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Evaluation of an interactive school-based sleep education program: a cluster-randomized controlled trial☆

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ABSTRACT

Objectives: Shortened sleep has negative consequences on adolescents' well-being. The present study evaluated an interactive school-based sleep education program (SEP) aimed at increasing adolescent sleep duration.

Design and intervention: A cluster-randomized controlled trial with 12 clusters (classes) was used. The intervention group received a SEP and the active control group received a healthy living program (HLP). Both groups underwent a 4-week class-based education program. The SEP students learned about the importance of sleep, the barriers to getting enough sleep, and how to improve their time management to increase their sleep opportunity. The HLP students learned about various health-related topics not including sleep.

Participants: A total of 210 students (mean age = 14.04 ± 0.32 years) were randomly assigned to the SEP (n = 102) or the HLP (n = 108) group, with 6 classes per group.

Measurements: Sleep (actigraphically measured), sleep knowledge, and time usage were assessed using linear mixed models at three time points: baseline, immediately after intervention, and 1-month follow-up.

Results: Sleep knowledge improved at follow-up in the SEP relative to the HLP group ($p = .017$). Although students were receptive of the program and self-reported the intention to create more time for sleep, no changes in sleep were found following the SEP. Some benefit may have been masked by exam preparations at the follow-up evaluation.

Conclusions: Sleep education alone may not be sufficient to change sleep behavior. A combination of sleep education, starting school later, and parental involvement may be needed to encourage and enable changes in adolescent sleep duration.

Introduction

Sleep is important for adolescents' optimal mental and physical performance. Reduced sleep in teenagers has been associated with decreased mental well-being,[1] cognitive performance, [2,3] and grades,[4] as well as increased body mass index (BMI).[5] Adolescents aged 14-17 are recommended to get between 8 and 10 hours of sleep per night,[6,7] but the majority fall short.[1,8] Shortened sleep duration in adolescence has been attributed to a complex set of interacting biological and sociocultural factors.[9] These include changes to the sleep homeostatic system, a delay in circadian timing,[9,10] increased bedtime autonomy and electronic device usage,[11] and increased school workload.[1] Together, these factors delay bedtimes in teenagers and combined with early school start times result in shortened nocturnal sleep.[1,12] Although sleep curtailment in adolescents is common worldwide, Asian adolescents' bedtimes are notably later than their Australasian and European peers, resulting in even shorter nocturnal sleep.[8]

In highly competitive East Asian countries such as Singapore, most secondary school students sleep less than 8 hours. On school days, more than 85% of secondary school students in Singapore report sleeping less than 8 hours and on weekends this is the case for more than 20%. Furthermore, students experience a large degree of "social jetlag", with an average weekend sleep extension of roughly

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2 hours.[1] Coping behaviors such as napping or weekend extension may temporarily alleviate the negative effects of chronic sleep deprivation but cannot fully restore functioning to the optimal level.[3,13]

The growing body of literature demonstrating the negative effects of sleep restriction on adolescents' functioning emphasizes the need for intervention. Sleep education is one such intervention. Typically, sleep education programs (SEPs) are targeted at improving sleep duration and related sleep behaviors, by improving sleep knowledge and sleep hygiene.[14-16] A literature review evaluating the effectiveness of SEPs in 12 studies found that sleep knowledge often increases when measured.[16] However, this increase in knowledge was not always accompanied by increased sleep duration or improved sleep hygiene.[14,16-18] The absence of change in sleep behavior in previous research could be due in part to methodological limitations. Earlier studies often did not have a control group undergoing an equivalent nonsleep focused education program. The lack of a control group could induce experimenter bias and demand characteristics, especially in studies where the researchers conduct the lessons.[16] Furthermore, most studies tested the effectiveness of their education programs using pre-post study designs instead of randomized controlled trials, which minimize sources of bias.[19] Finally, earlier research lacked objective measures of sleep and instead relied on self-reports, such as daily sleep diaries.

Recently, Rigney et al[19] addressed some of the methodological issues using a large randomized controlled study design to evaluate students aged 13-14 years old. Schools were randomly assigned to an intervention or control group and sleep duration was measured actigraphically in a subsample of participants. The intervention group increased their time in bed (TIB) immediately after the intervention. However, changes were small and in the "wrong" direction (10-minute increase in TIB, due to later wake times rather than earlier bedtimes) and were not sustained after 3 months, possibly because this age group was not sleep-deprived at baseline.[19] Similarly, although the SEP introduced by Wolfson et al[20] was effective in improving sleep health efficacy, sleep hygiene, TIB, and bedtimes; changes were not sustained at follow-up. The authors suggested that regular booster interventions may be needed to maintain behavioral change.

The mixed results of previous education programs highlight the difficulty of achieving behavioral change, even with improved methodology. Beyond educating students on the importance of getting sufficient sleep, they may need to be equipped with tools and strategies to achieve this goal. Improved time management has been found to be related to better school grades [21] and increased health-related quality of life in adolescents.[22] Activities that have the strongest relationships with sleep in adults and adolescents were time spent on school/work, transportation, and watching TV/other media use.[1,4,23,24] Teaching adolescents how to better manage their time may similarly encourage them to increase their nocturnal sleep opportunity, particularly in Singapore. As the prevailing culture is highly competitive,[25] parents strongly emphasize academic performance over sleep. Although students may not have much control over the amount of schoolwork or school start time, they can learn how to best manage their time to reduce the delay in bedtime.

The present study evaluated the effectiveness of an interactive SEP for secondary school students in Singapore, relative to an active control condition, using a cluster-randomized controlled design. The program aimed to increase students' sleep duration, by educating them on the importance of sleep and equipping them with time management skills to create more time for sleep. It was hypothesized that participants who receive sleep education would increase their sleep duration after the intervention and that this would be paired with an increase in sleep knowledge. Owing to the expected discrepancy in school day and weekend sleep duration, these were analyzed separately.

Methods

Participants

Participants were recruited from level 2 (grade 8) students from an all-boys secondary school in Singapore. All level 2 students ($N = 396$) underwent either the SEP or the active control program (healthy living program [HLP]), of whom 210 consented to participate in the data collection (mean age ± standard deviation [SD] = 14.04 ± 0.32 years). The twelve classes in the cohort were randomized into the intervention group (SEP: $n = 102$) or control group (HLP: $n = 108$), resulting in six classes per group. Five participants from the SEP group withdrew from the study (Fig. 1). All participants and their parents or legal guardians provided written informed consent and participants were financially compensated. Ethical approval was obtained from the National University of Singapore Institutional Review Board.

Design and procedure

A briefing session was held at the school for all level 2 students before they were invited to take part in the study. Parents were invited to attend a separate briefing session. A cluster-randomized controlled trial with two arms (SEP vs. HLP) and three assessment time points (baseline, postintervention, and 1-month follow-up) was used (Fig. 1). The sample size was determined based on previous research.[19] All procedures were completed during the school term between July and September 2018. At each time point, participants attended an after-school data collection session, during which they completed a set of online questionnaires. Over the course of the following week, participants wore a wrist actigraph to monitor sleep and indicated their daily time use on a smartphone-based application. The primary outcomes were actigraphically measured TIB (on school days and overall) and sleep knowledge at postintervention.

Intervention: SEP

The SEP took place at the school during classroom hours over four 1-hour lessons, delivered in weekly intervals across a 5-week period. Owing to a national holiday, a week was skipped so that lesson three and four were separated by an additional week. To encourage rapport with students during delivery of the lessons, students' principal and class teachers delivered the program to their students. Before the SEP, a 2-hour training session was conducted by the authors to educate the teachers. Teachers were equipped with a manual covering all aspects of the SEP and references for further information. Lessons were interactive, containing short videos, in-class activities, and discussion points, covering different aspects of sleep physiology, sleep hygiene, and time management (see supplementary materials for details on the development and content of the SEP). Each lesson was observed by a member of the research team, who provided necessary assistance to ensure coverage of the learning goals of each lesson. Student attendance was taken in every lesson.

Active control: HLP

Participants in the control group underwent the HLP following the same four-week 1-hour lesson format, at the same time as the SEP students. As with the SEP, this program was delivered by the students' principal and class teachers to their classes, supported by comprehensive lesson plans. In each lesson, participants watched a documentary covering a health-related topic excluding any sleep-related content (supplementary materials). Class discussions on the topic

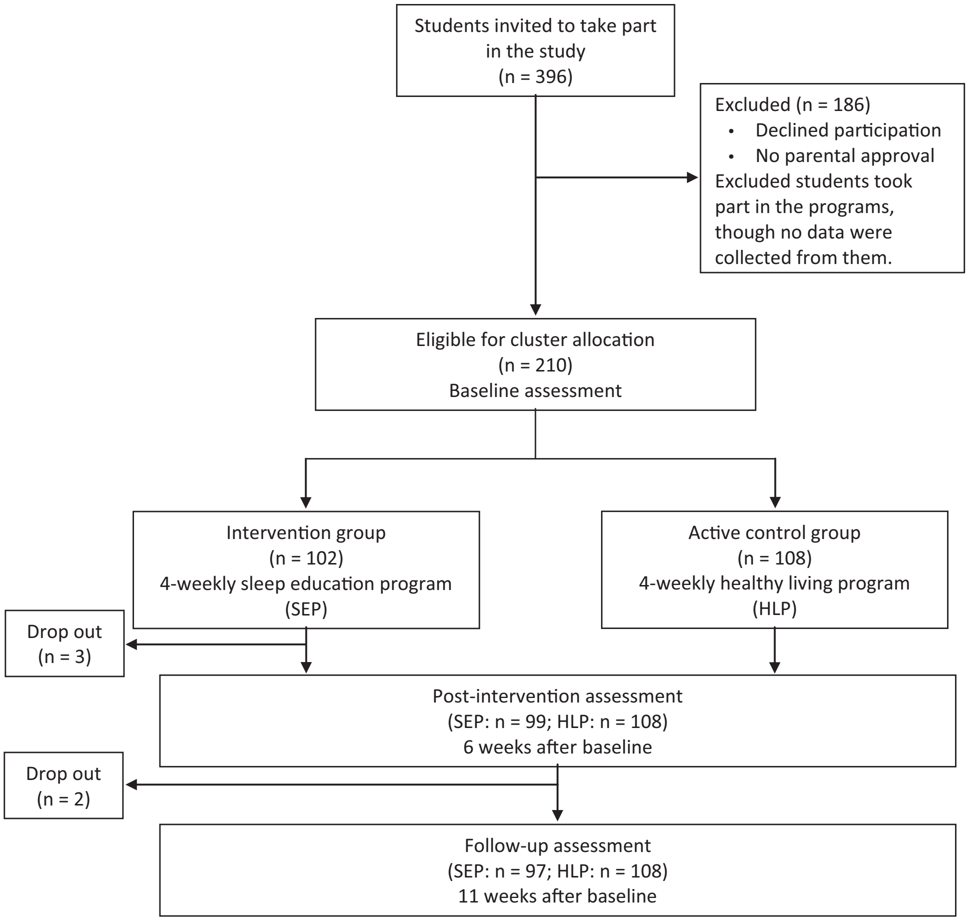

Fig. 1. Overview of study design.

followed the documentaries. Themes discussed during the HLP were not part of the students' present study curriculum. A head teacher made rounds to check on all classes in this group. Student attendance was taken in every lesson.

Outcome measures

Sleep knowledge

The level of sleep knowledge was assessed using a sleep knowledge questionnaire, consisting of 12 true/false questions. The questionnaire was designed to evaluate understanding of the content delivered in the SEP. Items in the questionnaire included topics of sleep physiology (e.g., "The sleep-wake cycle is the same in teenagers as in adults") and sleep hygiene (e.g., "Taking a nap in the afternoon can affect our sleep at night"). The same questions were used at each assessment point and all participants responded to all questions. Each correct response was awarded one point, with the total score calculated as the sum of correct responses. To prevent rehearsal, participants were not told that they would be completing the questionnaire at each time point.

Actigraphy

Objective sleep/wake patterns were assessed with wrist-worn actigraphy (Actiwatch 2 and Actiwatch Spectrum Plus, Philips Respironics Inc., Pittsburgh, PA). During each phase, participants were instructed to wear the Actiwatch on their nondominant hand for seven consecutive days. The use of the event marker was encouraged to indicate bedtimes and wake up times. Participants received instructions on how to use the Actiwatch and were provided with an information sheet for later referral.

Since adolescents are suggested to move more during sleep,[26] actigraphy data were processed using an optimized setting,[27] using a high-wake threshold (80 activity counts per epoch) and five immobile minutes (H5) for estimating the onset and offset of the nocturnal sleep period. The following variables were derived for school days and weekend days: bedtime, wake up time, TIB, total sleep time (TST), sleep onset latency, and sleep efficiency (SE). Bedtime was determined from the most informative combination of self-reported bedtimes (time-use diary), button presses, drop in light level, and drop in activity level.

Self-reported daily time usage

Self-reported daily time usage was measured for seven consecutive days using an in-house developed smartphone application, in which participants kept a chronological log of their daily activities (supplementary materials). To improve accuracy, participants could only fill in entries for events that took place within the past day. Text message reminders were sent daily to participants with missing data from the previous day. Those without smartphones or who were unable to install the application were given a paper diary to fill in in the same manner (baseline: n = 11, postintervention: n = 15, and follow-up: n = 20). Participants logged their activities for each 24-hour period at 5-minutes resolution by choosing from a given list of 13 primary activities (e.g., "School, homework & education") and subactivities (e.g., "Class" or "Homework"). "Media use" could be chosen as a primary activity (e.g., playing computer games for 75 minutes). The category "Secondary media use" encompassed the time spent in a primary activity such as transportation while using social media or playing games (e.g., spending 15 minutes texting during "Transportation"). Here, total daily media use will be reported, derived by aggregating primary and secondary media use. Self-reported TIB was derived from all episodes logged as "Sleep" at night. Days filled in with a single activity were excluded, as were incomplete days.

Health-related and other measures

The 11-item Kutcher Adolescent Depression Scale-[28] was used to measure severity of depression symptoms. Participants could opt to not answer a question about suicide. Higher scores relative to baseline indicate worsening depression symptoms, whereas lower scores suggest possible improvements.

Self-reported general health was assessed with the following question: "Compared to other people your age, would you say that your health is generally: Poor, Fair, Good, Excellent",[1] where higher scores indicate better health. The BMI (kg/m^2) was calculated based on self-reported height and weight. In addition, participants self-reported their grade point average (GPA).

Acceptability of the SEP

At the end of lesson 4, all SEP students were asked to fill in an anonymous online exit survey to assess their perceptions of the acceptability of the SEP. Students were asked to evaluate whether the program's aims were clear, how they experienced the content, and whether it contributed to changing their sleep behavior. Students also evaluated whether they thought the SEP should be implemented school-wide and to report reasons for not getting enough sleep.

Statistical analyses

Statistical analyses were performed with SPSS 25 (IBM Corp., Armonk, NY). Participants were included in the analyses if they provided data for at least two time points. Analyses were conducted on 88-99 participants from the SEP group and on 97-108 participants from the HLP group. Actigraphy data from two participants were removed at follow-up because of low SE (35.23% on school days and 55.67% on weekends) and reporting to school late on school days (> 2 h after school start time), respectively. For actigraphy and time use data, participants were only included in the analyses if they provided data for at least 3 school days and 1 weekend day, as measured over a period of one week for each time point. Sunday nights were considered school nights, as the following day was a school day, while Friday nights were considered weekend nights. Questionnaire data was cleaned to correct "unrealistic" data, such as implausible AM/PM entries in self-reported bedtimes or wake times.

The chi-square test and independent sample *t*-test were used to compare demographic characteristics at baseline between the SEP and the HLP groups. Linear mixed models, which can account for missing data, were used to determine the effects of group (SEP or HLP) and time (baseline, postintervention, and follow-up) on objective sleep, time use, sleep knowledge, and depression. Pairwise comparisons (Bonferroni-corrected) were used when significant main effects or interaction effects were found.

Results

Sample characteristics and depression

At baseline, groups did not differ in age, ethnicity, self-reported BMI, general health, and GPA (all *ps* > .05, Table 1). No differences between groups or time points were found for depression scores (all *ps* > .05, Table 2).

Table 1
Sample characteristics at baseline for each group

Characteristics	Sleep education		Healthy living		t/χ^2	*p*
	Mean/n	SD/%	Mean/n	SD/%		
Age	14.04	0.37	14.03	0.27	-0.344	.731
Ethnicity					4.131	.248
Chinese	81	79.4	92	85.2		
Indian	14	13.7	14	13.0		
Malaysian	4	3.9	2	1.9		
Other	3	2.9	0	0.0		
Body mass index	19.31	3.41	19.49	2.73	0.420	.675
General health	2.94	0.77	2.90	0.85	-0.393	.695
Grade point average	3.37	0.34	3.46	0.37	1.803	.073

SD = standard deviation.

Sleep knowledge

Relative to baseline, sleep knowledge increased postintervention and at follow-up (all *ps* < .001; mean ± standard error of the mean [SEM]: 9.13 ± 0.12 vs. 9.71 ± 0.12 vs. 9.74 ± 0.12, Table 2). The interaction effect indicated that participants from both groups had a higher sleep knowledge score after intervention than at baseline (SEP: *p* < .001; HLP: *p* = .027) and participants in the SEP group also had higher sleep knowledge scores at follow-up than at baseline (*p* < .001), whereas the HLP participants did not (*p* = .098). At follow-up, participants in the SEP group had a higher sleep knowledge score than the participants in the HLP group (*p* = .017).

Actigraphy

On school days, bedtime was slightly later from baseline to follow-up (mean ± SEM: 23:20 ± 00:03 vs. 23:32 ± 00:03, *p* < .001, Table 3) in both groups. No other significant differences between groups and time points were found for actigraphy variables on school days (all *ps* > .05).

On weekends, a significant main effect of time was found for TIB (*p* = .001) and TST (*p* = .002). There was a significant increase in TIB and TST from baseline to postintervention (mean ± SEM TIB: 8.66 ± 0.09 vs. 8.95 ± 0.09 hours, *p* = .004; TST: 7.79 ± 0.08 vs. 8.03 ± 0.08 hours, *p* = .007), which decreased again from postintervention to follow-up (mean ± SEM TIB: 8.65 ± 0.09 hours, *p* = .002; TST: 7.80 ± 0.08 hours, *p* = .007). This decrease was paired with a significant advance in bedtime from baseline to postintervention (*p* = .021), which was subsequently delayed at follow-up (*p* = .015; mean ± SEM: 00:08 ± 00:05 vs. 23:55 ± 00:05 vs. 00:09 ± 00:05). However, the nonsignificant Group × Time interaction showed that these changes did not differ between the SEP and the HLP groups. Although a statistically significant interaction was found for SE (*p* = .015), the group averages ranged only from 89.35% to 90.70% during the study, so any significant contrast would not bear meaningful clinical significance.

Self-reported daily time usage

School days

Self-reported TIB increased significantly from baseline to postintervention (*p* < .001), and decreased again at follow-up in both groups (*p* < .001; mean ± SEM: 7.08 ± 0.08 vs. 7.75 ± 0.08 vs. 7.07 ± 0.08 hours, Table 4). Time spent on media use decreased significantly from baseline to follow-up (*p* < .001) and from postintervention to follow-up (*p* = .004; mean ± SEM: 2.31 ± 0.11 vs. 2.13 ± 0.11 vs. 1.83 ± 0.11 hours) for all participants.

Table 2
Changes in sleep knowledge and depression scores from baseline to follow-up

Variable	Time point	Sleep education		Healthy living		Group		Time		Group × Time	
		Mean	SD	Mean	SD	F	p	F	p	F	p
Sleep knowledge	Baseline	9.14	(1.63)	9.11	(1.71)	2.581	.110	**18.950**	**<.001**	**3.142**	**.04**
	Postintervention	9.88	(1.98)	9.52	(1.59)						
	Follow-up	10.00	(1.76)	9.45	(1.83)						
Depression	Baseline	7.71	(5.47)	6.83	(5.24)	0.514	.474	0.710	.492	1.590	.205
	Postintervention	7.88	(6.05)	7.45	(5.26)						
	Follow-up	7.51	(6.23)	7.33	(5.65)						

SD = standard deviation.
Note. Significant main effects and interaction effects are highlighted in bold.

Participants spent more time on school, homework, and education at baseline and follow-up, than after intervention ($p = .018$ and $p < .001$, respectively; mean ± SEM: 10.11 ± 0.14 vs. 9.75 ± 0.14 vs. 10.83 ± 0.14 hours). Time spent on transportation decreased significantly from baseline and postintervention to follow-up ($p = .012$ and $p < .001$, respectively; mean ± SEM: 1.57 ± 0.04 vs. 1.63 ± 0.04 vs. 1.46 ± 0.04 hours). None of the two-way interactions were significant, indicating that the changes over time were similar between groups.

Weekends

Self-reported TIB decreased significantly from baseline to postintervention ($p < .001$), and increased again from postintervention to follow-up ($p < .001$; mean ± SEM: 9.33 ± 0.12 vs. 8.79 ± 0.12 vs. 9.51 ± 0.12 hours, Table 4). Time spent on media use decreased significantly from baseline to postintervention and follow-up (all *ps* < .001; mean ± SEM: 3.84 ± 0.18 vs. 2.73 ± 0.20 vs. 2.52 ± 0.19 hours). For school, homework, and education, time spent increased from successive time points (all *ps* < .001; mean ± SEM: 4.90 ± 0.19 vs. 6.09 ± 0.20 vs. 6.85 ± 0.19 hours). The interaction effect indicated that at baseline and follow-up, the HLP group spent more time on school, homework, and education than the SEP group ($p = .018$ and $p = .016$, respectively). All participants spent more time on transportation at baseline than after intervention ($p = .008$) and at follow-up ($p < .001$; mean ± SEM: 0.97 ± 0.06 vs. 0.78 ± 0.06 vs. 0.73 ± 0.06 hours).

Table 3
Changes in actigraphically measured sleep behavior from baseline to follow-up

Sleep measure	Time point	Sleep education		Healthy living		Group		Time		Group × Time	
		Mean	SD	Mean	SD	F	p	F	p	F	p
School days											
Bedtime (hh:mm)	Baseline	23:16	00:49	23:26	00:54	0.082	.774	**8.558**	**<.001**	2.620	.074
	Postintervention	23:26	00:56	23:24	00:52						
	Follow-up	23:33	00:52	23:30	00:54						
Wake up time (hh:mm)	Baseline	06:06	00:22	06:03	00:24	0.202	.653	2.976	.052	1.979	.140
	Postintervention	06:03	00:21	06:05	00:23						
	Follow-up	06:09	00:26	06:06	00:24						
Time in bed (hrs.)	Baseline	6.93	0.92	6.71	0.91	0.361	.549	3.002	.051	2.436	.089
	Postintervention	6.72	1.00	6.77	0.88						
	Follow-up	6.70	0.87	6.68	0.87						
Total sleep time (hrs.)	Baseline	6.16	0.82	6.00	0.84	0.075	.785	2.396	.092	2.332	.099
	Postintervention	5.96	0.88	6.06	0.81						
	Follow-up	5.99	0.76	5.98	0.79						
Sleep onset latency (min.)	Baseline	12.15	8.60	11.91	8.95	0.001	.974	0.691	.502	0.352	.703
	Postintervention	11.75	8.68	11.82	10.15						
	Follow-up	11.03	7.08	11.83	8.99						
Sleep efficiency (%)	Baseline	88.88	4.48	89.49	3.72	0.979	.324	0.849	.429	0.637	.530
	Postintervention	88.68	4.35	89.49	4.28						
	Follow-up	89.43	3.36	89.41	4.14						
Weekend											
Bedtime (hh:mm)	Baseline	00:11	01:29	00:07	01:15	0.210	.647	**5.081**	**.007**	0.066	.936
	Postintervention	23:55	01:06	23:52	01:02						
	Follow-up	00:11	01:09	00:06	01:17						
Wake up time (hh:mm)	Baseline	08:48	01:27	08:38	01:10	0.411	.522	0.314	.731	1.185	.307
	Postintervention	08:42	01:19	08:44	01:13						
	Follow-up	08:45	01:19	08:37	01:09						
Time in bed (hrs.)	Baseline	8.72	1.38	8.61	1.18	0.074	.786	**7.269**	**.001**	0.558	.573
	Postintervention	8.90	1.26	8.96	1.10						
	Follow-up	8.67	1.19	8.63	1.06						
Total sleep time (hrs.)	Baseline	7.80	1.21	7.80	1.08	0.061	.805	**6.244**	**.002**	1.128	.325
	Postintervention	7.94	1.01	8.10	1.01						
	Follow-up	7.83	1.08	7.77	0.90						
Sleep onset latency (min.)	Baseline	11.02	12.66	9.33	9.42	1.313	.253	0.483	.617	1.129	.325
	Postintervention	11.62	11.39	9.57	7.70						
	Follow-up	9.79	8.80	10.13	8.56						
Sleep efficiency (%)	Baseline	89.49	4.13	90.70	3.83	2.762	.098	0.812	.445	**4.262**	**.015**
	Postintervention	89.35	3.63	90.46	3.62						
	Follow-up	90.31	3.22	90.16	3.64						

SD = standard deviation.
Note. Significant main effects and interaction effects are highlighted in bold.

Table 4
Changes in self-reported time usage from baseline to follow-up

Activity (time spent in hours)	Time point	Sleep education		Healthy living		Group		Time		Group × Time	
		Mean	SD	Mean	SD	*F*	*p*	*F*	*p*	*F*	*p*
School days											
Self-reported nocturnal time in bed	Baseline	7.19	1.08	6.99	1.10	0.647	.422	**51.945**	<**.001**	0.704	.495
	Postintervention	7.72	0.96	7.71	1.15						
	Follow-up	7.13	1.00	7.05	1.00						
Media use	Baseline	2.34	1.37	2.30	1.42	0.157	.692	**15.040**	<**.001**	0.142	.867
	Postintervention	2.04	1.65	2.23	1.48						
	Follow-up	1.73	1.46	1.90	1.40						
School, homework & education	Baseline	9.95	1.94	10.25	1.77	0.013	.911	**36.763**	<**.001**	2.160	.117
	Postintervention	9.74	2.02	9.76	2.00						
	Follow-up	10.87	2.01	10.77	1.72						
Transportation	Baseline	1.55	0.56	1.59	0.56	0.738	.391	**11.165**	<**.001**	0.683	.506
	Postintervention	1.58	0.54	1.66	0.60						
	Follow-up	1.40	0.56	1.49	0.57						
Weekends											
Self-reported nocturnal time in bed	Baseline	9.30	1.58	9.32	1.49	0.233	.630	**16.593**	<**.001**	0.391	.677
	Postintervention	8.85	1.48	8.62	1.18						
	Follow-up	9.48	1.67	9.51	1.84						
Media use	Baseline	3.95	2.87	3.80	2.70	0.079	.779	**33.072**	<**.001**	0.105	.901
	Postintervention	2.83	2.30	2.81	2.39						
	Follow-up	2.57	2.41	2.43	2.23						
School, homework & education	Baseline	4.43	2.46	5.28	2.44	3.579	.060	**56.243**	<**.001**	**3.985**	**.019**
	Postintervention	6.11	2.46	6.05	2.55						
	Follow-up	6.42	2.84	7.28	2.99						
Transportation	Baseline	0.90	0.82	1.04	0.92	0.688	.408	**8.803**	<**.001**	0.747	.474
	Postintervention	0.76	0.66	0.85	0.61						
	Follow-up	0.75	0.82	0.72	0.69						

SD = standard deviation.
Note. Significant main effects and interaction effects are highlighted in bold.

Acceptability of the sleep education program

Most students (85.3%) felt the aims of the program were clear and the content easy to understand (74%). Over half of the students found the content interesting (56.6%) and the pacing of the lessons to be "just right" (57.6%). Most (70.1%) felt that it contributed to improving their sleep knowledge and found the strategies taught for increasing sleep opportunity useful (65%). Overall, 57.1% of the students thought the program should be implemented school-wide, suggesting that students were generally receptive to the program. In terms of behavioral change, the majority (63.8%) indicated that the program could help them change their future sleep behavior, and that they intended to use the strategies to create more time for sleep. In total, 27.7% of respondents felt that although they had learned from the program, they would have difficulty changing their sleep behavior, and the remaining 8.5% felt that they had not learned very much and did not think that the program could contribute to changing their behavior. Self-reported reasons (open-ended feedback) for not being able to get sufficient sleep included school and homework, electronic media use, and transportation time.

Discussion

The interactive school-based SEP evaluated in the present study aimed to educate secondary school students about sleep and to motivate them to increase their sleep opportunity, by providing them with strategies for better time management. In line with previous research, the program resulted in 1-month improvement in sleep knowledge in the sleep education group, but not in the active control group.[14,17,18] Furthermore, students were receptive to the SEP and indicated the intention to use the strategies to create more time for sleep. No changes in objective sleep behavior were found following the SEP, although a modest benefit might have been masked by exam preparation in the follow-up phase. No changes in depression scores were found.

Interestingly, both groups slept longer on weekend nights at postintervention than at baseline and follow-up, as measured by actigraphy, whereas self-reported TIB derived from the time use diary indicated the opposite. Self-reported TIB was longer than objectively measured TIB, which is in line with previous research indicating an overestimation of subjective compared with objective sleep duration.[29] Both groups spent significantly less time on media use at postintervention and follow-up. Although less electronic device use is related to more sleep in adolescents,[11] this change did not result in longer sleep here. Instead, compared with baseline, participants spent more time on other activities, such as homework.

Although this study was small-scale, including one school, and results presented here are preliminary, similar to previous sleep education studies,[30,31] the current findings highlight the difficulty in effecting behavioral change in adolescents. No changes in sleep behavior were found at the postintervention assessment; however, it may take more time for behavioral change to emerge in the current sample. Although sleep behavior did not change at follow-up, delayed benefits of the SEP may have been masked by students' exam preparation. This can be seen in the form of almost an hour of increased study time during weekdays in the follow-up period compared with baseline and postintervention periods (discussed further in the following paragraphs).

One contributor to shortened sleep in adolescents is the change in biological clock in this age group, pushing back their naturally preferred bedtime.[9,10] Although biological influences on sleep may be relatively immutable, adolescents in Asian societies have even later bedtimes on school days than Australasian and European students, suggesting cultural factors contributing to shortened sleep in Asian teenagers.[8] While sleep can be impacted by a variety of behaviors, including physical activity, diet, alcohol use and mental health, reasons reported by students in the present study for getting insufficient sleep include school and homework, electronic media use, and transportation time, which is in line with findings from adult populations.[23] Because school (work) and transportation time may be difficult to change, media use may be the best factor to target. Electronic media use in school-aged children and adolescents is related to later bedtimes and shorter total sleep time. Media use is suggested to affect sleep behavior through displacement of sleep, increased physiological arousal associated with playing games, and suppression of melatonin due to evening bright light exposure.[32] SEPs may benefit from emphasizing the consequences of late-night media use on sleep and encouraging students to decrease their media use at this time of day.[33]

The complexity of the issue suggests that educating adolescents on the importance of sleep alone might not be enough to change behavior, even after providing them with strategies to increase their sleep opportunity. Delaying school start times can result in increased sleep duration in secondary school students [12,34,35] and is associated with improvements in well-being,[12] lower BMI,[36] higher grades, and increased attendance.[35] This strategy may be particularly beneficial in countries where schools start relatively early, such as East Asian countries (07:30 for the partnering school here). In addition, parental guidance may encourage healthy sleep behavior in children. Adolescents with less bedtime autonomy tend to sleep more,[1,11,37] have earlier bedtimes, and experience less daytime sleepiness.[37] Thus, the key to increasing sleep duration in adolescents may lie in a combination of sleep education, later school start times, and parental involvement strategies. Bonnar et al[38] adopted a motivational SEP, which, combined with parental involvement and bright-light therapy, led to improved outcomes. The involvement of parents may be crucial in highly competitive societies such as Singapore where sleep has a relatively low priority, as parental beliefs are likely to reflect on their children.

Strengths of the present study include the objective measurement of sleep in all participants and the implementation of a cluster-randomized controlled trial with an active control program in students from the same school, with classroom teachers delivering the materials. Having a control group from the same school allows for more control over the delivery of the lesson program and the data collection. Although randomization at the class level could result in contamination, as demonstrated previously, [17] it is unlikely that participants from different groups discussed the content with each other.

The present study does not come without limitations. To implement the study in the school curriculum, the time points for data collection had to fit around the school calendar. The week of postintervention data collection included a public holiday that took place on one of the weekdays and the timing was not ideal in terms of consistency of academic load. The follow-up data collection took place two weeks before the exam week, and the pressure of the upcoming exams likely led students to sacrifice sleep for studying. Although both groups increased study time to the same extent, students who might have been persuaded to sleep more under other circumstances may have been dissuaded from doing so because of pressure to study. Furthermore, multiple teachers delivered the materials, differences in teaching styles may have influenced discussion of topics during the lessons. Additional limitations include the absence of a "don't know" response in the measure of sleep knowledge, which would have enabled more accurate reflections of sleep knowledge and the self-report nature of the assessment of acceptability of the program, which may have been subjected to response bias. Finally, time management skills were not measured objectively, and the study was conducted in an all-boys school. Numerous schools, including mixed-gender schools were approached to participate in the current study, however, only the partnering school agreed to join. Although obstacles such as finding schools willing to invest time and resources to execute such studies are not unique to the present study, [39,40] it is acknowledged that this may limit generalizability of the current findings to other contexts.

Conclusions

The SEP introduced in the present study improved sleep knowledge and was moderately well-received by the students. It did not lead to changes in sleep behavior, although delayed effects could have been masked by exam preparations taking place at the follow-up assessment. Future studies should focus on further identifying what factors prevent adolescents from getting sufficient sleep. To increase the effectiveness of SEPs, it is suggested to combine sleep education with later school start times and increased parental involvement. For behavioral change to happen in this population, it is crucial that students personally reevaluate the importance of sleep.

Disclosure

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Appendix A. Supplementary Data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.sleh.2019.10.006.

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