Sleep Medicine 60 (2019) 109–115

Contents lists available at ScienceDirect

Sleep Medicine

journal homepage: www.elsevier.com/locate/sleep

Original Article

A pilot cluster-randomised study to increase sleep duration by decreasing electronic media use at night and caffeine consumption in adolescents

Ahuti Das-Friebel [a], Nadine Perkinson-Gloor [b], Serge Brand [c, d, e, f], Julia F. Dewald-Kaufmann [g, h], Alexander Grob [b], Dieter Wolke [a], Sakari Lemola [a, *]

[a] University of Warwick, Department of Psychology, Coventry, United Kingdom
[b] University of Basel, Department of Psychology, Basel, Switzerland
[c] University of Basel, Psychiatric Clinics, Center for Affective, Stress, and Sleep Disorders, Basel, Switzerland
[d] University of Basel, Department of Sport, Exercise and Health, Division of Sport and Psychosocial Health, Basel, Switzerland
[e] Kermanshah University of Medical Sciences (KUMS), Sleep Disorders Research Center, Kermanshah, Iran
[f] Kermanshah University of Medical Sciences (KUMS), Substance Abuse Prevention Research Center, Kermanshah, Iran
[g] Hochschule Fresenius, University of Applied Sciences, Munich, Germany
[h] Department of Psychiatry and Psychotherapy, University Hospital, Ludwig-Maximilans-University Munich, Germany

ARTICLE INFO

Article history:
Received 18 July 2018
Received in revised form
6 November 2018
Accepted 17 November 2018
Available online 29 November 2018

Keywords:
Electronic media use
Caffeine consumption
Sleep
Mental health
Adolescence
School-based intervention

ABSTRACT

Objective: Bedtime electronic media use and caffeine consumption are risk factors for insufficient sleep and poor sleep quality during adolescence, which are in turn risk factors for mental wellbeing. Our study tested the effectiveness of a brief school-based psychoeducative intervention to primarily increase sleep duration, by decreasing bedtime electronic media use and caffeine consumption. Secondary outcomes included improving sleep quality and difficulties, daytime tiredness, and mental wellbeing.
Method: A pilot cluster-randomised controlled study was conducted involving a 25-min psychoeducative school-based intervention combined with parent information. 352 adolescents from seven schools participated (Intervention Group/IG = 192 students vs. Control Group/CG = 160 students; age: Mean = 15.09 years; SD = 1.65 years; Females = 163). The intervention included information on the importance of sleep and good sleep hygiene habits, particularly emphasizing behavioural rules of avoiding electronic media use at night and evening-time caffeine consumption. A leaflet containing the rules was also sent to parents of IG participants. Baseline and post-intervention sessions were held approximately four weeks apart.
Results: Multilevel analyses revealed a significant but modest decrease in electronic media use for participants in the IG versus CG, but showed no effect on caffeine consumption or sleep duration. Moreover, the intervention did not impact any secondary outcome.
Conclusions: Findings indicate the potential effectiveness of a short and easily administrable intervention to decrease electronic media use at night, which may be incorporated into school curricula and standardised for wider use in primary prevention. However, no further benefits of the intervention were found.

1. Introduction

A large number of adolescents do not get the recommended amount of sleep, which is eight to 10 h for 14–17 year olds [1], especially during the week [2]. In addition, evidence indicates that adolescents worldwide do not feel well restored upon awakening [3]. Insufficient sleep and poor sleep quality have negative implications for the physical, cognitive, and psychological wellbeing of

Abbreviations: IG, Intervention Group; CG, Control Group; ISI, Insomnia Severity Index; SDQ, Strengths and Difficulties Questionnaire; ITT, Intention to Treat.

* Corresponding author. Department of Psychology, University of Warwick, Coventry, CV4 7AL, United Kingdom. Fax: +44 24 765 24225.
E-mail address: s.lemola@warwick.ac.uk (S. Lemola).

https://doi.org/10.1016/j.sleep.2018.11.010
1389-9457/

adolescents. For instance, insufficient sleep is associated with increased daytime sleepiness and tiredness [3–5], poor academic performance [5,6], negative attitude towards life [5], and decreased mood, attention and emotion regulation [4,7,8]. Conversely, better sleep quality is associated with better school performance [6], and lower risk-taking behaviour [9].

Recent research has highlighted that night-time electronic media use is a risk factor for insufficient sleep and poor sleep quality amongst adolescents [10–14]. One reason for this is that the blue light emitted from electronic screens appears to delay melatonin secretion, which might affect the ability to fall asleep [15]. Electronic media use may also curtail sleep by simply replacing the time for sleep, communication via social media may involve emotional content interfering with relaxation and sleep induction, and incoming alerts may wake adolescents up after sleep onset [10]. However, there is also evidence to suggest that adolescents rely on late-night electronic media use as a sleeping aid (ie, to while away time) [16–18]. The increasing use of electronic media in bed before sleep, in part, may be complemented by the increasing ownership and use of smartphones among adolescents across the globe [19]. Furthermore, fear of missing out important social information may lead to adolescents keeping their phones online also during the night [20]. Smartphones allow adolescents to easily access, from the comfort of their beds, various forms of media such as telecommunication, gaming, videos/films and social networking around the clock. While the benefits of such digitalisation is indisputable, smartphone use also has its problems; with evidence highlighting its role in pathological disorders such as smartphone addiction [21], its negative impact on sleep quality and mental health [22], and more recently, its direct link with shorter sleep duration among adolescents [23]. In this view, Demirci et al., [22] showed that smartphone use can resemble behavioural addiction and be intertwined with symptoms of depression and anxiety.

A second risk factor for insufficient sleep that has become equally prominent in recent years is the increasing popularity and consumption of energy drinks and other caffeinated drinks amongst adolescents [14,24], perhaps due to the youth-directed marketization of these products. Energy drinks often contain a moderate to high amount of caffeine, which has been linked to high blood pressure and sleep disturbances in children and adolescents [25]. Electronic media use in the evening before sleep and excessive consumption of caffeinated products are discussed in the literature as major constituents of poor sleep hygiene.

Studies evaluating the effectiveness of psychoeducative interventions for improving sleep hygiene among adolescents [26–33] have yielded mixed results. While some studies report improvements in sleep duration [27,31] and sleep quality and wellbeing [31], others report only partial or no improvements in any outcomes [28,29,31,33]. It has been argued that parental involvement in sleep hygiene interventions for adolescents might be crucial in augmenting intervention effects [34]. Past studies involving parents have shown positive intervention effects [31,35].

Recognising the growing public health concern surrounding excessive electronic media use, caffeine consumption and its implications for adolescent sleep [14], and accounting for past research focusing on more extensive psychoeducative sleep hygiene interventions, our study piloted a brief intervention that targeted bedtime electronic media use and caffeine consumption in the evening amongst adolescents, with the aim of increasing sleep duration. Specifically, we assessed whether a 25-min psychoeducative school-based intervention combined with parental involvement focused on reducing bedtime electronic media use and/or consumption of caffeinated products in the evening, could ultimately increase sleep duration, and consequently improve sleep quality, daytime functioning and mental wellbeing of adolescents. It was an objective to develop a cost-effective primary prevention intervention that could potentially be disseminated on a large scale. A major purpose of primary prevention involves improving health behaviour of a large proportion of the population at low cost, with even small changes in a large number of individuals resulting in benefits at a population level [36].

We explored whether the intervention would lead to changes in the primary outcome variable sleep hygiene (ie, decrease in using electronic media in bed before sleep, and decrease in consumption of caffeinated drinks) and improved sleep duration on weekdays and weekends. Secondary outcomes investigated were decreased sleep difficulties, daytime tiredness, depressive symptoms, and attention and hyperactivity-related symptoms.

2. Method

2.1. Design and procedure

Using a cluster randomised controlled design, the third named author (NPG) allocated school classes to either the Intervention Group (IG; 17 classes; n = 190) or Control Group (CG; 15 classes; n = 158) matched regarding grade level (seventh graders: 5 classes IG and 4 classes CG; eighth graders: 3 classes IG and 3 classes CG; ninth graders: 7 classes IG and 6 classes CG; 10th graders: 0 classes IG and 1 class CG; 11th graders: 1 class IG and 0 classes CG; 12th graders: 1 class IG and 1 class CG), urbanity of the area of the school (rural: 5 classes IG and 5 classes CG; urban: 12 classes IG and 10 classes CG) and school track (comprehensive school: 3 classes IG and 1 class CG; lower track secondary schools: 6 classes IG and 6 classes CG; higher track secondary schools: 8 classes IG and 8 classes CG). The CG had fewer classes due to two school classes withdrawing post-randomisation, before the first session was conducted (see Fig. 1 for the study flowchart and dropout rates).

The study had two assessment points, baseline (t1) and post-intervention (t2, approximately four weeks apart (M = 27 days, SD = 4 days, Range = 20–35 days). At baseline 45 min (1 school lesson) were available for the study, which were split into approximately 20 min to complete the questionnaire followed by 25 min of intervention condition/control condition. The intervention involved psychoeducation including two major components. First, we presented information regarding the importance of sleep and the role that it plays in daily functioning, including academic performance, bodily functions, and appearance. Second, three sleep hygiene rules, which were communicated as “hints for healthy sleep”, were derived in an interactive discussion:

(1) Sleep duration rule: Avoid sleeping less than 8 h per night because normal sleep duration in adolescence should be between 8.5 and 9.5 h.
(2) Behavioural rule 1: Avoid electronic media use during the last hour before planned sleep and switch off electronic media devices when going to bed.
(3) Behavioural rule 2: Avoid caffeine consumption (seventh graders). Restrict caffeine consumption (8–12th graders); particularly do not consume caffeine in the evening.

It was emphasized that these rules particularly apply for students who often feel tired, lack energy or suffer from poor sleep; it was communicated that the rules may not necessarily apply to those who do not suffer from these circumstances regularly. As a starting point for the discussion, which was structured and moderated by the trained researchers, we used a 2-min video clip (https://www.nji.nl/nl/Databank/Databank-Effectieve-Jeugdinterventies/Erkende-interventies/SlimSlapen) [18] showing an adolescent girl using electronic media late at night including

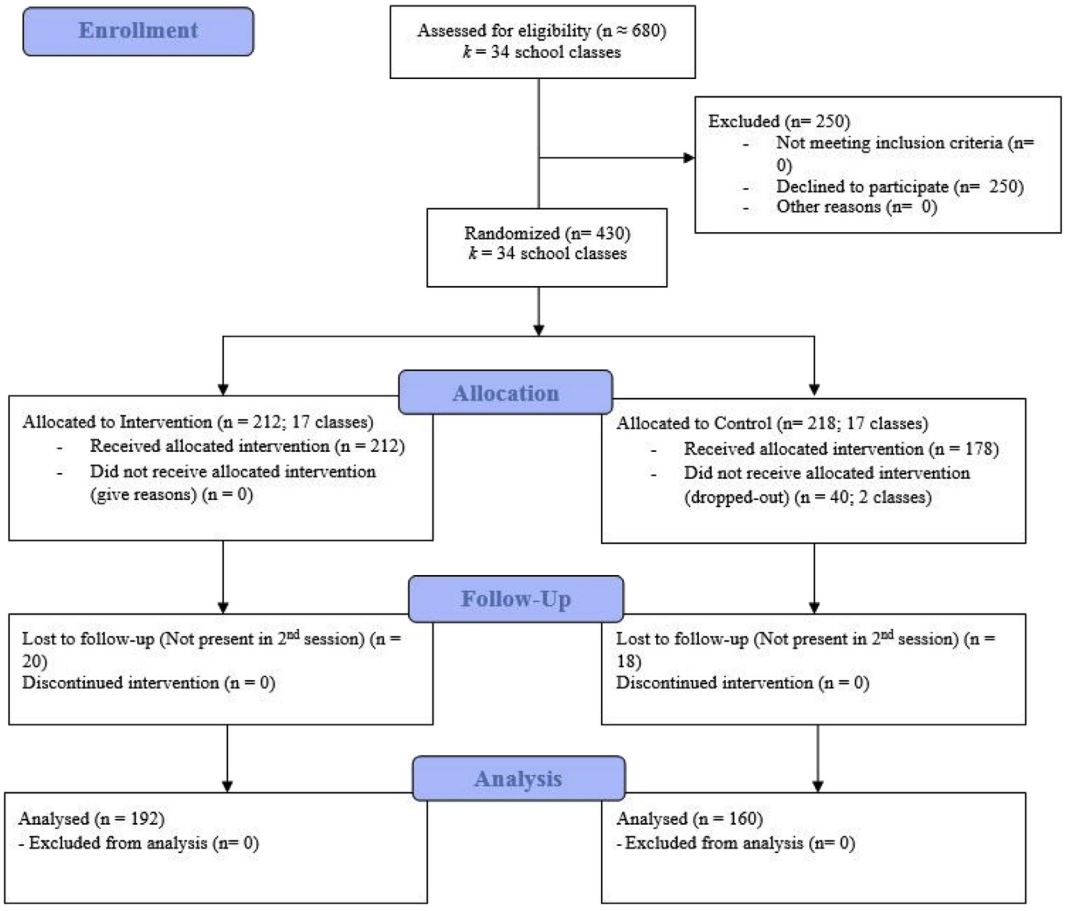

Fig. 1. CONSORT flow diagram depicting participation throughout the study.

mobile phone, laptop/computer, and TV and drinking energy and cola drinks after which she finds it hard to fall asleep.

We also distributed an information leaflet to participants outlining these sleep hygiene rules. Additionally, parents of participants in the IG received the information leaflets via post, communicating the role of sleep for health, wellbeing, and school performance in adolescence. The leaflet also contained the potential role of parents for adolescents' sleep habits, and the three sleep hygiene rules that were communicated to adolescents.

The participants in the CG were given a 25-min presentation exploring topics such as sleep in the animal kingdom as well as dreaming and sleep-walking in human beings. Parents of adolescents in the CG were not sent any material at t1. One month following the first session, a follow-up assessment was conducted and all participants completed the same questionnaire again. At t2, following the completion of the questionnaires, CG participants received all information related to the intervention as IG participants had at t1, including being shown the film, followed by the interactive discussion and the sleep hygiene rules.

Debrief information on the study was sent to the participants by mail.

2.2. Sample

The target overall sample size was N = 400 with an equal distribution between IG and CG (ie, 200 vs. 200), which would lead to achieved power of 0.85 to detect a small to medium sized effect of $d = 0.30$ with alpha level of $p = 0.05$ (2-tailed; G*Power) [37]. In total 42 schools (28 schools in the Canton Basel Stadt and 14 schools in the Canton Basel Landschaft; Switzerland) were approached. Seven schools and 34 school classes agreed to participate (with an estimated total N ≈ 640; estimate based on the normal class size of 20 students; the actual number of students per class was not recorded). Due to non-participation (n ≈ 250) and drop out after t1 (n = 38; 20 IG vs. 18 CG) of, the sample was reduced to N = 352 (192 IG vs. 160 CG; Age: mean = 15.09 years; SD = 1.65 years; age range: 12.15–20.58 years; Females = 163) (see Fig. 1). Participants and their parents were informed about the voluntary and confidential nature of the study. Informed consent was obtained from students as well as parents of students below the age of 18 years. The study was conducted between October 2012 and February 2013. The study was approved by the Ethics committee of Basel (EKBB; nowadays Ethics committee north/central Switzerland, EKNZ; Ref.Nr.EK 120/12).

2.3. Measures

2.3.1. Electronic media use in bed before sleep

Electronic media use in bed before sleep was assessed with four items. Participants responded on a 5-point scale, where *1 = never* and *5 = most of the time to always (at 5–7 days per week)* ($\alpha = 0.78$). Items assess how often participants watch television, play video games, talk on the phone or text, and spend time online (eg, *On a normal school night whilst you are already in bed, how often do you watch Videos/Films?).*

2.3.2. Consumption of caffeinated products

Three items assessed the amount of caffeine consumption, and included *In a regular day, how many (a) cups of coffee, (b) cans of*

energy drinks or (c) glasses of other caffeinated sweet beverages do you consume? Participants responded on a 4 point scale, where *1 = 0/less than 1 per day* and *4 = more than 3 per day*.

2.3.3. Sleep duration

This information was collected via separate questions for weekday and weekend bedtimes and awakening times. Sleep duration was calculated by subtracting the time when lights were switched off at night from the final awakening time in the morning.

2.3.4. Daytime tiredness

This was assessed using three items ((i) *Lately, I've been feeling tired or sleepy throughout the day; (ii) In school, I am often so tired that I almost fall asleep;* and, *(iii) I nap for at least 1 h during the day.*). Participants responded on a 5-point scale, where *1 = never* and *5 = mostly to always*, with higher scores indicating more tiredness ($\alpha = 0.69$).

2.3.5. Sleep difficulties

These was measured using five items from the German version of the Insomnia Severity Index (ISI) [38] adapted for use with adolescents. Participants responded on a 5-point scale, where *1 = not at all/very satisfied* and *4 = very much/very dissatisfied*. Items assessed satisfaction with current sleep, difficulties falling asleep and maintaining sleep and feeling rested after waking up; higher scores were more indicative of sleep difficulties ($\alpha = 0.71$).

2.3.6. Depressive symptoms

These were assessed using six items from the German version of the General Depression Scale [39]. Participants responded on a 4 point scale, where 0 = *occurred never or rarely* and *3 = occurred most of the time or* always, with higher scores being indicative of depressive symptoms ($\alpha = 0.73$).

2.3.7. Attention and hyperactivity symptoms

These were measured using five items from the Hyperactivity/Attention subscale of the Strengths and Difficulties Questionnaire (SDQ) [40]. Participants responded on a 3-point scale, where *1 = not applicable* to *3 = clearly applicable* ($\alpha = 0.58$).

2.4. Statistical analyses

A multilevel modelling approach was used for data analysis to account for the nested nature of the data with students clustered within school classes allocated either to the IG or CG. Models assessing the effect of the intervention on the outcome variables by treating group and time as independent variables, and participant and school class as random factors. An interaction term of Group*-Time was also included in each model. In total, seven models were computed, one for each of the primary and secondary variables. Each of the seven models adjusted gender and age as covariates. A Bonferroni-corrected alpha-level of $P < 0.0125$ was adopted for testing effects regarding the four primary outcome variables (nighttime electronic media use, caffeine consumption, weekday and weekend sleep duration). Analyses also included calculating the intracluster correlation coefficients for each outcome variable. Additionally, Intention to Treat (ITT) analysis was conducted using the last observation carried forward method (LOCF).

The descriptive analysis was conducted using SPSS® version 24 (IBM Corporation, Armonk NY, USA), and the multilevel and ITT analyses were implemented using the xtset, xtmixed and estat icc STATA (version 15) statistical packages.

3. Results

3.1. Sample characteristics

Table 1 shows the baseline values of all study variables for the full sample, and also separately for IG and CG. No significant differences between groups at baseline were found.

The multilevel analyses revealed that compared to girls, boys reported shorter weekend sleep ($\beta = -0.34$, SE = 0.13, $p = 0.007$), as well as lower levels of daytime tiredness ($\beta = -0.30$, SE = 0.08, $p < 0.001$), sleep difficulties ($\beta = -0.21$, SE = 0.07, $p = 0.002$), and depressive symptoms ($\beta = -0.23$, SE = 0.05, $p < 0.001$). Age-related effects were also found, such that with increasing age, participants reported higher levels of bedtime electronic media use ($\beta = 0.71$, SE = 0.12, $p < 0.001$), shorter weekday ($\beta = -0.28$, SE = 0.03, $p < 0.001$) and weekend sleep duration ($\beta = -0.32$, SE = 0.04, $p < 0.001$), increased daytime tiredness ($\beta = 0.18$, SE = 0.02, $p < 0.001$), sleep difficulties ($\beta = 0.08$, SE = 0.03, $p = 0.004$), and depressive symptoms ($\beta = 0.06$, SE = 0.01, $p < 0.001$).

3.2. Intervention effects on primary outcomes

Table 2 shows the results of the multilevel analyses. Results show a significant interaction term indicating that adolescents in the IG significantly decreased their electronic media use in bed before sleep between baseline and follow-up assessment compared to adolescents in the CG ($\beta = -0.91$, SE = 0.29, $p = 0.002$, $d = -0.24$). However, no intervention effect was found for adolescents' reports of consumption of caffeinated products ($\beta = 0.04$, SE = 0.11, $p = 0.721$, $d = 0.06$), weekday sleep duration ($\beta = 0.01$, SE = 0.08, $p = 0.902$, $d = 0.05$) and weekend sleep duration ($\beta = 0.09$, SE = 0.13, $p = 0.481$, $d = 0.13$). In all models, no significant main effect of group or time were found. Furthermore, no sex and age interactions were found.

Because baseline comparisons of both groups reflected near-significant differences for electronic media use and caffeine consumption (see Table 1) we additionally conducted sensitivity analyses using Propensity Score Matching (using the teffect psmatch and psmatch2 STATA packages). These analyses involve matching of participants between the groups based on their age, gender and (i) baseline electronic media use and (ii) baseline caffeine consumption. Results were consistent with the findings of the multilevel analyses (i.e. electronic media use in bed was significantly lower for participants in the IG versus CG; $\beta = -0.98$, S.E. = 0.37, $p = 0.008$, while no effect was found for caffeine consumption, $\beta = 0.14$, S.E. = 0.15, $p = 0.335$) (see Supplementary information).

3.3. Intervention effects on secondary outcomes

No significant intervention effects were found for daytime tiredness ($\beta = 0.01$, SE = 0.05, $p = 0.801$, $d = 0.01$), sleep difficulties ($\beta = -0.02$, SE = 0.05, $p = 0.745$, $d = -0.01$), depressive symptoms ($\beta = -0.08$, SE = 0.05, $p = 0.090$, $d = -0.10$) and hyperactivity symptoms ($\beta = 0.01$, SE = 0.03, $p = 0.834$, $d = 0.03$). Results showed a significant decrease in daytime tiredness and sleep difficulties over time in both groups ($\beta = -0.11$, SE = 0.04, $p = 0.004$ and $\beta = -0.12$, SE = 0.04, $p = 0.001$, respectively). One significant sex interaction for daytime tiredness was found ($\beta = -0.24$, SE = 0.07, $p = 0.001$), suggesting that boys relative to girls in the IG reported a stronger decrease in daytime tiredness. Similarly, one significant age interaction for depressive symptoms was found ($\beta = -0.05$, SE = 0.02, p = 0.007), suggesting that older versus younger participants in the Intervention Groups reported a stronger decrease in depressive symptoms. However, separate subgroup analyses for boys and girls as well as for younger and older participants were not significant at the Bonferroni corrected alpha level of $p < 0.0125$.

Table 1
Mean and standard deviation of study variables separately for Intervention and Control Group at baseline.

Variables	Full sample (N = 352)		Intervention Group (n = 192)		Control Group (n = 160)		Independent t-test/Chi square test		
	Mean/n	SD/%	Mean/n	SD/%	Mean/n	SD/%	t/χ^2	p	df
Age	15.09	1.65	14.97	1.71	15.25	1.56	1.61	0.109	1350
Female	163	46.31	83	43.2	80	50	1.61	0.205	1,1
Smartphone ownership	295	83.81	154	80.20	141	88.10	4.66	0.097	1,2
Weekday sleep duration (hh:mm)	08:06	00:56	08:08	00.58	08:04	00:53	−0.74	0.460	1341
Weekend sleep duration (hh:mm)	08:05	00:59	10:10	01:26	09:57	01:32	−1.39	0.165	1339
Daytime tiredness	2.07	0.80	2.03	0.74	2.13	0.86	1.31	0.193	1348
Sleep difficulties	2.21	0.71	2.23	0.68	2.19	0.75	−0.47	0.636	1348
Depressive symptoms	1.76	0.49	1.77	0.51	1.75	0.46	−0.31	0.754	1350
Hyperactivity symptoms	1.66	0.39	1.63	0.39	1.69	0.39	1.33	0.186	1349
Electronic media use in bed before sleep	9.52	4.13	9.20	3.97	9.92	4.30	1.65	0.101	1348
Watching TV/videos							6.01	0.199	1,4
Never	177	50.3	89	46.4	88	55.0	–	–	–
Once a week or less	58	16.5	39	20.3	19	11.9	–	–	–
Twice a week	39	11.1	22	11.5	17	10.6	–	–	–
3–4 times a week	29	8.2	18	9.4	11	6.9	–	–	–
5–7 times a week	47	13.4	24	12.5	23	14.4	–	–	–
Playing video games							7.74	0.171	1,4
Never	241	68.5	131	68.2	110	68.8	–	–	–
Once a week or less	46	13.1	28	14.6	18	11.3	–	–	–
Twice a week	32	9.1	12	6.3	20	12.5	–	–	–
3–4 times a week	21	6.0	15	7.8	6	3.8	–	–	–
5–7 times a week	9	2.6	5	2.6	4	2.5	–	–	–
Communication by phone or text message							9.68	0.085	1,4
Never	89	25.3	51	26.6	38	23.8	–	–	–
Once a week or less	47	13.4	34	17.7	13	8.1	–	–	–
Twice a week	39	11.1	21	10.9	18	11.3	–	–	–
3–4 times a week	58	16.5	30	15.6	28	17.5	–	–	–
5–7 times a week	116	33.0	55	28.6	61	38.1	–	–	–
To be online (on Facebook, Chatroom, etc)							10.72	0.057	1,4
Never	144	40.9	87	45.3	57	35.6	–	–	–
Once a week or less	49	13.9	31	16.1	18	11.3	–	–	–
Twice a week	39	11.1	21	10.9	18	11.3	–	–	–
3–4 times a week	51	14.5	26	13.5	25	15.6	–	–	–
5–7 times a week	66	18.8	26	13.5	40	25.0	–	–	–
Caffeine consumption	4.45	1.20	4.40	1.18	4.50	1.22	0.79	0.429	1350
Number of cups of coffee							6.94	0.074	1,3
Less than 1 a day	305	86.6	162	84.4	143	89.4	–	–	–
1 per day	37	10.5	27	14.1	10	6.3	–	–	–
2–3 per day	5	1.4	2	1	3	1.9	–	–	–
More than 3 per day	1	0.3	0	0	1	0.6	–	–	–
Number of cans of energy drinks							2.76	0.429	1,3
Less than 1 a day	288	81.8	160	83.3	128	80.0	–	–	–
1 per day	49	13.9	25	13	24	15.0	–	–	–
2–3 per day	11	3.1	6	3.1	5	3.1	–	–	–
More than 3 per day	2	0.6	0	0	2	1.3	–	–	–
Number of glasses of other caffeinated drinks							5.00	0.287	1,4
Less than 1 a day	96	27.3	52	27.1	44	27.5	–	–	–
1 per day	145	41.2	87	45.3	58	36.3	–	–	–
2–3 per day	87	24.7	43	22.4	44	27.5	–	–	–
More than 3 per day	23	6.5	10	5.2	13	8.1	–	–	–

Table 2
Outcome variables are shown as a function of group and time. Models were built to compare the Intervention and Control Groups over time, controlling for the clustering of the data.

Variables		Group			Time			Group × Time			ICC[b] (SE)
	n[a]	β	CI	p	β	CI	p	β	CI	p	
Media use in bed	688	−0.55	−1.37, 0.27	0.190	0.05	−0.37, 0.48	0.800	−0.91	−1.48, −0.34	0.002	0.75 (0.02)
Caffeine consumption	696	−0.08	−0.43, 0.27	0.651	−0.15	−0.31, 0.02	0.077	0.04	−0.18, 0.26	0.721	0.63 (0.03)
Weekday sleep duration	656	−0.05	−0.25, 0.14	0.589	−0.01	−0.13, 0.11	0.847	0.01	−0.16, 0.18	0.902	0.58 (0.04)
Weekend sleep duration	648	0.19	−0.10, 0.48	0.209	0.02	−0.17, 0.20	0.870	0.09	−0.16, 0.33	0.481	0.61 (0.04)
Daytime tiredness	688	−0.02	−0.19, 0.14	0.788	−0.11	−0.19, −0.04	0.004	0.01	−0.09, 0.12	0.801	0.78 (0.02)
Sleep difficulties	688	0.10	−0.09, 0.29	0.298	−0.12	−0.20, −0.05	0.001	−0.02	−0.11, 0.08	0.745	0.79 (0.02)
Depressive symptoms	696	0.05	−0.06, 0.15	0.379	0.02	−0.05, 0.08	0.579	−0.08	−0.17, 0.01	0.090	0.60 (0.03)
Hyperactivity symptoms	694	−0.04	−0.15, 0.06	0.418	−0.02	−0.06, 0.03	0.510	0.01	−0.06, 0.07	0.834	0.68 (0.03)

Note. Models were built adjusting for sex and age. Sex, age and constant values are not displayed in the table; significance is considered at the Bonferroni corrected alpha level of $p < 0.0125$ level.

[a] Number of data points in the model; there were 2 data points per participant (baseline and follow-up).

[b] ICC: Intracluster correlation coefficient.

3.4. ITT analysis

Results from the ITT analysis echoed the results found in the multilevel analysis for primary and secondary variables, in terms of effect size and statistical significance (See Supplementary Information).

4. Discussion

Our study evaluated the effectiveness of a brief school-based psychoeducative intervention with parent involvement aimed to decrease bedtime electronic media use, caffeine consumption in the evening, and increase sleep duration among adolescents. Results showed that the intervention modestly reduced bedtime electronic media use for participants in the IG versus CG, but did not have an impact on caffeine consumption or sleep duration. We also found that participants in the IG did not show improvements in sleep quality, sleep-related problems, daytime tiredness, or depressive and hyperactivity-related symptoms.

The modest decrease in electronic media use may have been triggered by an increase in participants' knowledge regarding the negative impact of bedtime electronic media use on sleep and mental health. This is in line with studies showing that psychoeducative sleep interventions increase participants sleep-related knowledge [27,29,31]. Moreover, it is possible that increased parental monitoring of adolescents' bedtime routine and encouraging of good sleep hygiene as a potential consequence of the information leaflet for parents regarding adolescent sleep and sleep hygiene, may have triggered the adolescents' behaviour change [31,34,35,41]. As a limitation, we cannot disentangle the relative contribution of the psychoeducative intervention for the adolescents and the parental information leaflets, or whether the combination of the two approaches was crucial for the reported decrease in adolescents' bedtime electronic media use.

Our results also showed that the decreased electronic media use did not have an impact on sleep duration and any of the secondary outcomes, thereby not lending support to previous findings that suggested that bedtime electronic media use is a risk factor for poor sleep, and consequently for poor mental wellbeing during adolescence [10–14,42]. Notably, these previous findings were based on cross-sectional data and therefore do not inform about causality. Therefore it remains possible that electronic media use is not a causal factor for poor sleep in adolescence but rather its consequence; adolescents who find it difficult to fall asleep might use their electronic devices as a sleeping aid [17].

However, one has also to bear in mind the following alternative explanations for finding no intervention effects on sleep duration and difficulties, daytime tiredness and mental wellbeing. First, the effect size associated with the intervention was modest ($d = -0.24$), and the decrease in media use might have been too small to result in changes of sleep and other secondary outcomes. Second, we did not measure the quality of the experience related to electronic media use at night, which might be more important for sleep quality and mental health [43]. For instance, interactions on social media may have emotionally arousing effects, and lead to increased worrying which may negatively impact sleep [44]. Third, through our primary prevention approach, we targeted a sample of adolescents at relatively low-risk of poor mental health. It is possible that intervention effects would have been more pronounced if specifically adolescents with highly elevated levels of media use or poor sleep were targeted. Previous studies that tailored sleep hygiene interventions according to the specific needs of at-risk individuals were more successful in improving sleep patterns and mental wellbeing in adolescents compared to our one size fits all approach [27]. It is possible that future smart device-assisted interventions delivering individualized information to participants, may fit the purpose of specifically tailored interventions which can be widely administered at low cost.

4.1. Limitations

Our study is not without limitations. First, the a priori power and sample size calculations did not account for the clustered design of the study. The results of the high intracluster correlations (displayed in Table 2) suggest that the study was underpowered to detect modest effects. Further, in this pilot study, the small sample size did not allow for subgroup analyses among more vulnerable participants. It is for instance possible that interventions are more effective for adolescents with excessive electronic media use or excessive caffeine consumption. Second, the study had only a short follow-up period of four weeks, which disallowed assessing longer-term effects of the intervention. Third, all measures were based on subjective reports and could have been affected by memory biases. In a related vein, the assessment of caffeine consumption did not have an option to indicate no caffeine consumption at all, therefore, the measure may not have been sensitive to distinguish between abstainers and consumers of low amounts of caffeine. Fourth, we cannot discard the possibility that participants were aware that they were part of the IG or the CG, potentially leading their responses at follow-up to be biased by social desirability effects. Finally, the study did not collect any information regarding parental styles or parental relationship quality with the child, which may have helped ascertain the psychosocial mechanisms related to parenting that could have contributed to the intervention effects.

5. Conclusion

By using a cluster randomised controlled design, we evaluated the effectiveness of a 25-min school-based psychoeducative intervention combined with parental involvement on improving sleep duration by decreasing bedtime electronic use and caffeine consumption among adolescents. We found a modest decrease in electronic media use for participants in the IG versus CG, while there were no other differences between the groups in all other measures, including secondary measures of mental wellbeing. While the intervention was only partially and modestly successful, it indicates the feasibility of a short and easily administrable intervention that could be incorporated into school curricula and standardised for a wider use in primary prevention of late night electronic media use. The findings also suggest the need for better understanding whether and how night time electronic media use impacts adolescents' sleep, mental health, and wellbeing. Due to the limitations of our pilot study, we suggest that future research uses larger samples with a higher number of school classes to account for the similarity in behaviours such as electronic media use among peers in school classes. Moreover, research could also complement subjective reports with objective measures of sleep through actigraphy. Studies that experimentally disentangle the effects of different types of electronic media use and the role of the individual electronic media use experience for adolescents' sleep are needed to allow researchers and policy makers to address a growing public health concern.

Acknowledgements

We would like to thank Dr. Ed de Bruin from the University of Amsterdam for allowing the use of the video clip on poor adolescent sleep hygiene for the intervention.

Funding

This research was funded by Biäsch Stifung (Stiftung Suzanne und Hans Biäsch zur Förderung der Angewandten Psychologie). However, the funder had no role in the research work and interpretation of results

Conflict of interest

The authors declare no conflict of interest.

The ICMJE Uniform Disclosure Form for Potential Conflicts of Interest associated with this article can be viewed by clicking on the following link: https://doi.org/10.1016/j.sleep.2018.11.010.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.sleep.2018.11.010.

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