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School start time changes in the COMPASS study: associations with youth sleep duration, physical activity, and screen time

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SCHOOL START TIME CHANGES IN THE COMPASS STUDY: ASSOCIATIONS WITH YOUTH SLEEP DURATION, PHYSICAL ACTIVITY, AND SCREEN TIME

Background: To date, no longitudinal population-based studies of school start times have been conducted within Canada. School schedule changes provided an opportunity to examine start times in association with youth sleep, physical activity, and screen time over time.

Methods: This longitudinal study included grade 9-12 students attending 49 Ontario secondary schools that participated in at least two consecutive years of the COMPASS study (2012-2017). Fixed effects models tested whether differences in within-student change in self-reported sleep duration, moderate-to-vigorous physical activity, and screen time were associated with school start time changes, adjusting for student- (grade, sex, ethnicity, spending money) and school-level covariates (median income, urbanicity, geographical area).

Results: Thirteen start time changes of 5-10 minutes were reported. Ten-minute advances at earlier clock times (8:30AM-8:20AM; 8:40AM-8:30AM) were associated with steeper sleep duration declines than schools with consistent start times but had no effect at later times (9:00AM-8:50AM). While sleep change did not differ with 5-minute delays, 10-minute delays (8:50AM-9:00AM) were associated with additional sleep (23.7 minutes). Apart from one school that shifted from 8:30AM to 8:35AM, in which screen time and physical activity decreased more steeply, no effect was found for screen time, and 5-minute delays were associated with more physical activity (10.9 minutes) and advances with less activity (-8.0 minutes).

Conclusions: Results support start time delays as a valuable strategy to help ameliorate sleep debt among youth. Interference with physical activity or increased screen time appear unlikely with modest schedule changes. Potential adverse impacts on sleep require consideration with 10-minute advances.

Keywords (maximum of 6): sleep duration; school start time; youth; adolescents; physical activity; sedentary behaviour; screen time

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INTRODUCTION

Sufficient sleep is essential for the health, development, and daily functioning of adolescents. Short sleep increases the risk of obesity, poor dietary intake, accidents/injuries, substance use, emotional dysregulation, reduced executive functioning, and lower academic achievement.[1-5] The *Canadian 24-hour Movement Guidelines* recommend youth age 14- to 17-years-old sleep an average of 8- to 10-hours a night,[6] yet at least one-third of Canadian youth report sleeping less than 8 hours.[7] Sleep duration is consistently shown to decline with age over adolescence.[7-9] In addition to the numerous social changes during this period (e.g., reduced parental monitoring, increased academic demands and social/extracurricular activities, part-time employment) that may contribute to later bedtimes, puberty is associated with a natural circadian shift towards later sleep onset.[10,11] As a result, adolescents have greater morning sleep needs, which often conflict with school start times (SST). Accordingly, the American Academy of Pediatrics[12,13] released a policy statement recommending SST of 8:30AM or later, and more recently, several Canadian organizations (e.g., Canadian Academy of Child and Adolescent Psychiatry, College of Family Physicians of Canada, American Thoracic Society) have called for delayed SST to align with adolescent sleep-wake patterns.

Past research generally supports the benefits of delayed SST for weekday sleep durations among youth, with the difference primarily attributable to later waketimes.[14-16] Some evidence also suggests later SST result in less daytime sleepiness and trouble staying awake.[14-17] Outcomes apart from sleep have received relatively less attention. The strongest available evidence indicates delayed SST promote reduced: caffeine use, depressive symptoms, tardiness to class, and absenteeism.[14-16,18,19] Several studies have also support beneficial effects on academic performance.[20,21] Shifts to later SST may also improve physical activity and sedentary behaviour levels, if sleep deprivation was contributing to physical inactivity and increased time spent sedentary. Conversely, reservations for delaying SST include potential interference with after-school sports and extracurricular activities,[22] as well as skepticism that youth will use the time afforded by later SST for sleep.[22,23] Screen use is often regarded as a primary contributor to late bedtimes and reduced sleep among youth,[24,25] but has yet to be studied in relation to SST.

Reviews and meta-analyses identify a continued need for prospective and experimental research, as the majority of past studies have used cross-sectional designs or lacked comparison groups.[14-17] A 2017 Cochrane review deemed existing evidence to be limited and of very low-quality, and hence, was unable to draw conclusions regarding the true beneficial and adverse effects of later SSTs.[15] Also, SST research has predominately been conducted in US schools, with only a few Canadian studies. In two large youth Canadian population studies, students attending schools with later SST reported longer sleep durations and were more likely to meet sleep duration recommendations.[26,27] Similarly, a small Quebec study found students assigned morning school schedules to have shorter objective sleep durations and more daytime sleepiness than their peers following afternoon schedules.[28]

To date, no longitudinal studies have been conducted in Canada, yet the SST changes have been a topic of recent public interest. Shifts to school schedules to save on bus costs have raised concerns about the potential impact on student health and wellbeing.[29] Also, some school boards contemplating delayed SSTs have expressed a need for further evidence to inform scheduling decisions, while others are reportedly reluctant to make the change.[30,31] Scheduling changes among schools participating in the COMPASS study provided an opportune natural experiment to examine whether changes to SST were associated with subsequent changes to sleep duration, physical activity, and sedentary behaviours of youth over time. In a large cohort of students attending Ontario secondary schools, the current study aimed to evaluate whether SST delays and advances of different durations and at various clock times influenced one-year changes in sleep duration, physical activity, and screen time. We hypothesized that SST delays would be associated with longer sleep duration, more physical activity, and less screen time in youth, while the opposite would be observed with SST advances.

METHODS

Design

The *COMPASS Study* collects longitudinal data from students in grades 9 through 12 and the Canadian secondary schools they attend.[32] Each year, by collecting whole-school samples and using a rolling cohort design, graduating grade 12 students leave the cohort and newly admitted grade 9 students enter into the cohort, and therefore, each individual student has the potential to provide up to 4 years of longitudinal data. COMPASS uses a multilevel and quasi-experimental design to examine how changes in school and surrounding area policies, programs, and built environment characteristics impact multiple youth health behaviours and outcomes over time. A full description of COMPASS and its methods are available in print[32] or online (www.compass.uwaterloo.ca). All procedures were approved by the University of Waterloo Office of Research Ethics and appropriate school board committees.

Data Collection Tool

The *COMPASS student questionnaire (Cq)* collects student-level data pertaining to multiple health behaviours and outcomes, correlates, and demographic characteristics. In each school, the Cq was completed once annually by whole-school samples during class time. The cover page contains measures to generate a unique student code for each respondent to allow student data to be linked over multiple years while preserving anonymity.[33]

Measures

Student-level measures

Sleep duration was assessed by asking students how much time in hours (0-9) and 15-minute intervals (0, 15, 30, 45) they usually spend sleeping per day. Similarly, students were asked the amount of time per day they usually spend engaging in different forms of *screen use* ("watching/streaming TV shows or movies," "playing video/computer games," "talking on the phone," "surfing the internet," and "texting, messaging, emailing"). To determine *Moderate-to-Vigorous Physical Activity (MVPA),* students were asked how many minutes of hard and moderate physical activity they engaged in on each of the last 7 days to calculate a daily average. The physical and sedentary activity measures have been previously validated (see Wong et al.[34] and Leatherdale et al.[35] for psychometric properties).

Student-level correlates included student-identified sex (male, female), grade (9-12), and self-identification as White, Black, Asian, Latin American/Hispanic, Off-Reserve Aboriginal, other, or mixed. In addition, student-reported weekly spending money (don't know/missing, 0, $1-40, $40-100, $100+) was included as an indicator of socioeconomic status (SES) and/or part time employment.

School-level measures

Beginning July 27, 2017, Ontario public/separate school boards were contacted via email to request a list of *school start times (SST)* by year for schools in their board that had participated in the COMPASS study. Private school boards were not approached. A follow-up email was sent to school boards that had not responded on September 20, 2017.

School-level covariates included school-area average median household income, urbanicity, and geographical area (Greater Toronto Area, and Eastern, Southwestern, Northern Ontario). Median household income was generated using the census divisions that corresponded with school postal codes according to data from the 2011 National Household Survey. Urbanicity was determined based on school postal codes and Statistics Canada classifications of "rural" area and "small," "medium," and "large urban" population centers.[36] Rural and small population-center categories were collapsed based on the low frequency of rural schools.

Participants

School boards and schools were purposefully selected in the COMPASS study based on whether they permitted active-information passive-consent parental permission protocols. Eligible schools were approached after board approval. Students could decline to participate at any time.

The current study used data from Ontario publicly-funded secondary schools participating in at least two consecutive years of the COMPASS study from Year one (Y1:2012/13) to five (Y5:2016/17). In total, SST data were collected for 49 Ontario publicly-funded secondary schools (three schools did not respond). Schools and their students could be entered more than once in the models, for each two consecutive years that they participated in the study (i.e., Y1-Y2, Y2-Y3, Y3-Y4, and/or Y4-Y5; 22 schools participated in all 5 years; 21 schools participated in 4 years; 4 schools participated in 3 years).

The average student response rate was 80% each year. Missing respondents resulted primarily from scheduled spares (i.e., study periods) or absenteeism during data collection. Within those 49 schools, students missing outcome (sleep duration, screen time, or MVPA) data were excluded by each year of participation (see table 1). Also, as done previously,[7,9] students with sleep duration responses interpreted as probable misreports (less than 1 hour) or considered outliers (≥3 SDs outside the sample mean) were removed, as they were considered biologically implausible on a consistent basis.

	Y1 (2012/13) N=17,084	**Y2 (2013/14)** N=28,259	**Y3 (2014/15)** N=27,215	**Y4 (2015/16)** N=25,909	**Y5 (2016/17)** N=21,552
Sleep duration					
Non-missing	17,005	28,064	27,007	25,694	21,383
> 1 hour	16,139	26,571	25,533	24,235	20,240
> μ - 3SDs	15,832	26,061	25,031	23,774	19,834
MVPA					
Non-missing	16,594	27,509	26,347	25,094	20,918
Screen time					
Non-missing	17,005	28,064	27,007	25,694	21,383

Table 1. Grade 9-12 students with valid data on sleep, MVPA, and screen time measures at the 49 Ontario Secondary Schools by year of participation in the COMPASS study.

To explore longitudinal changes, student-level data were linked over time within schools for each set of two consecutive years. The process of linking is described in more detail by Qian and colleagues.[33] The main reasons for non-linkage included students transferring schools or dropping out, not providing data for grade or sex, free/study periods or absenteeism, or inaccurate data provided in the linkage measures.

Within 49 schools, the final sample included 27,930 *unique* students (7698 students were included for the first time in Y1; 9244 in Y2; 5910 in Y3; and 5078 in Y4). Students that were linked for multiple years could be entered more than once into the models, for each set of two consecutive years that they participated. As a result, 41,790 student *sets* of data were included in the analyses (Y1-Y2 N=7698; Y2-Y3 N=12,775, Y3-Y4 N=11,660, Y4-Y5 N=9657).

Statistical Analysis

Results from preliminary data analysis on the within-subject change revealed: (1) increases or decreases in sleep duration, MVPA, and screen time are not always linearly related to the SST advances or delays of 5 or 10 minutes; and, (2) the effect of SST delays or advances depends on previous year SST (i.e., clock time range). To accommodate these findings, SST changes were categorized as four treatment groups (5 or 10 minutes earlier [-5, -10] or later [+5, +10]) with no change (0) as the control, and previous year SST clock time range was categorized into four groups (8:00-8:29AM; 8:30-8:59AM; 9:00-9:29AM; 9:30-10:00AM). Their interaction (i.e., the interaction between SST change and previous year SST clock time range) was included in the model. Schools that participated for multiple consecutive years in the study, could be entered more than once in the models (i.e., for each two consecutive years of linked data [Y1-Y2, Y2-Y3, Y3-Y4, and/or Y4-Y5]). Fixed effects models were used to test the association between SST change and within-student change in sleep duration, with student- (grade, sex, ethnicity, weekly spending money) and school-level covariates (school area urbanicity, median household income, geographical area). Models tested for significant difference-in-difference in terms of whether the change in student sleep duration from the year prior (within-student change) differed in students attending schools with SST changes (intervention schools) in comparison to what would be expected based on students attending schools with no SST change from the year prior (control schools). The model was repeated with student MVPA and screen time as outcome variables. Difference in difference models were used because: (1) the models are straightforward (the effect of change [SST] on change [student sleep duration, MVPA, and screen time]); (2) they eliminate the unobservable time-invariant effect; (3) they reduce selectin bias; and (4), preliminary analyses indicated within-subject sleep durations, MVPA, and screen time results were highly correlated. All analyses were implemented in SAS 9.4.

RESULTS

SST ranged from 8:00AM to 9:35AM. Based on responses, 11 of the 49 individual schools made SST changes between 2012/13 and 2016/17, with three schools (Schools 7, 8, and 9) changing their start time twice during this period (see Table 2 for SST changes). The 2-minute SST change at School 10 (9:33AM to 9:35AM) was removed from the models as we hypothesized it would be insufficient to result in a meaningful change in the outcomes of interest. The 13 SST changes at the remaining 10 schools were in the range of 5 to 10 minutes earlier or later.

See Table 3 for the number of schools classified by each set of two consecutive linked years that they participated and were entered into the models, classified by their previous year SST clock range and the SST change. Schools with SST changes that participated in multiple years of the study can act as controls for a different set of years in which there was no SST change. Given that schools could be entered into the model more than once (for each set of 2 consecutive years that they participated in the study), there were a total of 160 sets of school data entered into the models for the 49 unique schools.

The student descriptive statistics at baseline (i.e., for the first time the students participated and were entered into the models; Y_1 N=7698; Y_2 N=9244, Y_3 N=5910, Y_4 N=5078) are presented in Table 4. At baseline, students reported an average of 7.0 hours/day of sleep, 8.2 hours/day of total screen time, and 122.9 minutes/day of MVPA.

School #	SST change (min)	Student (N)[a]
Y2: 2013/14		
1	+5 (8:10 → 8:15)	212
2	+5 (8:30 → 8:35)	337
Y3: 2014/15		
3	-10 (8:30 → 8:20)	205
Y4: 2015/16		
4	-5 (8:05 → 8:00)	124
5	+5 (8:15 → 8:20)	303
6	-10 (8:40 → 8:30)	229
7	+10 (8:50 → 9:00)	90
8	+10 (8:50 → 9:00)	95
9	+10 (8:50 → 9:00)	240
10	+2 (9:33 → 9:35)	172
Y5: 2016/17		
11	-5 (8:05 → 8:00)	408
7	-10 (9:00 → 8:50)	92
8	-10 (9:00 → 8:50)	101
9	-10 (9:00 → 8:50)	248

[a] Number of students attending the school with data successfully linked for the year in which the SST change occurred and the year prior.

Table 2. SST changes in publicly-funded Ontario secondary schools that participated in at least two consecutive years of the COMPASS study (years 1-5 [2012-2017]).

Previous Year SST Range	SST change (min)	Schools (N) Year 1 & 2	Year 2 & 3	Year 3 & 4	Year 4 & 5	Total
8:00-8:29AM	-5	0	0	1 8:05→8:00	1 8:20→8:15	2
8:00-8:29AM	0	11	22	21	17	71
8:00-8:29AM	+5	1 8:10→8:15	0	1 8:15→8:20	0	2
8:30-8:59AM	-10	0	1 8:30→8:20	1 8:40→8:30	0	2
8:30-8:59AM	0	14	19	14	12	59
8:30-8:59AM	+5	1 8:30→8:35	0	0	0	1
8:30-8:59AM	+10	0	0	3 8:50→9:00	0	3
9:00-9:29AM	-10	0	0	0	3 9:00→8:50	3
9:00-9:29AM	0	0	4	4	3	11
9:30-10:00AM	0	1	2	1	2	6
Total sets of linked school data		28	48	46	38	160
Total sets of linked student data		7698	12,775	11,660	9657	41,790

Note: Schools and students that participated for multiple years can be entered more than once, for each set of two consecutive years they participated in the study.

Table 3. Publicly-funded Ontario secondary schools by prior year SST and SST change for each set of two consecutive linked years that they participated in the COMPASS study (years 1-5 [2012-2017]).

		N= 27, 930
Student-level covariates		**% (N)**
Grade at baseline		
	9	57.9 (16,180)
	10	22.5 (6291)
	11	18.1 (5062)
	12	1.4 (397)
Ethnicity		
	White	73.1 (20,416)
	Black	4.2 (1182)
	Asian	5.6 (1558)
	Indigenous	2.4 (674)
	Latin American/Hispanic	1.9 (532)
	Other/Mixed	12.8 (3568)
Weekly spending money		
	0	20.3 (5665)
	$1-$40	36.8 (10,273)
	$40 -$100	22.2 (6203)
	$100+	7.2 (2000)
	Don't Know/Missing	13.6 (3789)
School-level covariates		**% (N)**
SST at baseline		
	8:00-8:29AM	49.4 (13,808)
	8:30-8:59AM	37.9 (10,597)
	9:00-9:29AM	9.2 (2559)
	9:30-10:00AM	3.5 (966)
School area mean income		
	$25,000-50,000	7.7 (2155)
	$50,000-75,000	51.1 (14,259)
	$75,000-100,000	29.4 (8220)
	$100,000+	11.8 (3296)
School area urbanicity		
	Large Urban	56.9 (15,887)
	Medium Urban	16.4 (4567)
	Small/Rural	26.8 (7476)
Geographical location		
	Eastern Ontario	36.2 (10,100)
	Greater Toronto Area	11.6 (3233)
	Northern Ontario	22.5 (6291)
	Southwestern Ontario	29.7 (8306)
Movement behaviours (minutes per day)		**Mean (SD)**
Sleep duration		418.1 (134.4)
MVPA		122.9 (84.2)
screen time		490.0 (319.61)

Table 4. Descriptive statistics among students attending publicly-funded Ontario secondary schools that participated in at least two consecutive years of the COMPASS study (years 1-5 [2012-2017]).

Previous year SST range	SST change (min)	Difference-in-Difference (min)	95% CI	
Sleep duration (min/day)				
8:00-8:29	-5	-1.96	-12.50	8.58
8:00-8:29	+5	1.17	-9.62	11.96
8:30-8:59	**-10**	**-15.49**	**-26.93**	**-4.05**
8:30-8:59	+5	3.26	-9.62	16.14
8:30-8:59	**+10**	**23.65**	**12.05**	**35.25**
9:00-9:29	-10	6.56	-6.16	19.28
MVPA (min/day)				
8:00-8:29	-5	**-7.96**	**-15.54**	**-0.37**
8:00-8:29	+5	**10.92**	**2.97**	**18.87**
8:30-8:59	-10	3.43	-4.94	11.80
8:30-8:59	**+5**	**-17.55**	**-26.95**	**-8.15**
8:30-8:59	+10	4.68	-3.79	13.15
9:00-9:29	-10	-0.09	-9.38	9.20
Screen time (min/day)				
8:00-8:29	-5	-19.10	-45.81	7.61
8:00-8:29	+5	16.45	-11.26	44.17
8:30-8:59	-10	22.24	-6.88	51.35
8:30-8:59	**+5**	**-35.08**	**-68.09**	**-2.08**
8:30-8:59	+10	12.88	-16.56	42.31
9:00-9:29	-10	-25.10	-57.31	7.10

Models adjusted for student- (grade, sex, ethnicity, weekly spending money) and school-level (school area median income, geographical area, urbanicity) covariates. Bolded rows indicate significant difference-in-difference results.

Table 5. Difference in sleep duration, moderate-to-vigorous physical activity (MVPA), and screen time from the year prior among students attending schools when school start time (SST) changes were made in comparison to students attending schools with consistent SSTs

Sleep Duration

Table 5 reports differences in within-student change in sleep duration, MVPA, and total screen time from the year prior at schools when there were SST changes compared to student change at schools when SST remained consistent. When three schools shifted from 8:50AM to 9:00AM (i.e., 10 minute *delays* in the 8:30-8:59AM prior year SST range), students slept an additional 23.7 minutes (95% CI [12.1, 35.3]) per day on average, when compared to the sleep duration change reported by their counterparts at schools with consistent SST. However, when these three schools reverted to their original start times of 8:50AM (10-minute *advances* in the 9:00-9:29AM prior year SST range), the change in student sleep durations from the year prior resembled the change found among students attending schools that did not change their SST. In contrast, 10 minute SST advances in the two schools with prior year SST in the range of 8:30-8:59AM (i.e., 8:30AM to 8:20AM; 8:40AM to 8:30AM), were associated with a steeper decline in sleep duration from the year prior than reported by their counterparts at schools with consistent SST. On average, the SST advance of 10 minutes in the 8:30-8:59AM range was associated with a 15.5 minute (95% CI [26.9, -4.1]) greater reduction in sleep compared to the difference expected if the SST had remained consistent. Sleep duration difference from the year prior did not differ among students attending the one school that shifted from 8:30AM to 8:35AM (a 5-minute delay in the 8:30-8:59AM range), compared to that reported at schools with consistent SST. Likewise, 5-minute advances (8:05AM to 8:00AM; 8:20AM to 8:15AM) or delays (8:10AM to 8:15AM; 8:15AM to 8:20AM) in the 8:00-8:29AM range were not associated with different sleep duration differences compared to consistent SST.

MVPA

There were conflicting changes in MVPA following changes to SSTs. In earlier clock time ranges, 5-minute SST advances (8:05AM to 8:00AM; 8:20AM to 8:15AM) were associated with a greater reduction in MVPA from what would be expected based on schools that kept consistent SST, resulting in 8 minutes (8.0, 95% CI [-15.5, -0.4]) less MVPA on average; whereas, 5-minute SST delays (8:10AM to 8:15AM; 8:15AM to 8:20AM) were associated with 10.9 minutes (95% CI 3.0,18.9]) of additional MVPA. In contrast, at the one school that delayed SST from 8:30AM to 8:35AM (8:30-8:59AM previous year SST range), the difference in MVPA from the year prior was associated with 17.6 minutes (95% CI [-27.0, -8.2]) less MVPA than reported by students attending schools with consistent SST. The other SST changes did not result in different one-year within-student MVPA changes than expected if SST had remained consistent.

Total Screen Time

Differences in total screen time from the year prior did not differ in students at schools with SST changes, with the exception of one school that went from 8:30AM to 8:35AM (8:30-8:59AM previous year SST range). Students attending this school reported a steeper decline in total screen time from the year prior, amounting to 35.1 minutes (95% CI [-68.1, -2.1]) less screen time, relative to students attending schools with consistent SST.

DISCUSSION

This study represents the first longitudinal analysis of SST and youth health behaviours in a large Canadian population sample. Shifts in SST among schools participating in the COMPASS study allowed for a natural experiment to assess whether it was associated with youth sleep duration, physical activity level, and screen time. In line with past cross-sectional Canadian studies[26,27] and longitudinal and experimental evidence from other countries,[14-21,37,38] the current findings support delaying SST as advantageous for youth sleep. Results indicate delays of 10 minutes from 8:50AM to 9:00AM were beneficial and advances from 8:30AM to 8:20AM or from 8:40AM to 8:30AM were detrimental for student-reported sleep durations. However, 10-minute advances at later clock times (from 8:50AM to 9:00AM) and changes of 5 minutes had no effect.

While previous experimental research has focused on longer delays, this study demonstrated that relatively minor changes may be beneficial for youth health. Short SST delays are likely more feasible and palatable to school stakeholders reluctant to delay SST. Based on the current study, revisions to school schedules are not uncommon within secondary schools, and even 10-minute changes were sufficient to see an influence on sleep duration. To the authors knowledge, the shortest delay evaluated in a previous longitudinal study was 25-minutes, which was associated with a 29-minute increase in school night sleep duration.[37] In a review of experimental evidence, 25-60 minute delays were associated with 25-77 added minutes of weeknight sleep in a dose-response pattern.[16] Other evidence[14] that included five longitudinal studies with delays of 25-65 minutes reported a small-to-medium effect size, but the clock time and delay length were not significant moderators. Results of the current study varied by the previous year SST clock time range and duration of the change; however, it should be noted that the health outcomes were assessed in 15-minute intervals. Therefore, the difference-in-difference results (i.e., ~15-24 minutes of sleep for a 10-minute SST change) cannot be interpreted as precise estimates of the sleep gain or loss. Likewise, for this reason, it is plausible that the smaller SST changes of 5-7 minutes did not show an effect because the difference in sleep duration was not sufficient for students to change their response by a full 15 minutes.

Youth do not appear to engage in additional screen time when SST are delayed. Students attending the one school that shifted from 8:30AM to 8:35AM, reported decreased total screen time, and no effect was found for other SST shifts. Taken together with the sleep models, results refute notions that the time afforded by delayed SST will be spent on screens and not to maximize sleep. In support, previous experimental studies indicate bedtimes remain consistent with SST delays, countering hypotheses that students will simply stay awake later.[16,22] Results were less clear regarding MVPA. For schools with previous year SST in the range of 8:00-8:29AM, 5-minute SST delays were beneficial for MVPA, while 5-minute advances were associated with less MVPA. In contrast, 5-minute delays had a detrimental effect on MVPA at the one school that shifted from 8:30AM to 8:35AM. It is plausible that a change in addition to the SST shift occurred at this school (e.g., changes to intramural scheduling or facility availability) and could account for the opposing results for both MVPA and screen time. Alternatively, the impact of SST changes may vary by contextual differences not accounted for in the models. To the authors' knowledge, no past SST studies have assessed screen use and few have included physical activity measures. Two studies using pre-post designs found no change in sports participation rates.[37,39] Similarly, no athletic programs were cancelled or adversely affected in US school districts implementing delayed SST, contrary to concerns over the impact of later SST on after-school programs and athletic practices and competitions.[23] In fact, more students participated in athletics, sports programs grew, and teams reportedly performed better after SST were delayed.[23]

SST in this study ranged from 8:00AM to 9:35AM, consistent with a nationally representative sample.[26] Research evidence of the benefits of delayed SST was the primary motivator for US schools that implemented changes;[23] hence, the importance of this study to inform scheduling decisions in Canadian schools. Despite recommendations, many schools and boards are hesitant to institute delayed SST policies due to logistical and financial concerns, such as potential impacts on transportation and after-school activities (e.g., sports practices and competitions, extracurricular programs).[22,23] However, contrary to expectations, some schools report savings on busing costs and greater extracurricular participation.[22,23,40,41] Also, at the population level, benefit-cost projections estimate delayed SST policies have potential for significant economic gains.[42]

Key strengths of this study include the large sample, longitudinal data, and quasi-experimental design. No previous Canadian longitudinal studies on SST have been conducted, and among the handful done in other countries, over half lacked comparison groups. However, the current study is not without limitations. SST changes were not randomized to schools. School and boards are often unable or unwilling to allow researchers necessary control over scheduling and data collection, and even so, overly controlled studies often fail to speak to "real-world" implementation.[15] Quasi-experimental designs offer a robust method for examining the impact of an intervention (in this case the intervention is a natural experiment not implemented by researchers) when randomization is not feasible.[43] Models were limited to the SST changes occurring within the COMPASS study, and therefore, 5- and 10-minute delays or advances were not available in all previous year SST ranges. Further research is also needed to confirm whether health behaviour changes found over one year are maintained.

The primary limitation of this study pertains to the use of self-report measures, which are subject to recall and social desirability biases. Self-reported measures tend to overestimate sleep duration when compared with objective methods,[39] although they have been validated for studying group differences in large youth samples.[40,41] As the sleep measures assess average daily duration without differentiation between school days and weekends, the impact of SST changes on school night sleep may be underestimated. Students typically sleep less on school days and “catch up” on lost sleep over the weekend.[7] As discussed above, the estimated minutes of sleep, MVPA, and screen time difference-in-differences need to be interpreted with caution considering student health behaviours were reported in 15-minute intervals. Lastly, future SST studies should assess additional indicators of sleep (e.g., bed and wake times, sleep quality, sleep onset latency, sleepiness during the day), physical activity (e.g., sports participation, active travel), and screen use (e.g., timing [before bedtime]), as well as other health behaviours and outcomes (e.g., academic achievement, mental health, substance use, bullying, accidents/injuries) over time.

Conclusion

Overall, this study lends support to delayed SST as an effective intervention to help ameliorate the widespread sleep deprivation among adolescents and suggests caution when making schedule advances. SST delays of 10-minutes were associated with longer sleep durations, without having any apparent adverse impacts on screen time or physical activity levels. The remarkable sensitivity of the youth sleep durations to relatively minor SST delays underscores the critical importance of SST to student health.

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Highlights

- This longitudinal study examined SST changes as a natural experiment
- 10-minute SST delays advances were associated with longer sleep durations
- 10-minute SST advances were associated with steeper declines in sleep duration
- Modest SST shifts did not increase total screen time or interfere with MVPA