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Evaluation of novel school-based interventions for adolescent sleep problems: does parental involvement and bright light improve outcomes?☆

Daniel Bonnar, MPsych(Clin) [a], Michael Gradisar, PhD [a,*], Lynette Moseley, MPsych(Clin) [a], Anne-Marie Coughlin, PhD, ClinPsych [a], Neralie Cain, MPsych(Clin) [a], Michelle A. Short, PhD [b]

[a] Flinders University, School of Psychology, Adelaide, South Australia, Australia
[b] Centre for Sleep Research, University of South Australia, Adelaide, South Australia, Australia

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ABSTRACT

Objectives: The current study aimed to evaluate school-based motivational sleep education programs (SEPs) with adjunct bright light therapy (BLT) and/or parental involvement (PI).
Design: Randomized controlled trial.
Setting: Six high schools, matched on socio-economic status (SES).
Participants: A total of 193 adolescents (mean age, 16.3 ± 0.4 years, 79%f).
Intervention: Classes were randomly assigned to (i) SEP + BLT, (ii) SEP + PI, (iii) SEP + BLT + PI, or (iv) classes-as-usual (CAU). Sleep education programs involved 4 × 50 minute classes (over 4 weeks) based on a Motivational Interviewing framework (*Sleep Med* 2011;12:246-251). Students in BLT groups attempted a weekend phase advance using portable green light LED glasses (500 nm; 506 lux). Parents of PI groups watched a series of 4 YouTube clips (2-3 minutes in length) outlining their adolescent's learning in class and how they could assist. Students in the CAU groups continued their regular classes.
Measurements: Online questionnaires measuring sleep knowledge, sleep patterns (bedtime, sleep latency, total sleep time [TST], etc) and mood at preintervention and postintervention and 6-week follow-up. Intervention groups also completed a motivation-to-change questionnaire and provided qualitative feedback.
Results: Improvements in sleep knowledge ($d = 0.59$-0.88), sleep onset latency ($d = 0.45$-0.50), TST ($d = 0.32$-0.57), and mood ($d = 0.24$-0.46) were observed in all intervention groups relative to the CAU group. Similar improvements were observed in a subgroup of students identified as having delayed sleep timing (ie, sleep knowledge: $d = 0.45$-0.92; sleep onset latency: $d = 0.59$-0.82; TST: $d = 0.82$-1.18). Increases in motivation to regularize out of bedtimes, obtain morning bright light (BLT groups), and avoid sleeping-in on weekends occurred (all $P < .005$).
Conclusions: This motivational SEP produced meaningful and similar benefits for adolescents in all intervention groups. Longer BLT (ie, over school holidays) and more intensive parental inclusion should be investigated in future studies.

Introduction

A primary biologic regulatory process causing late sleep times during adolescence is delayed circadian timing, whereby the 24-hour circadian rhythm delays during adolescent development.[1] Psychosocial pressures (eg, study, part-time work, and peer influence) have been found to further compound adolescents' late sleep times.[2,3] Consequently, adolescents' can obtain insufficient sleep when late sleep times combine with early school start times.[4] To relieve accumulated sleep debt incurred during the school week, adolescents often sleep in on weekends.[1,2,5] Unfortunately, weekend sleep-ins prevent morning bright light (BL) exposure, which can help to regulate circadian rhythms and sleep timing.[1,6-8] Hence, a vicious cycle of delayed sleep timing and chronic sleep restriction can develop.

Delayed sleep timing and associated sleep restriction during adolescence are associated with a number of short-term consequences and long-term negative health consequences, including

☆ Australian New Zealand Clinical Trials Registry: ACTRN12613000975796.
* Corresponding author at: Flinders University, School of Psychology, GPO Box 2100, Adelaide, SA, 5001, Australia. Tel.: +61 8 82012192; fax: +61 8 82013877.
E-mail address: grad0011@flinders.edu.au (M. Gradisar).

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excessive sleepiness,[9] poor academic performance,[10] school non-attendance,[11] depressed mood,[12-14] and an increased risk of car accidents.[15] Hence, the significant impact from adolescent sleep difficulties highlights the need for appropriate interventions.

The widespread nature of adolescent sleep problems has prompted some researchers to suggest that this issue should be addressed within a public health framework rather than on an individual basis.[3,4] The school classroom and sleep education programs (SEPs) have been proposed as an ideal setting to modify and improve adolescents' sleep.[3,16] Accordingly, several studies have devised and implemented SEPs but have thus far shown little efficacy.[3] Most of these studies are also subject to methodological shortcomings such as small sample size, no control group, and/or no follow-up.[17-22] In an earlier study, Moseley and Gradisar[16] attempted to overcome these issues and trialed a cognitive-behavioral–based SEP with 81 high school students. Although students in the intervention increased their sleep knowledge and regularized their delayed sleep timing at postintervention, no long-term behavioral change occurred (at 6-week follow-up). A key finding was that adolescents were not motivated to change sleep behaviors.

To address the issue of low intrinsic motivation, Cain et al[23] adapted Moseley and Gradisar's[16] SEP to fit a motivational interviewing (MI) framework.[24,25] Results from 104 adolescents showed students in the SEP condition increased their sleep knowledge, and this time was motivated to increase sleep duration and regularize bedtimes relative to classes-as-usual students (CAU; the control condition). However, no significant improvements in sleep behaviors or mood were found. Two important findings from these studies were: (i) although students knew it was important to make behavioral changes (eg, regularize sleep timing), they were not confident in doing so, and (ii) students were reluctant to spend time outside obtaining BL to regulate sleep timing. To improve treatment outcomes in MI-structured SEP programs, additional support in these 2 areas is required.

One method of overcoming low confidence to affect change is to provide support from significant others.[23,25] Parental support could be incorporated into SEPs to increase adolescents' confidence in making and maintaining successful sleep-related behavioral change.[3] Evidence from clinical trials suggests that parental involvement (PI) in the regulation of adolescent sleep practices produces positive outcomes.[6] However, parent involvement in these studies typically consists of strict enforcement measures, such as parent-set bedtimes.[26] In contrast, it has been suggested that SEPs should aim to create environments in which adolescents feel supported by their parents to endorse healthier sleep practices while maintaining a sense of autonomy.[3] One possible way of achieving this objective is to provide sleep education to parents using a noninvasive method (eg, online videos) and encourage them to assist or engage in dialog if requested by their teenage child. Accordingly, one aim of the current study was to investigate whether the inclusion of parents in SEPs improved sleep and mood outcomes for students.

Bright light therapy (BLT) is a common intervention used to regularize the sleep patterns of adolescents with delayed sleep timing.[6-8,27] Incremental advances of wake-up time with immediate exposure to BL advances delayed circadian rhythms, thereby improving the timing of sleep patterns (ie, individuals fall asleep and wake up earlier).[28-31] Considering students are mostly unwilling to spend time outside immediately after waking, an alternative novel source of BL (eg, portable light devices) could better enable students to "re-time" their sleep patterns. Although BL devices have been used effectively with adolescents in clinical trials,[6-8,27] they have not yet been used in an SEP. Thus, a second aim of the current study was to evaluate whether including BL in an MI-structured SEP program would lead to improved outcomes.

The primary motive of the SEPs in the present study is to increase sleep knowledge and motivation-to-change sleep behaviors (eg, reducing weekend sleep-ins) to improve adolescents' sleep (ie, bedtimes, sleep onset latency, and total sleep time [TST]). However, it is also important to assess functional outcomes of sleep improvements.[32] Depressed mood has been recently quantified as likely stemming from sleep disturbance during adolescence.[13] Given the significant impact of both sleep and mood on adolescent morbidity and mortality,[33,34] the present study will investigate whether SEPs also improve depressed mood. Investigations will center on comparisons between adolescents in SEP classes vs CAU (control condition), as well as performing analyses on a subgroup of adolescents with delayed sleep timing.

Method

Participants

Participants were 193 year 11 students (mean age, 16.3 ± 0.4 years; 79%f) from 5 coeducational schools and 1 all-girls school in the Adelaide metropolitan area. Schools were matched on SES. The mode school start and end times were 8:40 am and 3:15 PM, respectively. Two classes from each school participated, acting as either a CAU (n = 52) or 1 of 3 intervention conditions: SEP + PI (n = 63), SEP + BL (n = 35), or SEP + PI + BL (n = 43). Figure 1 presents participant flow through the study. Year 11 students were selected for this study due to the increased occurrence and frequency of sleep difficulties in older adolescence,[5] while not having the workload associated with the final year of secondary schooling. As the SEP was interested in regularizing the sleep patterns of adolescents whose sleep timing was delayed, a subclinical group of students with delayed sleep timing (DST) (n = 88) was identified.[16,23] The 2 criteria selected to identify these students were discrepant weekday-weekend out-of-bedtimes (>2 hours) and reduced sleep duration on school nights (<8 hours). The only exclusion criterion was atypical development (ie, autism spectrum disorder, IQ disability); however, no students met this criterion. Seven students (4%) reported taking medications known to affect sleep, including antidepressants (n = 5), dexamphetamine (n = 1), and occasionally sleeping tablets (n = 1). Students were asked to make no changes to their medication use during the study. The study was approved by both the Southern Adelaide Clinical Human Research Ethics Committee and the Ethics Committee of the Department of Education and Child Development, South Australia.

Design

The study used a 4 (program: SEP + PI, SEP + BL, SEP + PI + BL, CAU) × 3 (time: preintervention, postintervention, 6-week follow-up) mixed-model design. Primary outcome measures were bedtime, TST, sleep onset latency (SOL) on school nights, and the secondary outcome of depressed mood.

Measures

Sleep knowledge

Sleep knowledge was measured using a quiz adapted from Cain et al.[23] Adolescents answered true, false, or don't know to 16 items relating to information about adolescent sleep. Correct answers were scored 1 and incorrect and "don't know" responses as 0. All groups completed the quiz preintervention and postintervention. Participants were not told they would be completing the quiz a second time so as to prevent studying. Internal consistency was $\alpha = .55$.

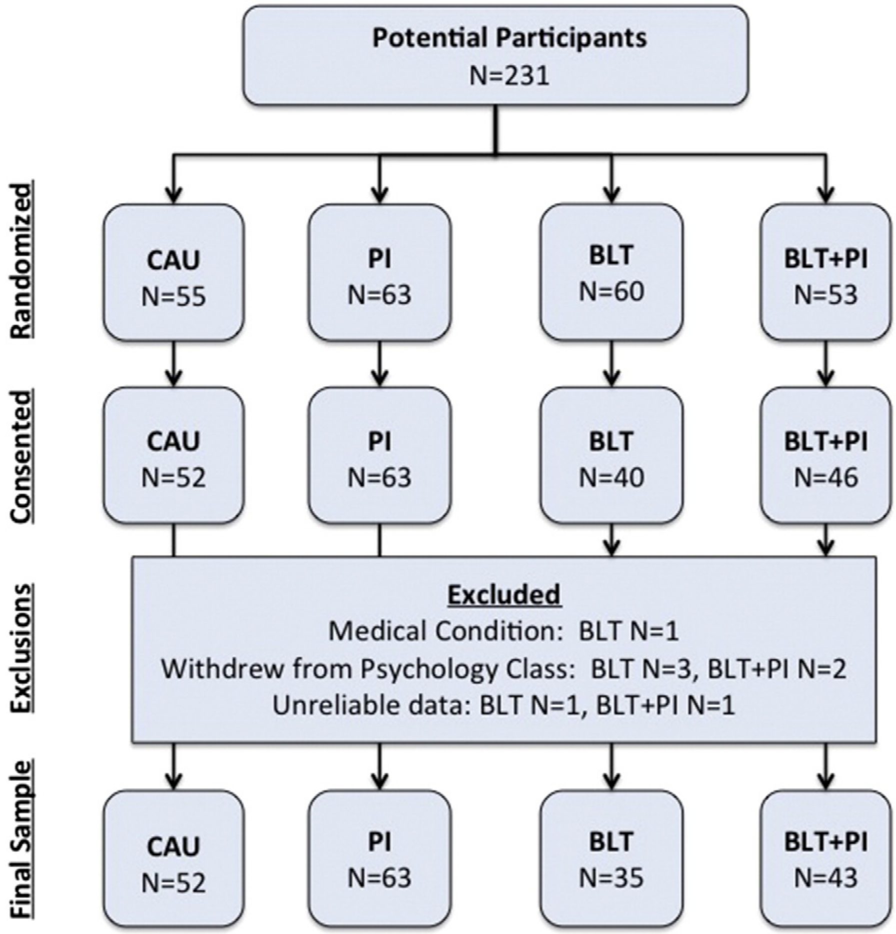

Fig. 1. Participant flow through the study.

Sleep patterns

A Sleep Patterns Questionnaire[16,23] was administered to assess students' self-reported sleep habits over the previous week (ie, school nights, Sunday to Thursday; weekend nights, Friday and Saturday). Questions measured typical bedtime, lights-out time, sleep onset latency, TST, wake-up time, and out of bedtime. This information was also used to calculate the discrepancy between weekday and weekend out-of-bedtimes for the delayed sleep timing subgroup.

Depression

The Short Mood and Feelings Questionnaire (SMFQ)[35] was used to measure symptoms of depression, due to the link between reduced sleep duration and depression in adolescents.[13,14,36] The SMFQ is a 13-item self-report measure, with each item rated on a 3-point Likert scale (0, not true; 1, sometimes; 2, true). A total score (0-26) is obtained by summing responses to all items, with higher scores indicating greater frequency of depression symptoms. The SMFQ is responsive to improvements in adolescents' sleep.[6] The internal consistency in the current study was $\alpha = .89$.

Motivation

The Behavioural Intentions Questionnaire was adapted from Cain et al[23] and used to assess students' motivation to change targeted sleep behaviors. It is based on the on the 5 stages of change model, as outlined in the Transtheoretical Model of Behaviour Change.[24] The Behavioural Intentions Questionnaire is a 5-item self-report measure in which respondents select commitment language statements[37] that indicate their intention for behavioral change (0, I don't plan to; 1, I want to; 2, I need to; 3, I will; 4, I already do; 5, I tried to). Students in the intervention groups completed the questionnaire before and after their motivational exercises (ie, lessons 2 and 3).

Portable light devices

Students in both the BLT and BLT + PI groups were provided with a pair of re-timers (re-timer.com) to help phase advance their sleep timing. Re-timers are worn like a pair of glasses, with 2 LEDs per eye, emitting constant diffused green light (500 nm, 506 lux). Portable green light has been found to be effective in phase advancing circadian timing.[38] Students asked to report the days they attempted to phase advance using the re-timers as well as the duration of use. The number of students who attempted a phase advance decreased over the weekend (Saturday: 74%; Sunday: 67%). On average, the amount of time BL was obtained marginally increased (Saturday: 29 minutes; Sunday: 34 minutes).

Procedure

School principals were approached, and permission was obtained to conduct SEPs in their school. Two classes were provided by each school and randomly assigned to either the CAU condition or 1 of 3 intervention conditions (see below for details). Usual class teachers distributed information sheets and parental consent forms to be signed by parents and countersigned by students. The consent form return rate was 87%. All students participated in the SEP, but data were only analyzed for those who returned consent forms.

All students completed an online questionnaire battery at 3 time points (preintervention, postintervention, and 6-week follow-up). The questionnaires assessed students' sleep knowledge, sleep patterns, mood, and motivation-to-change sleep-related behaviors. One week after baseline data were collected, students in the intervention conditions commenced the sleep education classes (see Appendix A for lesson outlines). Classes were 50 minutes in length, held once per week for 4 consecutive weeks, and conducted by qualified school teachers who were also registered psychologists trained in MI (authors LM and A-MC). Classes were adapted from Cain et al[23] but modified to reflect the addition of parental involvement and BL devices. For example, in the SEP + PI condition, all information regarding BL was excluded, whereas information regarding BL was tailored to incorporate the use of re-timers in the SEP + BL and SEP + PI + BL conditions. Data were collected from February 2014 to May 2014.

SEP + PI

In addition to the sleep education classes outlined in Cain et al,[23] a series of 4 YouTube videos containing a mixture of diagrams typically used in sleep education (eg, case study sleep diaries) interlaced with video commentaries (by author MG) were accessible to parents once a week during the course of the program. Video content was derived from the scientific literature (eg, sleep problems associated with decreased academic performance[10]) and coincided with information taught in the classes to students. Video lengths ranged between 2 and 4 minutes to make them easily accessible for the busiest of parents, who were e-mailed the video Web links. Videos in this condition were identical to the combined condition with the exception of lesson 3's video that included information about the benefits of incrementally waking up earlier in dim light for the SEP + PI group. Thus, no information regarding BL was included in the SEP + PI video.

On the third weekend of the sleep program, between lessons 3 and 4, students were instructed to incrementally advance their wake up time by 30 minutes each day and stay in dim light for 30 to 60 minutes immediately after waking. For example, if a student's typical Saturday wake-up time was 10 AM, they would wake on Saturday at 9:30 AM and then on Sunday at 9 AM, staying in dim light on both occasions. Dim light requirements included keeping curtains closed, dimming overhead lights or keeping indoor lights off, using devices with dimmed screens,[39,40] and wearing sunglasses if going outside in the first hour after waking. This behavioral experiment allowed the SEP + PI condition to act as a control for the SEP + PI + BL condition, as it is important to determine if any potential benefits found in the SEP + BL condition was due to BL or simply waking up earlier.[7,8]

SEP + BL

In addition to the sleep education classes, portable light devices (ie, re-timers) were distributed to students in lesson 3 for use on the third weekend of the SEP. Students were instructed to incrementally advance their wake-up time over the weekend by 30 minutes each day and use the re-timers for 30 to 60 minutes immediately after waking. In cases where a student's weekday and weekend wake-up times did not differ, students were instructed to maintain their sleep schedule but still use the re-timers when they awoke. Some students reported typically waking up earlier on one day of the weekend (eg, Saturday for sport), but not the other. In these instances, students were instructed to only advance their wake-up time and use the re-timers for the day they usually slept in past their weekday rise time (eg, Sunday). Parents of students in this condition did not have access to parental videos.

SEP + PI + BL

In addition to the sleep education classes, parents had access to YouTube videos, and students used the re-timers on the third weekend of the of the SEP. Videos in this condition were the same as in the SEP + PI condition with the exception of lesson 3's video, which included information about the behavioral experiment their adolescent was participating and the rationale and operation procedure for using the re-timers.

Of the total 106 potential parent participants in the SEP + PI and SEP + PI + BLT groups, the numbers of views for each of the YouTube videos were 86, 67, 59, and 44. The average minutes watched were lower than each video length in each case: week 1, average 1:34 minutes watched (of 2:01 minutes); week 2, 2:52 minutes (of 3:19 minutes); week 3, 2:19 minutes (of 2:43 minutes); week 4, 1:44 minutes (of 2:04 minutes). Therefore, not all parents watched the videos, and all videos were not watched in their entirety.

Statistical analyses

Before commencing data analyses, data for all variables were inspected for missing values and outliers. Consequently, a further 2 students were excluded based on their responses being considered unreliable. All quantitative data analyses were conducted using the SPSS (version 22; SPSS, Chicago, IL), and an α level of .05 was used. Linear mixed-model regressions were used to analyze primary and secondary outcome variables. Effect sizes of negligible ($d < 0.20$), small ($d = 0.20$-0.49), moderate ($d = 0.50$-0.79), and large ($d > 0.80$) were calculated.[41] Nonparametric χ^2 analyses were used to examine variations in students' motivation-to-change sleep behaviors between lessons 2 and 3. Qualitative data were categorized according to emerging themes by authors DB and MG.

Results

3.1. Effects of SEP (whole class)

For sleep knowledge, there was a significant interaction, $F(1,11) = 5.54$, $P = .001$. From preintervention to postintervention, there was a negligible change for the CAU group ($d = 0.06$), whereas there were medium-to-large improvements in each of the intervention groups (PI: $d = 0.59$; BLT: $d = 0.88$; BLT + PI: $d = 0.81$). The intervention groups' sleep knowledge improved, on average, by 10.6% at postintervention, whereas the CAU group improved by 1%.

For primary outcome variables, there was no significant interaction for bedtime on school nights, $F(1,11) = 1.75$, $P = .065$ (see Fig. 2A), yet there was for sleep onset latency (SOL), $F(1,11) = 1.76$, $P < .0001$ (see Fig. 2B). From preintervention to postintervention, there was a negligible SOL change for the CAU group ($d = 0.15$), whereas there were small-to-moderate improvements in each of the intervention groups (PI: $d = 0.45$; BLT: $d = 0.47$; BLT + PI: $d = 0.50$). Figure 2B shows that the intervention groups improved, on average, by 14.6 minutes at postintervention, whereas the CAU group improved by 5.9 minutes. From postintervention to the 6-week follow-up, there was a negligible change in SOL for all 3 intervention groups, and a negligible change for the CAU group.

There was a significant interaction for TST on school nights, $F(1,11) = 5.68$, $P < .0001$ (see Fig. 2C). From preintervention to postintervention, there was a negligible change for the CAU group ($d = 0.08$), whereas there were small-to-moderate improvements in each of the intervention groups (PI: $d = 0.53$; BLT: $d = 0.32$; BLT + PI: $d = 0.57$). Figure 2C shows that the intervention groups improved, on average, by 27 minutes at postintervention, whereas the CAU improved by 5 minutes. From postintervention to follow-up, there was a negligible change in TST for the PI and PI + BLT group and a negligible change for the CAU group. A further small improvement was observed in the BLT group ($d = 0.30$).

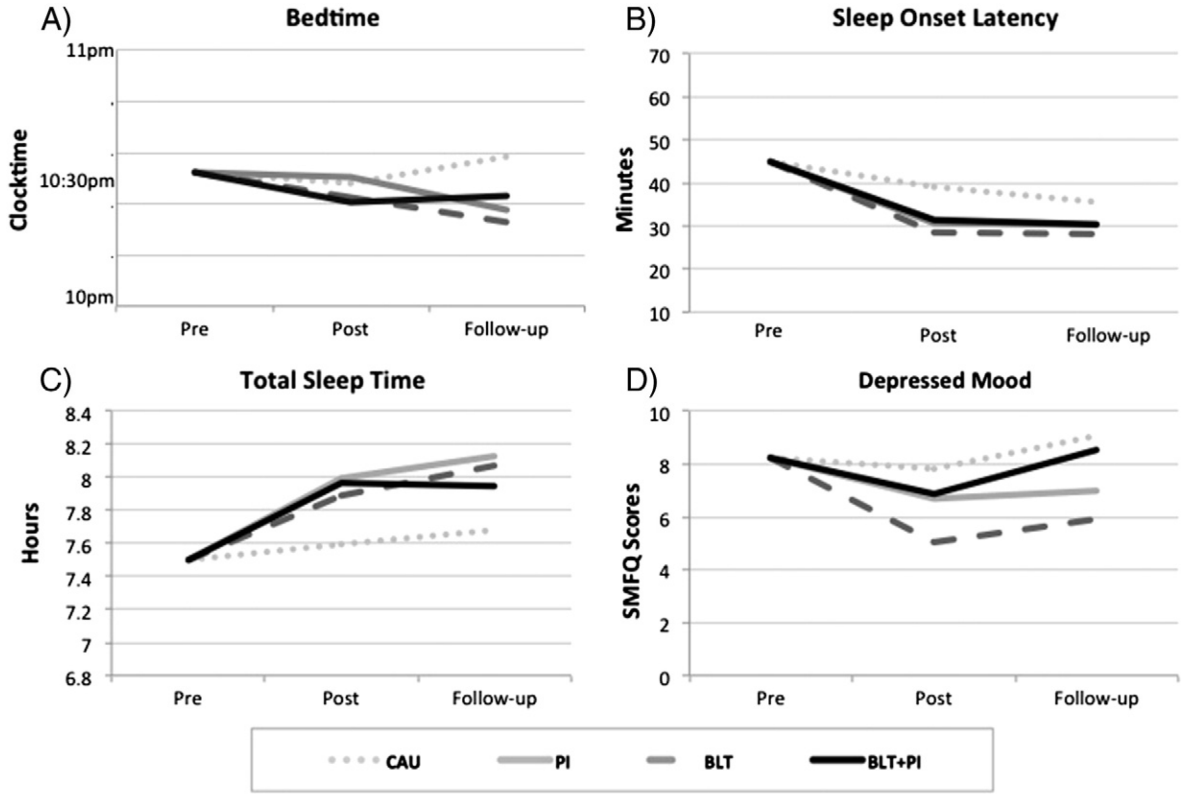

Fig. 2. Changes in sleep behaviors and depressed mood for the whole class.

For the secondary outcome of depressed mood, there was a significant interaction, $F(1,11) = 2.74$, $P = .003$ (see Fig. 2D). From preintervention to postintervention, there was a negligible change for the CAU group ($d = 0.02$) yet small improvements in each of the intervention groups (PI: $d = 0.27$; BLT: $d = 0.46$; BLT + PI: $d = 0.24$). The intervention groups improved, on average, by 7.8% at postintervention, whereas the CAU group improved by 1.6% (Fig. 2D). From postintervention to follow-up, there was a negligible change in depressed mood for the CAU group and the PI and BLT intervention groups. However, the improvements observed postintervention for the BLT + PI group were not maintained and increased to preintervention levels.

Effects of SEP (delayed sleep timing subgroup)

For sleep knowledge, there was a significant interaction, $F(1,11) = 2.87$, $P = .042$. From preintervention to postintervention, there was a negligible change in the CAU group ($d = 0.09$), whereas there were medium-to-large increases in each of the intervention groups (PI: $d = 0.72$; BLT: $d = 0.45$; BLT + PI: $d = 0.92$). The intervention groups improved, on average, by 10% at postintervention, whereas the CAU group improved by <1%.

Similar to the findings for the whole class, there was no significant interaction for bedtime on school nights for the DST students, $F(1,11) = 1.08$, $P = .38$ (see Fig. 3A). However, for SOL, there was a significant interaction, $F(1,11) = 3.74$, $P < .0001$ (Fig. 3B). From preintervention to postintervention, there was a small change for the CAU group ($d = 0.33$), yet medium or large changes in each of the intervention groups (PI: $d = 0.59$; BLT: $d = 0.72$; BLT + PI: $d = 0.82$). Figure 3B shows that the intervention groups improved, on average, by 23 minutes at postintervention, whereas the CAU group improved by 12.6 minutes. From postintervention to follow-up, there was a negligible change in SOL for all 3 intervention groups and a negligible change for the CAU group.

Total sleep time on school nights also showed a significant interaction for the DST students, $F(1,11) = 6.02$, $P < .0001$ (Fig. 3C). From preintervention to postintervention, there was a small change for the CAU group ($d = 0.24$) and large improvements in each of the intervention groups (PI: $d = 1.18$; BLT: $d = 0.82$; BLT + PI: $d = 1.13$). Figure 3C shows that the intervention groups improved, on average, by 45 minutes at postintervention, whereas the CAU group improved by 15.6 minutes. From postintervention to follow-up, there was a negligible change in TST for the CAU group and also in the PI and BLT + PI groups. However, a further small improvement was found in the BLT group ($d = 0.24$). Finally, for depressed mood, there was no significant interaction, $F(1, 11) = 0.89$, $P = .55$ (Fig. 3D).

Intervention groups: motivation (whole class)

Motivation to get up at the same time everyday improved during the program for the whole class, $\chi^2(5) = 14.65$, $P = .012$, and DST students, $\chi^2(5) = 11.12$, $P = .049$, with a decrease in the number of students endorsing the statement, "I don't plan to" (whole class: 22.4% vs 16%; DST: 22.2% vs 14.8%), and an increase in the response rate for all other categories for the whole class (eg, "I want to", "I need to", "I will", etc) but only "I tried to" for DST students (11.1% vs 20.4%). There was no change in students' motivation to increase TST during the program (whole class) $\chi^2(5) = 8.17$, $P = .15$; (DST students) $\chi^2(5) = 10.17$, $P = .07$. Motivation to avoid sleeping-in on weekends more than 2 hours past their normal school-day wake-up time improved during the program for the whole class, $\chi^2(5) = 27.55$, $P < .001$, and DST students, $\chi^2(5) = 13.65$, $P = .018$, with a decrease in the number of students reporting "I don't plan to" (whole class, 29.6% vs 16.8%; DST students, 33.3% vs 20.4%) and an increase in students responding "I need to" for the whole class (8.8% vs 17.6%) and increases in all other categories for the DST students. Finally, motivation to spend at least 30 minutes getting BL

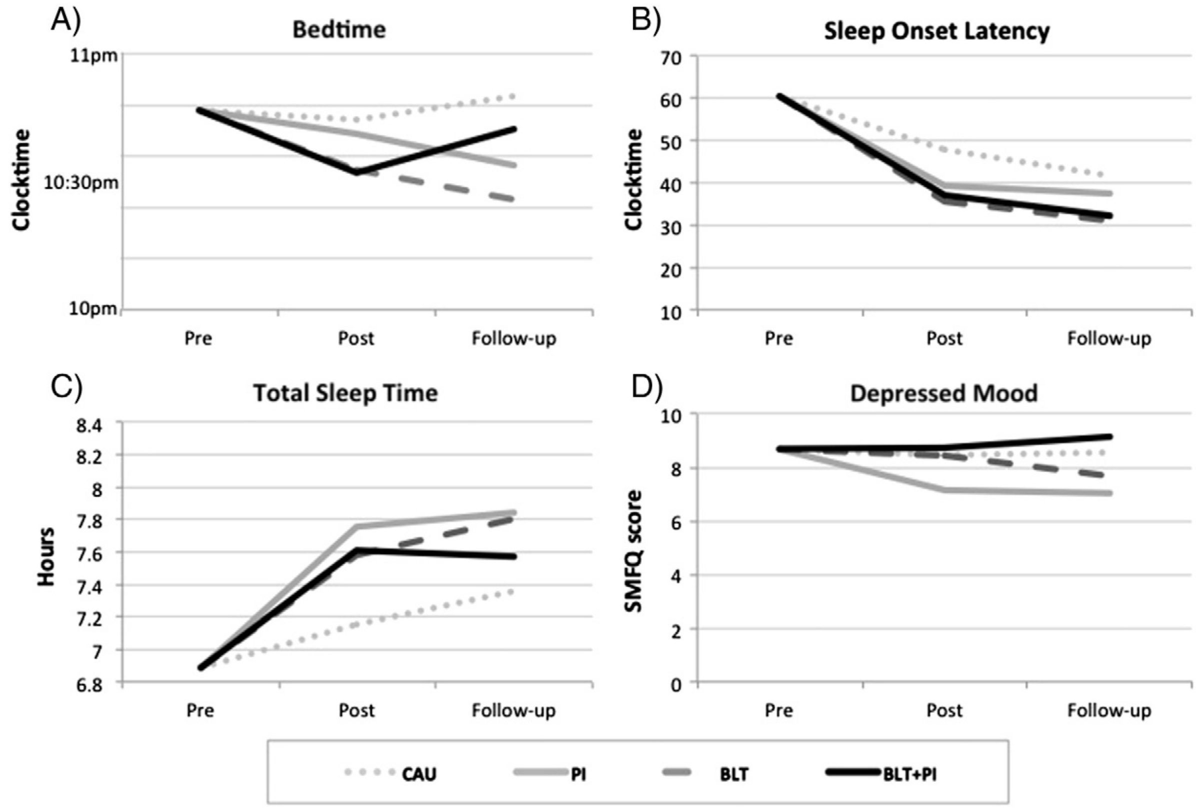

Fig. 3. Changes in sleep behaviors and depressed mood for DST students.

after waking (even on weekends) increased for the whole class, $\chi^2(5) = 16.70$, $P < .005$, and DST students, $\chi^2(5) = 22.06$, $P = .001$, with a decrease in the number of students reporting "I don't plan to" (whole class, 16.9% vs 7.7%; DST students, 7.9% vs 7.1%) and an increase in students responding "I will" for the whole class (7.7% vs 15.4%) and "I tried to" (3.6% vs 17.9%) for DST students.

Program feedback (students and teachers)

At postprogram, students provided qualitative feedback regarding what they had learned. Responses were categorized into 2 main themes: information about sleep (75%) and practical sleep tips (63.5%), for example, "I've learnt ways that I can improve my sleep and how not getting enough sleep can affect me"; "I've learnt why sleep is important and ways to get better/more sleep." Students also provided possible improvements to the program. Although some indicated no changes (25%), many suggested increasing interactive class activities (43%). Updated lesson materials (ie, newer videos) and changes in lesson implementation (eg, more frequent lessons) were also cited (20%), as was a more gradual approach in advancing weekend wake-up times (5%). A small number of students (9%) in the BL conditions (ie, BLT and BLT + PI) recommended using the re-timers for a longer period, whereas others said they should be removed from the program (4%). Although some students reported experiencing no changes in their sleep (15.6%) or responded "N/A" (11.3%), a proportion reported feeling less tired/more alert during the day (38.2%). Other categories included finding it easier to wake-up in the morning (11.3%), reduced SOL (6.9%), improved mood (6%), increased TST (5.2%), earlier bedtimes (2.6%), and feeling worse (2.6%). Finally, using a 5-point scale, students rated the program as being interesting ($M = 3.8 \pm 0.7$), informative ($M = 4.1 \pm 0.8$), enjoyable ($M = 3.8 \pm 0.7$), and clear ($M = 4.3 \pm 0.8$).

All teachers ($n = 9$) agreed the program presented relevant material (eg, "identifying sleep needs and methods of addressing sleep issues") not previously covered in the school curriculum and was best delivered by an individual qualified as both a teacher and registered psychologist. To further improve the program, teachers suggested negotiating with the school timetable more effectively, longer follow-up, providing students with more detailed information about the light devices, extending BLT, and more formal parental involvement (ie, face to face).

Discussion

The current study evaluated novel school-based sleep education programs using adjunct BLT and/or parental involvement within an MI framework. Contrary to our previous studies[16,23] and work by other groups,[17-21,42] students not only improved their sleep knowledge but also their sleep (ie, 15-minute SOL decrease, 27-minute TST increase) and mood, relative to a control group. With the exception of the PI + BLT group for mood, all improvements were maintained at the 6-week follow-up. Improvements were similar for all intervention groups, suggesting the addition of BL and parental involvement conferred no extra benefits. Students were more motivated during the program, and qualitative feedback was largely positive and constructive. Similar, yet larger improvements (eg, 45-minute TST increase) were also observed in a subclinical group of students identified as having DST,[16,23] with the exception of no change in mood. In context, the effects found in the present study are larger than comparable studies (eg, whole class TST: mean $d = 0.47$ vs $d = 0.12$[23,43]), setting a new "empirical benchmark" to compare future SEPs.[44]

In comparison to clinical studies that have used individualized treatments,[6-8] the improvements in TST observed for students with DST were somewhat smaller (eg, 60 minutes vs 45 minutes). Although an extra 45-minute sleep per night is less impressive than improvements found in clinical trials, the present intervention was able to achieve this in a large group over a short timeframe. With an 87% response rate, this suggests SEPs for adolescents with subclinical sleep timing issues is a worthy mode of intervention. It is also worth noting that TST increased despite there being a lack of motivation to do this, suggesting further improvements in TST are achievable if students can be sufficiently motivated.

Unlike a previous SEP,[23] there was an increase in motivation across a range of sleep-related behaviors during the program. In particular, students were motivated to obtain morning BL, which was a key objective of the study, as this can assist in advancing students' delayed circadian timing. Cain et al[23] found in their study that students were mostly unwilling to spend time outside to obtain sunlight and proposed that an alternative source of BL may be required. Our findings support this idea and suggest that adolescents may prefer artificial light devices to sunlight, which is particularly helpful when natural light is less available (ie, northern Europe and parts of the United States).

Although a decrease in depressed mood was observed for students overall, no change occurred for DST students. These findings are difficult to reconcile. Depressed mood has been associated with later chronotypes and delayed sleep phase in adolescent samples,[14,45,46] and advancing sleep timing has resulted in reductions in depressed mood for adolescents with delayed sleep phase disorder.[6] In the present study, bedtimes did not advance in DST adolescents, and circadian timing (eg, dim light melatonin onset) was not measured. Therefore, a lack of change in depressed mood may be due to a lack of phase advancing. Depression during adolescence has recently been attributed to wakefulness during the night.[13] Despite an average 23-minute improvement in SOL for DST students, there was significant room for improvement (>30 minutes). With further decreases in SOL, it may be possible that depressed mood would begin to improve.

Anonymous feedback from students and teachers indicated that the program was generally well received in terms of interest, enjoyment, clarity, relevance, and delivery. However, to further improve the program, a large proportion of students (43%) recommended increasing the number of interactive class activities. This reoccurring finding[16] highlights the need to find the right balance between didactic presentations and learning activities that directly involve students. To maximize student engagement with SEPs, future studies will need to address this issue.

Limitations and future research directions

Because of limitations on resources, BL devices were only distributed and used by students (BLT groups only) on 1 weekend during the program. In comparison, BLT is conducted for longer periods (eg, 2 weeks) in clinical trials with adolescents,[6-8] allowing for greater phase advance of a delayed circadian rhythm. Furthermore, BLT was difficult to administer for some adolescents due to weekend morning commitments (ie, Saturday morning sport). This light exposure may have confounded the dim light condition. To maximize benefits and reduce confounds, BLT should be extended to reflect clinical practice (ie, during school holidays) when social obligations are reduced. Parental involvement was deliberately kept noninvasive in an attempt to include them while maintaining student autonomy. However, a recent meta-analysis[43] found motivational interviewing is most effective when both parent and child participate in sessions together. This was suggested by teachers' feedback. A more intensive approach (eg, face-to-face education session) to parental involvement is, therefore, warranted, yet maintaining adolescents' autonomy[3] as well as including measures of compliance (ie, light exposure durations) to validate adolescents' self-reports. This specific field of research is dominated by outcomes measured via self-report. Although costly (time and finances), validation of subjective reports with objective data (eg, dim light melatonin onset and wrist actigraphy) is needed, although caution is needed when measuring TST in adolescents with actigraphy.[47] Finally, now that meaningful changes in sleep have been produced from a school-based sleep intervention, it is important to discover how long benefits last (eg, 6-month and 12-month follow-ups), to be comparable to other school interventions (eg, physical activity and smoking prevention).[48,49]

Conclusion

This is the first out of 8 published SEP studies to find an increase in sleep knowledge and improvements in sleep using a controlled design and follow-up. However, the inclusion of BL devices and parental involvement conferred no additional benefits. To further enhance treatment outcomes over and above those observed in the current study, extended use of BLT over a school holiday period as well as more formal and intensive parental involvement (eg, face-to-face engagement) should be considered in future school-based sleep interventions.

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Appendix A

Lesson 1 [P]

Objective

To provide accurate information about sleep need for adolescents and to help students gain a better understanding of what constitutes a “sleep problem.”

Lesson plan

(1) Class discussion—What is a sleep problem? Do you think you have a sleep problem?
(2) Video excerpts—information about adolescent sleep need, how poor sleep affects school performance, and what happens in the brain when we sleep.
(3) PowerPoint presentation—individual differences in sleep need, information about sleep cycles and sleep stages, explain definition of “sleep problem.”
(4) Homework—complete a sleep diary.

Lesson 2 [P,C]

Objective

To provide information about factors that affect sleep quality and duration, as well as "tips" to help students improve their sleep.

Lesson plan

(1) Review homework—view sample sleep diaries; do I have a sleep problem? [P]
(2) PowerPoint presentation—sleep pressure, circadian rhythms [P]
(3) Role-play—delayed versus "normally timed" body clock [P]
(4) PowerPoint presentation—4 key sleep tips [P]
(5) Homework—the pros and cons of getting up earlier on weekends [C].

Lesson 3 [C,D,A]

Objective

To provide information that will motivate students to change their sleep habits. By the end of the lesson, students will be encouraged to experiment with making behavioral changes relating to their sleep.

Lesson plan

(1) Survey—students' weekend sleep behavior [C]
(2) Role-play—motivational exercise using pros and cons generated for homework [C,D]
(3a) Bright light—educate students on how green light advances sleep timing/
(3b) Dim light—educate students on how simply getting up earlier helps sleep
(4) Homework—behavioral experiment (get up on the weekend at my usual weekday out-of-bed time) and sleep diary [P].

Lesson 4 [A,M]

Objective

To bring together learning from lessons 1 to 3 and provide further information about good sleep hygiene.

Lesson plan

(1) Class discussion—Did you succeed in reaching your weekend goals? [C,D]
(2) Relaxation and mindfulness exercises [A]
(3) PowerPoint presentation—sleep hygiene recommendations, stages of change and relapse prevention [M].

Note: P = "Pre-contemplation" lesson component targeted.

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