants, 81% lived in 2-parent households, 52% had at least 1 parent who was university educated, 6% had no siblings, and 14% were overweight at baseline. Participants not included ($n = 549$) were older on average, and fewer had university-educated mothers. Detailed descriptions of participant characteristics have been published previously (28).

A 4-group solution was optimal for classifying participants into distinct screen-time trajectory groups. Goodness-of-fit statistics improved with each additional group over the 2-group solution. The Vuong-Lo-Mendell-Rubin likelihood ratio test for $K - 1$ versus K groups indicated that the 4-group solution provided the best fit. Further, the 5-group solution yielded a group with fewer than 5% of the sample, and entropy declined slightly, indicating that classification was not improved.

On the basis of their overall appearance, the 4 screen-time trajectory groups were labeled as follows: 1) “steady-low” (73% of the sample), exhibiting the fewest screen-time hours in survey cycle 1 (24 hours/week) and displaying a slight decrease over time; 2) “steady-high” (10% of the sample), averaging the highest screen time (53 hours/week); 3) “increasers” (9% of the sample), averaging 28 hours/week at baseline and increasing by approximately 1 hour/survey cycle; and finally 4) “decreasers” (8% of the sample), reporting an average 55 hours/week in survey cycle 1 and decreasing by approximately 2 hours/survey cycle (Figure 1). At the end of the follow-up period, the average screen time of “decreasers” was similar to that of participants in the “steady-low” group, while the average screen time of “increasers” reached that of the average in the “steady-high” group. At 0.79, entropy of the model was high, and the average posterior probability across groups ranged from 0.75 to 0.92.

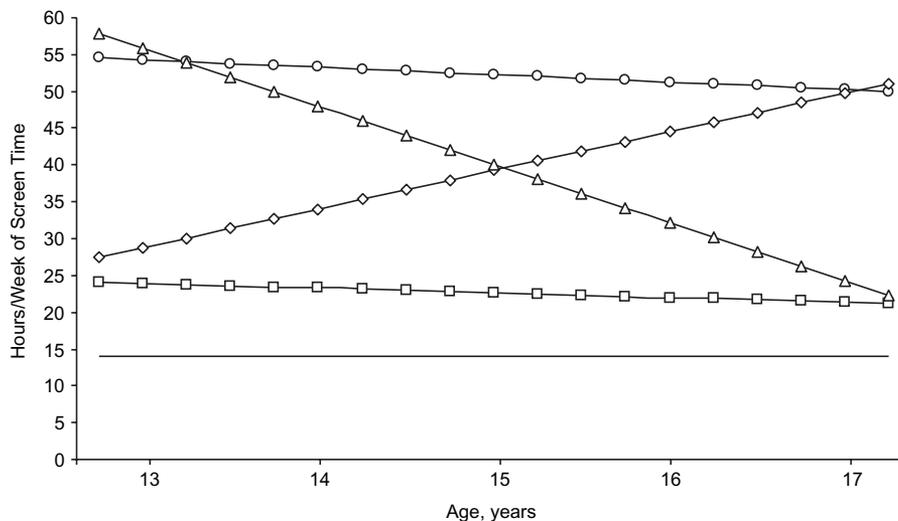


Figure 1. Screen-time trajectories in the Nicotine Dependence in Teens Study, Montreal, Canada, 1999–2005. □, steady-low (73%); ○, steady-high (10%); ◇, increasers (9%); △, decreasers (8%); and —, recommended.

There were statistically significant differences across trajectory groups in the distributions of sex, family status, and number of siblings but not in average MVPA (Table 1). Changes in body mass index and percent body fat over time are shown in Table 2. Estimated means and standard errors for skinfold thickness used in the equations are also shown. In boys, the average numbers of hours of television/video games and computer/Internet use per week over the 19 survey cycles were, respectively, 15 and 10 for “steady-low,” 32 and 26 for “steady-high,” 24 and 18 for “decreasers,” and 26 and 22 for “increasers.” Among girls, these were 14 and 7, respectively, for “steady-low,” 33 and 21 for “steady-high,” and 26 and 14 for both “decreasers” and “increasers.”

After controlling for baseline percent body fat, percent body fat was 2.9 (95% confidence interval (CI): 0.7, 5.0) percentage units higher on average among boys who were “increasers” than among boys in the “steady-low” refer-

ence group (Table 3). Similarly, percent body fat was 2.4 (95% CI: 0.5, 4.2) percentage units higher among “steady-high” than “steady-low” boys. Screen-time trajectory was not statistically significantly associated with percent body fat in girls overall.

The effect of “steady-high” or increasing screen time on percent body fat was apparent only among inactive boys (Table 3). In contrast, screen time was statistically significantly associated with percent body fat only among active girls. Specifically, physically active girls whose screen time decreased during follow-up had a lower percent body fat in survey cycle 19 than girls in the “steady-low” screen-time group ($\beta = -3.3$, 95% CI: $-6.8, 0.2$). Physically active girls whose screen time increased had a higher percent body fat in survey cycle 19 ($\beta = 3.0$, 95% CI: $-0.2, 6.2$).

In secondary analyses, participants were categorized according to excess weight and excess fat status. Distributions differed little by sex. In survey cycle 19, 69% of girls and

Table 1. Selected Characteristics of Study Participants by Screen-Time Trajectory Group, Nicotine Dependence in Teens Study, Montreal, Canada, 1999–2005

	Screen-Time Trajectory Group							
	Steady-Low (n = 548)		Steady-High (n = 73)		Increasers (n = 64)		Decreasers (n = 59)	
	%	Median No. Q1–Q3	%	Median No. Q1–Q3	%	Median No. Q1–Q3	%	Median No. Q1–Q3
Boys	42		70		56		71	
2-parent household	83		81		73		68	
Participant has no siblings	5		11		11		2	
Parent(s) university educated	55		38		45		37	
MVPA/week ^a								
Boys		13.6 (8.3–18.3)		12.8 (9.0–19.9)		11.1 (5.6–18.2)		12.3 (7.4–18.1)
Girls		7.4 (3.6–12.5)		10.4 (7.0–14.3)		6.9 (4.1–10.7)		6.9 (3.4–12.9)

Abbreviations: MVPA, moderate-to-vigorous physical activity; Q1–Q3, interquartile range.

^a Averaged over 19 survey cycles.

Table 2. Change in Adiposity Indicators Between Survey Cycles 1 and 19, by Screen-Time Trajectory Group, Nicotine Dependence in Teens Study, Montreal, Canada, 1999–2005

Sex and Trajectory Group	No.	Body Mass Index, ^a mean (SE)			Percent Body Fat, mean (SE)			Skinfold Thickness, ^b mean (SE)		
		Survey Cycle 1	Survey Cycle 19	Change	Survey Cycle 1	Survey Cycle 19	Change	Survey Cycle 1	Survey Cycle 19	Change
Boys	358									
Steady-low	229	19.7 (0.2)	22.5 (0.2)	2.8 (0.1)	19.8 (0.5)	23.3 (0.5)	3.5 (0.4)	22.1 (0.7)	26.5 (0.7)	4.4 (0.6)
Steady-high	51	20.0 (0.6)	23.1 (0.7)	3.1 (0.3)	21.2 (1.3)	26.9 (1.9)	5.7 (1.0)	24.5 (1.9)	32.1 (2.7)	7.7 (1.4)
Increasesers	36	21.0 (0.6)	24.5 (0.8)	3.5 (0.4)	23.9 (1.4)	29.4 (1.8)	5.6 (1.1)	27.9 (2.1)	34.9 (2.7)	7.0 (1.5)
Decreasers	42	19.2 (0.5)	22.0 (0.4)	2.8 (0.3)	18.2 (1.0)	21.8 (1.1)	3.6 (1.0)	19.6 (1.3)	24.6 (1.7)	5.0 (1.4)
Girls	386									
Steady-low	319	19.8 (0.2)	22.3 (0.2)	2.5 (0.1)	21.9 (0.4)	31.0 (0.4)	9.1 (0.3)	25.2 (0.6)	39.5 (0.7)	14.4 (0.5)
Steady-high	22	19.2 (0.4)	21.0 (0.4)	1.8 (0.3)	21.5 (1.2)	29.5 (1.0)	8.0 (1.1)	24.2 (1.8)	36.8 (1.7)	12.5 (1.8)
Increasesers	28	19.8 (0.7)	22.3 (0.7)	2.6 (0.3)	22.7 (1.4)	32.8 (1.9)	10.2 (1.2)	26.5 (2.2)	42.9 (3.3)	16.4 (2.2)
Decreasers	17	19.3 (0.9)	21.1 (0.9)	1.8 (0.8)	20.2 (1.6)	28.1 (1.4)	7.9 (1.6)	22.7 (2.2)	34.3 (2.4)	11.6 (2.5)

Abbreviation: SE, standard error.

^a Units: kg/m².

^b Units: mm.

67% of boys were “neither overweight nor overfat”; 18% of girls and 19% of boys were “overweight and overfat”; 6% of girls and 7% of boys were “overweight but not overfat” (i.e., muscular build), and finally 6% of girls and 7% of boys were “overfat but not overweight” (i.e., nonmuscular slight/skinny build). Screen-time group membership status was not statistically significantly associated with combined excess weight and excess fat status in girls. In boys, however, there were marked differences between the groups. Compared with boys who were “steady-low,” “increasers” were 2.2 times (95% CI: 0.8, 6.1) more likely to be “overweight and overfat” and 5.1 times more likely to be “overfat but not overweight” (95% CI: 1.7, 15.5) than to be “neither overweight nor overfat” at survey cycle 19. “Increasesers” were far less likely to be “overweight but not overfat,” but the relative risk could not be estimated because of “zero” cells (i.e., none of the 87/358 boys in the “steady-high” or “increaser” groups were categorized as “overweight but not overfat” at survey cycle 19).

DISCUSSION

Despite the known health risks associated with excessive sedentary behavior, almost 90% of Nicotine Dependence in Teens Study participants reported more than the recommended 2 hours of total recreational screen time per day (52). This proportion is consistent with recent estimates among nationally representative samples of youth (53–55) and underscores an urgent need for population-level strategies aimed at reducing screen time.

This is the first study to identify distinct longitudinal trajectories of screen time during adolescence. Specifically, 4 groups exhibiting highly contrasting screen-time patterns were identified. By far the majority of adolescents maintained a typical “flat” pattern of 25–30 hours of screen time per week. However, close to 30% of the sample had screen-time patterns that increased, decreased, or remained high

over time and, importantly, these “atypical” patterns had the greatest impact on adiposity. Our findings suggest that youth with high levels of screen time are not necessarily at risk of increased percent body fat if screen use decreases over time. Similarly, even (relatively) low levels of screen time can place youth at greater risk of increased percent body fat if screen use increases over time. These longitudinal findings generally support the displacement hypothesis (56), which posits that increased television viewing may relate to percent body fat by reducing discretionary time for physical activity. While evidence for this hypothesis is generally weak (15, 57), it is largely based on cross-sectional designs, which may mask the association between screen time and percent body fat.

There is controversy in regard to which measure of body fat or body composition (i.e., body mass index, percent body fat, waist circumference, skinfold thickness, etc.) best captures the health-relevant aspects of adiposity. Although simpler to obtain than other indicators of adiposity, body mass index does not distinguish muscle from fat mass and can therefore result in muscular individuals being misclassified as overweight. Use of body mass index in this analysis would have led to normal-weight boys with relatively high percent body fat being classified as having a healthy weight status and lean overweight boys as having an unhealthy weight status. This misclassification likely underlies the inconsistent evidence in the literature with respect to screen time and overweight. Nevertheless, multiple indicators capturing both body size and body composition likely provide a more complete assessment of adiposity in adolescence and should be incorporated into studies within this area of research.

Previous reports suggest that physical activity modifies the effect of sedentary behavior on adiposity (46, 47), at least among boys. More specifically, boys with high screen-time levels may not be at greater risk of unhealthy increases in percent body fat if they are physically active (28). Among girls, however, no level of physical activity

Table 3. Differences in Percent Body Fat at Age 17–18 Years According to Screen-Time Trajectory Group Overall and Stratified by Physical Activity Status, Nicotine Dependence in Teens Study, Montreal, Canada, 1999–2005^a

Trajectory group	Boys						Girls										
	All (n = 358)		Physically Active (n = 177)		Physically Inactive (n = 181)		All (n = 386)		Physically Active (n = 192)		Physically Inactive (n = 194)						
	β	95% CI	Referent	β	95% CI	Referent	β	95% CI	Referent	β	95% CI	Referent					
Steady-low	-0.2	-2.2, 1.8	Referent	-1.9	-4.9, 1.0	Referent	1.1	-1.6, 3.8	Referent	-1.5	-4.0, -0.9	Referent	-3.3	-6.8, 0.2*	Referent	-0.0	-3.4, 3.4
Decreasers	2.9	0.7, 5.0***	1.1	-1.8, 4.1	4.8	1.7, 7.8***	4.8	1.7, 7.8***	1.2	-0.7, 3.2	3.0	-0.2, 6.2*	3.0	-0.2, 6.2*	0.6	-1.9, 3.0	
Increases	2.4	0.5, 4.2*	2.1	-0.5, 4.6	2.3	-0.3, 5.0*	2.3	-0.3, 5.0*	-1.2	-3.4, 1.0	-1.9	-4.6, 0.8	-1.9	-4.6, 0.8	0.1	-3.4, 3.7	
Steady-high	0.8	0.7, 0.9*****	0.7	0.6, 0.8*****	0.9	0.7, 1.0*****	0.9	0.7, 1.0*****	0.8	0.7, 0.9*****	0.7	0.6, 0.8*****	0.7	0.6, 0.8*****	0.9	0.8, 1.0*****	
Baseline percent body fat	-0.1	-0.1, -0.0**	-0.0	-0.1, 0.1	-0.2	-0.5, 0.0	-0.2	-0.5, 0.0	-0.0	-0.1, -0.1	0.0	-0.08, 0.15	0.0	-0.08, 0.15	-0.1	-0.4, 0.3	
No. of MVPA/week																	

Abbreviations: CI, confidence interval; MVPA, moderate-to-vigorous physical activity.

* $P < 0.1$; ** $P < 0.05$; *** $P < 0.01$; **** $P < 0.001$ (chi-square).^a β coefficients (95% CI) obtained from multiple linear regression models refer to the difference in percent body fat relative to participants in the steady-low trajectory group after taking covariates into account.

appears sufficient to compensate for high levels of screen time (28, 29). The current results support the notion that physical activity may “buffer” the deleterious effects of high levels of screen time, but that this protective effect is restricted to boys. Public health messaging aimed at reducing screen time in adolescents may need careful structuring to reflect these differences between sexes.

Notable strengths of this analysis include that trained technicians measured anthropometric indicators, that baseline percent body fat was taken into account thereby minimizing potential confounding by intraindividual determinants of adiposity, and that latent class growth analysis, which allows for any number of population intercepts and slopes, was used to identify distinct screen-time patterns. Limitations include that we did not measure sedentary activities other than screen time (i.e., time spent reading, talking on the telephone, doing homework) so that our measure of time spent in sedentary activities might be underestimated. However, it is widely believed that television, video, and computer use are the most important contributing factors to sedentary behavior in adolescents (58–60). Screen-time data were based on self-reports that may be subject to recall bias; however, up to 19 measures of screen time were available for each participant, across all seasons, thereby reducing intraindividual random error. The baseline response proportion was relatively low so that the results may have limited external generalizability. However, the low response is unlikely to have affected the reported estimates because nonparticipation related to issues extraneous to those of interest in this analysis. In addition, our findings on the proportion of adolescents who exceeded recommended levels of leisure-time screen use mirror those of nationally representative samples. Finally, although diet is a well-established determinant of overweight, no diet indicators were included in the models. Participants completed a food frequency questionnaire in survey cycle 17, which yielded indicators of number of “junk” and “healthy” food servings per day. Despite evidence of the validity of the food frequency questionnaire, the indicators are prone to difficulties in interpretation since they tend to be poor estimates of overall energy intake (61); without complementary measures of total caloric or specific nutrient intake (obtained through repeat 24-hour diet recalls, for example), the utility of these indicators is limited. Nevertheless, we tested each diet indicator in our models, and neither was statistically significantly associated with percent body fat in any of the models. Further, their inclusion in the models did not change the estimates substantially.

In conclusion, almost 90% of adolescents in the Nicotine Dependence in Teens Study cohort reported levels of screen time in excess of recommended levels. Physically inactive boys who increased or maintained high screen time and physically active girls who increased screen time gained the most body fat. Future research should identify determinants of specific screen-time patterns during adolescence and, in particular, of “atypical” patterns most associated with higher percent body fat accumulation. The excessive screen-time levels observed herein underscore an urgent need for population-level strategies aimed at reducing screen time. Further, given the risks for increased adiposity associated with specific screen-time trajectories, monitoring screen time

in youth by parents and health-care professionals may help to identify those at risk of screen-time-related health problems. Because interventions to reduce sedentary behaviors have demonstrated efficacy (62, 63), targeted approaches among high-risk groups may be warranted in addition to population-wide strategies aimed at reducing screen time generally.

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Author affiliations: Department of Social and Preventive Medicine, Université de Montréal, Montreal, Quebec, Canada (Tracie A. Barnett, Jennifer O'Loughlin, Igor Karp, Andraea Van Hulst); Centre de Recherche du CHU Sainte-Justine, Montréal, Quebec, Canada (Tracie A. Barnett, Marie Lambert); Centre de Recherche du Centre Hospitalier de l'Université de Montréal, Montreal, Quebec, Canada (Jennifer O'Loughlin, Igor Karp); Institut National de Santé Publique du Québec, Montreal, Quebec, Canada (Jennifer O'Loughlin); Department of Kinesiology and Physical Education, McGill University, Montreal, Quebec, Canada (Catherine M. Sabiston); Centre de Formation Médicale du Nouveau-Brunswick, Moncton, New Brunswick, Canada (Mathieu Bélanger); Department of Research, Regional Health Authority A, Moncton, New Brunswick, Canada (Mathieu Bélanger); Department of Family Medicine, Université de Sherbrooke, Sherbrooke, Quebec, Canada (Mathieu Bélanger); and Department of Pediatrics, CHU Sainte-Justine and Université de Montréal, Montreal, Quebec, Canada (Marie Lambert).

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