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School-based sleep education programs for short sleep duration in adolescents: a systematic review and meta-analysis

School-based sleep education programs for short sleep duration in adolescents: a systematic review and meta-analysis

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ABSTRACT

BACKGROUND: Insufficient sleep among students is a major school health problem. School-based sleep education programs tailored to reach large number of students may be one of the solutions. A systematic review and meta-analysis was conducted to summarize the programs' effectiveness and current status.

METHODS: Electronic databases were searched up until May 2015. Randomized controlled trials of school-based sleep intervention among 10-19 years old students with outcome on total sleep duration were included. Methodological quality of the studies was assessed using the Cochrane's risk of bias assessment.

RESULTS: Seven studies were included, involving 1876 students receiving sleep education programs and 2483 attending classes-as-usual. Four weekly 50-minute sleep education classes were most commonly provided. Methodological quality was only moderate, with a high or an uncertain risk of bias in several domains. Compared to classes-as-usual, sleep education programs produced significantly longer weekday and weekend total sleep time and better mood among students at immediate posttreatment, but the improvements were not maintained at follow-up.

CONCLUSIONS: Limited by the small number of studies and methodological limitations, the preliminary data showed that school-based sleep education programs produced short-term benefits. Future studies should explore integrating sleep education with delayed school start time or other more effective approaches.

Key words: sleep education; sleep knowledge; adolescents; school-based; sleep

BACKGROUND

Insufficient sleep is becoming more prevalent among adolescents in the past 20 years.[1,2] A recent meta-analysis reported that 53% of adolescents have insufficient sleep on school nights, defined as less than 8 hours.[3] Studies have shown that insufficient sleep is associated with an increased risk of delinquent behaviors, mood disturbances, suicidal ideation, obesity, poor academic performance, and car crashes.[4-8] A recent study showed that 7 nights of 5 hours' total bed time could affect cognitive functions, subjective alertness, and mood in high-performing adolescents, and 2 nights of recovery sleep could not fully reverse the impairments.[9] A combination of factors, including circadian phase delay, reduced sleep pressure, early school start times, caffeine use, electronic media usage, modern lifestyles, and social obligations has minimized the opportunities for adolescents to obtain adequate sleep.[4]

Various programs have been implemented to tackle insufficient sleep in adolescents. Cognitive-behavioral therapy[10] is the most common strategy, while mindfulness-based intervention,[11] light therapy,[12] and sleep education program[13] have also been used. Treatments are provided in groups, individually, or delivered through the internet, and some involve parents. However, previous studies are limited by small sample size, poor randomization procedure, inadequate control groups, lack of follow-up, and no control for confounding factors.

A school is a place where an intervention program can reach a large number of adolescents. School-based interventions have been used for the treatment and prevention of a number of health conditions, including obesity, diabetes, tobacco, alcohol and substance use, sexual abuse, depression, anxiety, suicide, and eating disorders.[14,15] In a recent review of school-based sleep programs,[13] the authors have an impression that the programs can enhance sleep knowledge but may not result in sustained behavioral changes. To summarize the effectiveness and current status of school-based sleep education program, a systematic review and meta-analysis was performed.

METHODS

Selection of studies

This meta-analysis was conducted with reference to the Preferred reporting items for systematic reviews and meta-analyses (PRISMA).[16] The MEDLINE, PsycINFO, Excerpta medica database (EMBASE), Cumulative index to nursing and allied health literature (CINAHL), Dissertations and thesis A&I, and Cochrane library from inception through 21 May 2015 were searched using the search terms: (adolescen* OR student*) AND sleep AND (random* OR controlled trial OR clinical trial OR RCT), mapped to the titles or abstracts using "multi-field search" function. The reference lists of the included studies and relevant reviews were hand-searched for additional articles. The publications that cited the included studies were identified by SCOPUS and checked if they were relevant articles.

School-based sleep intervention was defined as a program that seeks to synthesize sleep knowledge and/or employ cognitive and behavioral sleep-related strategies.[13] Adolescents were defined as those aged 10-19 years. Total sleep duration must be one of the outcome measures, in order to reflect the programs' effectiveness on insufficient sleep.

By title, abstract, and full-text screening, we excluded: 1) animal studies; 2) case reports, case series, guidelines, statements, and comments; 3) studies unrelated to sleep or psychiatry; 4) studies unrelated to adolescents; 5) non-intervention studies; 6) non-randomized uncontrolled studies; 7) non-school-based interventions; 8) languages other than English and Chinese; 9) studies with no statistics on sleep variables; and 10) duplicated studies.

Study selection

Two investigators selected relevant publications independently according to the eligibility criteria. Any disagreement was resolved by thorough discussion and consultation with the

senior investigator. When the same group of authors published more than 1 article on the same study, we selected the article with the most comprehensive dataset.

Data collection process

One investigator extracted the data and another checked the accuracy of the data. Data was extracted from the original articles and by contacting the corresponding authors when necessary to maximize the data for meta-analysis. With no clear answers from the corresponding authors after 3 months, the particular item was considered missing.

Primary outcome was sleep duration. Secondary outcomes included other sleep-wake variables, sleep knowledge, daytime sleepiness, mental health parameters, and social and academic performance. Participants' characteristics, study design, and the content and duration of sleep intervention were recorded.

Risk of bias in individual studies

The Cochrane's risks of bias assessment was used to evaluate the methodological quality of the included studies in 7 domains, including random-sequence generation, allocation concealment, blinding of participants, personnel, and outcome assessment, incomplete outcome data, selective outcome reporting, and other sources of bias. The ratings of each domain can be '–' (low risk of bias), '+' (high risk of bias) or '?' (uncertain risk). Two independent investigators assessed the risk of bias of each study. Any disagreement was resolved by discussion and consultation with the senior investigator.

Statistical analysis

All statistical analyses were performed using the Comprehensive meta-analysis software version 3.0. The summary measure was the standardized mean difference (SMD) and its 95% confidence interval (CI) between intervention and control. Due to differences in demographic

and socio-cultural characteristics, it was expected that studies were heterogeneous a priori and the outcomes would vary more than expected by chance; therefore, the random-effects model[17] and inverse-variance method were employed to calculate summary estimates. Heterogeneity between studies was evaluated using the Cochran's Q statistic, with p-value less than 0.10 indicating significant heterogeneity.[18] The I^2 statistic was computed as a compliment to the Q statistic. As suggested by Higgins et al.,[19] I^2 values of 0%, 25%, 50%, and 75% indicate no, low, moderate, and high heterogeneity. Publication bias was examined by visual inspection of a funnel plot if there were at least 10 studies available.

RESULTS

Description of the included studies

The database search identified 1607 citations, while manual search obtained 722 citations. Figure 1 presents the flowchart of the systematic review. Some potential studies were excluded due to non-school-based intervention, non-randomized study design, primary outcome not reported or reported as total time in bed instead of total sleep time, or a lack of control group. Only 7 studies were included in our systematic review and meta-analysis (Table 1).[20-26] There were 1876 adolescents receiving sleep education programs, while 2483 adolescents attended classes-as-usual. Sample size of the studies ranged from 21 to 3713. The adolescents had a mean age of 14.7 years, and 61.0% were females. Four studies included year 9 to year 12 students; 2 studies included year 6 and 7 students, while 1 study included year 7 to year 11 students. A cluster randomized design was used in 4 of the 7 studies, in which classes were randomized to treatment or control. Although the other 3 were randomized controlled studies, only a small number of eligible students were recruited. Four studies were conducted in Australia, 1 in Brazil, 1 in New Zealand, and 1 in Hong Kong, and all were published in English.

Description of school-based sleep programs

The intervention programs in 5 studies were very similar, which were supported by the Australian Centre for Education in Sleep and consisted of 4 weekly 50-minute sleep education classes (Table 2). The study conducted in Brazil used a short program that lasted only 4 days. There were multiple components in Wing et al.'s program, including a 1-hour town hall seminar, 2 40-minute small class workshops, a slogan competition, brochure/leaflets, and a sleep educational website. Four studies involved parents in their sleep education programs.

Risk of bias of individual studies

Table 3 summarizes the risks of bias according to the Cochrane criteria. As all studies were comparing intervention and no intervention, they were rated to have high risk of bias in the blinding of participants and personnel. Three of the 7 included studies were rated to have high risk of bias due to the selective recruitment of cluster members; while 1 study had high risk of bias due to incomplete outcome data. All studies did not report whether there was blinding of outcome assessment; while 6 studies did not report whether allocation concealment was performed, and 4 studies did not report whether random sequence generation was arranged.

Comparison between intervention and control

Compared to classes-as-usual, adolescents who received school-based sleep education programs had significantly longer weekday and weekend total sleep time at immediate posttreatment (SMD = 0.23, 95% CI = 0.17, 0.29, p = 0.0001 and SMD = 0.46, 95% CI = 0.04, 0.88, p = 0.03, respectively) and better mood (SMD = 0.81, 95% CI = 0.16, 1.45, p = 0.01), but there was no significant difference in weekday sleep onset latency (p = 0.2) and

sleep knowledge (p = 0.1). There was no heterogeneity regarding the significant finding on weekday total sleep time at immediate posttreatment (Q = 2.07, p = 0.84, I^2 = 0.00%), mild to moderate heterogeneity regarding weekend total sleep time (Q = 3.64, p = 0.16, I^2 = 45.09%), but high heterogeneity on improved mood (Q = 14.6, p = 0.001, I^2 = 86.33%).

At follow-up, which ranged from 6 weeks to 1 year, there was no significant difference between intervention and control in weekday total sleep time (p = 0.2), weekday sleep onset latency (p = 0.2), and sleep knowledge (p = 0.2). Two studies examined whether there was any improvement in adolescents' sleep hygiene practices, but both found no difference between intervention and control. Another study showed that there was reduced consumption of caffeine in the intervention group. Funnel plot was not done due to the small number of included studies.

DISCUSSION

Sleep deprivation is a significant school health issue and its impact has been well documented. Several biological and external factors have been identified to be associated with insufficient sleep among students. Tobacco and caffeine consumption, computer use, evening light, and a negative family environment are risk factors for insufficient sleep, while good sleep hygiene and parent-set bedtimes are protective factors.[27] Our systematic review showed that a school-based sleep education program could provide short-term benefits, but the improvements could not be maintained. The effectiveness on weekday sleep at immediate posttreatment was consistent across studies; however, the benefits on weekend sleep and mood had moderate to high heterogeneities, suggesting that the content and duration of the programs and whether parents are involved may be relevant to their effectiveness. However, we did not have sufficient number of studies for moderator analyses; hence the importance of program duration, content, and parental involvement are unclear.

The most common format was 4-weekly 50-minute sessions to cover sleep knowledge, weekend sleep behavior, and sleep hygiene. More focused interventions to reduce screen time and involve parents in bedtime setting were not always included. Previous studies have found that adolescents have limited intention to improve their sleep habit, are not motivated to apply what they have learned to improve their sleep, and are not convinced that strategies taught will work.[13] With such negative findings, there is no doubt that classroom-based intervention, provided with little attention to motivational issues, has limited long-term impacts. As there may be a possible familial influence in preventing or reversing the risk factors for adolescents' insufficient sleep and a high concordance between parents and adolescents in their sleep habits, levels of physical activity, and computer use,[28,29] school-based sleep education programs should target parents and adolescents as a dyad. Another strategy that has been proved effective for prolonging weekend sleep duration is delayed school start time. A delay of school start time by 25-60 minutes has been shown to increase weekday sleep by 25-77 minutes.[30] Only relying on sleep education programs may be ineffective in tackling the sleep insufficiency issue in adolescents.

The major limitations in our review are the small number of studies and their methodological limitations, making a definite conclusion difficult. The inclusion of students with normal sleep duration in the study might have reduced the power to detect significant differences.

IMPLICATIONS FOR SCHOOL HEALTH

Our systematic review and meta-analysis showed that school-based sleep education programs may have short-term benefits on sleep duration and mood. However, all improvements were not sustained at follow-up. There were heterogeneities in the effectiveness of the programs, suggesting that a particular approach might be more effective. We believe an integration of a school-based sleep education program and a delay in school start time may produce better

results than either one of the interventions. Future studies should explore whether parent-adolescent as a dyad for promoting sleep health is feasible and more effective than the current programs.

REFERENCES

1. Keyes KM, Maslowsky J, Hamilton A, Schulenberg J. The great sleep recession: changes in sleep duration among US adolescents, 1991-2012. Pediatrics. 2015;135(3):460-468.

2. Chung KF, Cheung MM. Sleep-wake patterns and sleep disturbance among Hong Kong Chinese adolescents. Sleep. 2008;31(2):185-194.

3. Gradisar M, Gardner G, Dohnt H. Recent worldwide sleep patterns and problems during adolescence: a review and meta-analysis of age, region, and sleep. Sleep Med. 2011;12(2):110-118.

4. Owens J; Adolescent Sleep Working Group; Committee on Adolescence. Insufficient sleep in adolescents and young adults: an update on causes and consequences. Pediatrics. 2014;134(3):e921-932.

5. Peach HD, Gaultney JF. Sleep, impulse control, and sensation-seeking predict delinquent behavior in adolescents, emerging adults, and adults. J Adolesc Health. 2013;53(2):293-299

6. Lovato N, Gradisar M. A meta-analysis and model of the relationship between sleep and depression in adolescents: recommendations for future research and clinical practice. Sleep Med Rev. 2014;18(6):521-529.

7. Chung KF, Kan KK, Yeung WF. Sleep duration, sleep-wake schedule regularity, and body weight in Hong Kong Chinese adolescents. Biol Rhythm Res. 2013;44(2):169-179.

8. Titova OE, Hogenkamp PS, Jacobsson JA, Feldman I, Schiöth HB, Benedict C. Associations of self-reported sleep disturbance and duration with academic failure in community-dwelling Swedish adolescents: sleep and academic performance at school. Sleep Med. 2015;16(1):87-93.

9. Lo JC, Ong JL, Leong RL, Gooley JJ, Chee MW. Cognitive performance, sleepiness, and mood in partially sleep deprived adolescents: the Need for Sleep Study. Sleep. 2015 Nov 19. pii: sp-00462-15. [Epub ahead of print]

10. Paavonen EJ, Huurre T, Tilli M, Kiviruusu O, Partonen T. Brief behavioral sleep intervention for adolescents: an effectiveness study. Behav Sleep Med. 2015 Sep 17:1-16. [Epub ahead of print]

11. Bei B, Byrne ML, Ivens C, Waloszek J, Woods MJ, Dudgeon P, Murray G, Nicholas CL, Trinder J, Allen NB. Pilot study of a mindfulness-based, multi-component, in-school group sleep intervention in adolescent girls. Early Interv Psychiatry. 2013;7(2):213-220.

12. Gradisar M, Dohnt H, Gardner G, Paine S, Starkey K, Menne A, Slater A, Wright H, Hudson JL, Weaver E, Trenowden S. A randomized controlled trial of cognitive-behavior therapy plus bright light therapy for adolescent delayed sleep phase disorder. Sleep. 2011;34(12):1671-1680.

13. Cassoff J, Knauper B, Michaelsen S, Gruber R. School-based sleep promotion programs: Effectiveness, feasibility and insights for future research. Sleep Med Rev. 2012;17(3):207-214.

14. Amini M, Djazayery A, Majdzadeh R, Taghdisi MH, Jazayeri S. Effect of school-based interventions to control childhood obesity: a review of reviews. Int J Prev Med. 2015;6:68.

15. Hennessy EA, Tanner-Smith EE. Effectiveness of brief school-based interventions for adolescents: a meta-analysis of alcohol use prevention programs. Prev Sci. 2015;16(3):463-474.

16. Moher D, Liberati A, Tetzlaff J, Altman DG. Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement. Ann Intern Med. 2009; 151(4):264-269.

17. DerSimonian R, Laird N. Meta-analysis in clinical trials. Control Clin Trials. 1986; 7(3):177-188.

18. Higgins JPT, Green S. Cochrane handbook for systematic reviews of interventions. 5.0.1 Edition: The Cochrane Collaboration 2008.

19. Higgins JPT, Thompson SG, Deeks JJ, Altman DG. Measuring inconsistency in meta-analyses. Br Med J. 2003; 327(7414): 557-560.

20. Beijiamini F, Louzada FM. Are educational interventions able to prevent excessive daytime sleepiness in adolescents? Boil Rhythm Res. 2012;43(6):603-612.

21. Bonnar D, Gradisar M, Moseley L, Coughlin AM, Cain N, Short MA. Evaluation of novel school-based interventions for adolescent sleep problems: Does parental involvement and bright light improve outcomes? Sleep Health. 2015;1(1):66-74.

22. Cain N, Gradisar M, Moseley L.A motivational school-based intervention for adolescent sleep problems. Sleep Med. 2011;12(3):246-251.

23. Kira G, Maddison R, Hull M, Blunden S, Olds T. Sleep education improves the sleep duration of adolescents: a randomized controlled pilot study. J Clin Sleep Med. 2014;10(7):787-792.

24. Moseley L, Gradisar M. Evaluation of a school-based intervention for adolescent sleep problems. Sleep. 2009;32(3):334-341.

25. Rigney G, Blunden S, Maher C, Dollman J, Parvazian S, Matricciani L, Olds T. Can a school-based sleep education programme improve sleep knowledge, hygiene and behaviours using a randomised controlled trial. Sleep Med. 2015;16(6):736-745.

26. Wing YK, Chan NY, Man Yu MW, Lam SP, Zhang J, Li SX, Kong AP, Li AM. A school-based sleep education program for adolescents: a cluster randomized trial. Pediatrics. 2015;135(3):e635-643.

27. Bartel KA, Gradisar M, Williamson P. Protective and risk factors for adolescent sleep: a meta-analytic review. Sleep Med Rev. 2015 Jun;21:72-85. [Epub ahead of print]

28. Tu AW, Watts AW, Masse LC. Parent-adolescent patterns of physical activity, sedentary behaviors and sleep among a sample of overweight and obese adolescents. J Phys Act Health. 2015;12(11):1469-1476.

29. Fuligni AJ, Tsai KM, Krull JL, Gonzales NA. Daily concordance between parent and adolescent sleep habits. J Adolesc Health. 2015;56(2):244-250.

30. Minges KE, Redeker NS. Delayed school start times and adolescent sleep: A systematic review of the experimental evidence. Sleep Med Rev. 2015 Jun 29;28:82-91. [Epub ahead of print]

Figure 1. Selection of trials for inclusion in the review

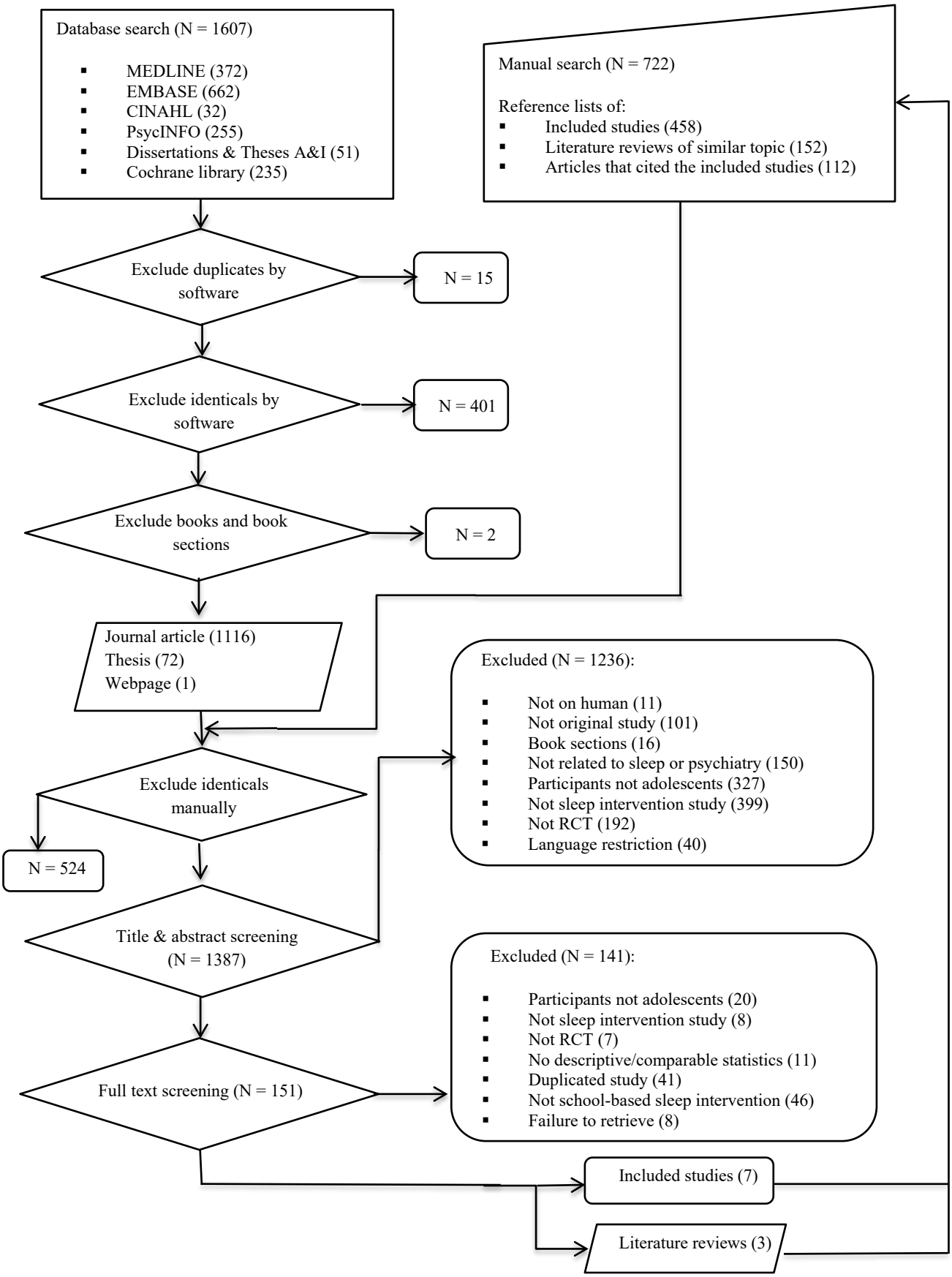
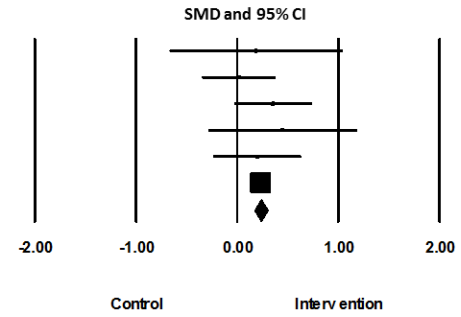


Figure 2. Efficacy of school-based sleep education programs at immediate posttreatment

(a) Weekday total sleep time

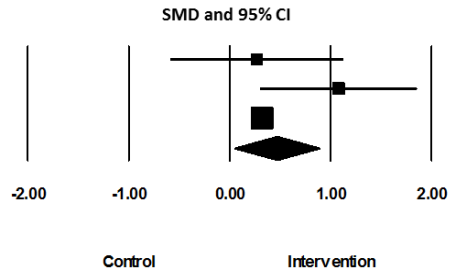
First author, year	SMD	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value
Beijiamini, 2012	0.19	0.44	0.19	-0.67	1.05	0.43	0.67
Bonnar, 2014	0.02	0.19	0.04	-0.35	0.38	0.09	0.93
Cain, 2010	0.35	0.20	0.04	-0.03	0.74	1.79	0.07
Kira, 2014	0.45	0.38	0.14	-0.29	1.19	1.19	0.23
Moseley, 2009	0.20	0.22	0.05	-0.24	0.64	0.89	0.37
Wing, 2015	0.23	0.03	0.00	0.17	0.30	6.95	0.00
Total	0.23	0.03	0.00	0.17	0.29	7.20	0.00



Heterogeneity: $Tau^2 = 0.00$; $Q = 2.07$, $df = 5$ ($p = 0.84$); $I^2 = 0.00\%$

(b) Weekend total sleep time

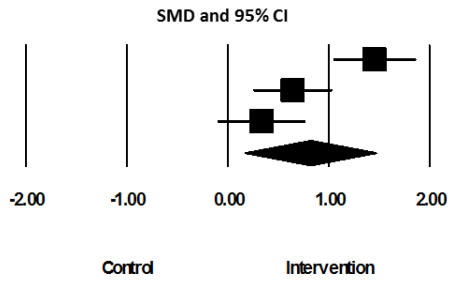
First author, year	SMD	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value
Beijiamini, 2012	0.27	0.44	0.19	-0.59	1.13	0.61	0.54
Kira, 2014	1.08	0.40	0.16	0.30	1.86	2.72	0.01
Wing, 2015	0.32	0.03	0.00	0.25	0.39	9.55	0.00
Total	0.46	0.21	0.05	0.04	0.88	2.16	0.03



Heterogeneity: $Tau^2 = 0.07$; $Q = 3.64$, $df = 2$ ($p = 0.16$); $I^2 = 45.09\%$

(c) Mood

First author, year	SMD	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value
Bonnar, 2014	1.45	0.21	0.04	1.04	1.87	6.91	0.00
Cain, 2010	0.65	0.20	0.04	0.25	1.04	3.21	0.00
Moseley, 2009	0.33	0.22	0.05	-0.11	0.77	1.49	0.14
Total	0.81	0.33	0.11	0.17	1.46	2.46	0.01



Heterogeneity: $Tau^2 = 0.28$; $Q = 14.63$, $df = 2$ ($p = 0.00$); $I^2 = 86.33\%$

Table 1. Randomized controlled trials of school-based sleep education programs

1st Author (yr)	Country	Mean age, yr (SD)/ % female	Student characteristics	Follow-up	Sample size (tx/control)	Treatment	Outcome measure	Results reported
Beijamini (2012)	Brazil	NR, 13-14/ 66.7%	2 classes of 13-14 yr old students	Nil	21 (10/11)	4 daily 50-min sleep edu classes	SDur, SPatt, Sleepiness, reaction time.	No diff between treatment and control.
Bonnar (2015)	Australia	16.8 (0.4)/ 79.0%	2 classes of yr 11 students from 5 coed and 1 all-girl schools (total 12 classes). No student was excluded due to autism or IQ.	6 wks	115 (63/52)	4 weekly 50-min sleep edu classes + parental involvement	SDur, SPatt, SKnow, BIQ, mood	Improved SKnow, SOL, TST and mood than control.
Cain (2011)	Australia	16.2 (0.4)/ 59.7%	Yr 11 psychology classes from 3 co-ed schools (total 6 classes)	3 mths	104 (53/51)	4 weekly 50-min sleep edu classes	SDur, SPatt, sleepiness, SKnow, BIQ, DASS	Improved SKnow than control. No diff in other variables.
Kira (2014)	New Zealand	14.7 (1.1)/ 44.8%	Students from a yr 9 health edu class and a combined yr 11 and 12 class.	6 mths	29 (15/14)	4 weekly 50-min sleep edu classes over 5 wks (first and last wk include research activities)	SDur, SPatt, SPro SKnow, SHyg,	Longer weekend SDur than control than control. No diff in SPro, SKnow, and SHyg.
Moseley (2009)	Australia	15.6 (0.6)/ 67.0%	Yr 11 psychology classes from a private and a public school (total 4 classes)	6 mths	81 (41/40)	4 weekly 50-min sleep edu classes	SDur, SPatt, sleepiness, SKnow, BIQ, DASS.	Improved SKnow than control. No diff in other variables.
Rigney (2015)	Australia	12.2 (0.6)/ 72.3%	Yr 6 and 7 students at 12 co-ed schools	18 wks	296 (149/147)	4 50-min sleep edu classes	SDur, SPatt, SKnow, SHyg, actigraphy.	Increased RIB, delayed WT, but no diff in SKnow and SHyg. Changes not sustained at follow-up.
Wing (2015)	Hong Kong	14.7 (1.5)/ 59.5%	All yr 7 to yr 11 students	8 wks	3713 (1545/2168)	1-hr seminar, 2 40-min small class workshops, slogan competition, brochure, educational website, 1-hr sleep edu seminar for parents and teachers	SDur, SPatt, SPro, SKnow, sleepiness, GHQ	Improved SKnow, lower use of caffeine, and better mental and behavioral health than control.

All studies are parallel-arm in design with classes-as-usual as control.

Abbreviations: BIQ, behavior intentions questionnaire; BT, bed time; co-ed, co-education; DASS, Depression anxiety stress scale; diff, difference; ed, education; GHQ, general health questionnaire; mth, month; SHyg, sleep hygiene; SKnow, sleep knowledge; SPatt, sleep pattern; SPro, sleep problems; TIB, time in bed; TST, total sleep time; wk, week; WT, wake up time; yr, year.

Table 2. Summary of the sleep education programs

1st Author (yr)	Types and duration of sleep education program	Co-intervention
Beijamini (2012)	4 daily 50-minute sleep education sessions. Conducted by a school teacher. Include class teaching, creating posters, sleep quiz, and program evaluation.	Nil
Bonnar (2015)	Based on a motivational interviewing framework, 4 weekly 50-minute classes were provided. Conducted by school teachers who are registered psychologists. Include class discussion, role play, survey, relaxation and mindfulness exercises, video excerpts, PowerPoint presentation, and homework.	Parents were e-mailed web links once weekly for 4 consecutive weeks. There were 4 videos of 2-4 minutes in length containing diagrams and commentaries related to sleep education.
Cain (2011)	Same as in Bonnar et al.'s study	Nil
Kira (2014)	Based on the Australian centre for education in sleep program. 4 weekly 50-min classes were provided. Conducted by a health education teacher. Include peer-led discussion and PowerPoint presentation. A copy of all presentations and additional information was provided to students.	Parents were provided a workbook, which contains a summary of the students' workbooks and additional information.
Moseley (2009)	Adolescent well-being: day and night education program. 4 weekly 50 minutes classes were provided. Conducted by school teachers who are registered psychologists. Sleep-related components are embedded within a wider context of well-being.	Nil
Rigney (2015)	Same as in Kira et al.'s study, with an addition of a group project and presentation session.	Parents were provided educational information and invited to a student project presentation evening.
Wing (2015)	Healthy sleep, healthy school life program. Contain 1- hour town hall seminar, 2 40-minute small class workshops, slogan competition, brochure/leaflets, and sleep educational website. Seminar conducted by experienced physicians, and workshops by trained research staff. Workshop includes sleep facts, factors contributing to sleep loss, effects of chronic sleep deprivation, good sleep practice, review of own sleep diary, and time and stress management.	1-hour seminar, brochure/leaflets, sleep educational website for teachers and parents.

Table 3 Risks of bias of the included trials using Cochrane's criteria

1st Author (yr)	Random sequence generation	Allocation concealment	Blinding of participants and personnel	Blinding of outcome assessment	Incomplete outcome data	Selective reporting	Selective recruitment of cluster members	Sample power
Beijamini (2012)	?	?	–	?	+	+	+	?
Bonnar (2015)	?	?	–	?	+	+	–	?
Cain (2011)	?	?	–	?	+	+	–	?
Kira (2014)	+	+	–	?	–	+	+	+
Moseley (2009)	?	?	–	?	+	+	?	?
Rigney (2015)	+	?	–	?	+	+	–	+
Wing (2015)	+	?	–	?	+	+	+	+

'?': uncertain risk of bias; '+': low risk of bias; '–': high risk of bias