Effectiveness of a cognitive-behavioral sleep hygiene intervention for adolescents with ADHD: a randomized controlled trial

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RESEARCH

Effectiveness of a cognitive-behavioral sleep hygiene intervention for adolescents with ADHD: a randomized controlled trial

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Abstract

Objective: Sleep problems are frequent and impairing in adolescents with ADHD. This randomized controlled trial investigates the effectiveness of a newly developed CBT sleep hygiene intervention for adolescents with ADHD – SIESTA. **Method**: Adolescents with ADHD and sleep problems (N = 92, M_{age} = 14.36, SD = 1.43, 47% males) were randomized to receive SIESTA next to treatment as usual targeting ADHD (SIESTA+TAU) or TAU only. Adolescent and parent ratings, actigraphy and sleep diaries, were collected at pre-, post-, and at 4 month follow-up test. A linear mixed effects model was used with an intent-to-treat approach.**Results**: Results indicated significant improvement in SIESTA+TAU compared to TAU from pre- to post-test on sleep hygiene (η_p^2 =.21), chronic sleep reduction (η_p^2 =.15), and sleep-wake problem behaviors (η_p^2 =.05). Actigraphy and sleep diaries showed no significant differences, with both groups improving on sleep diaries. The improvements in sleep hygiene were maintained at follow-up (η_p^2 =.09). Of secondary outcomes, depressive symptoms reduced significantly more from pre- to post-test in SIESTA+TAU than in TAU only (η_p^2 =.09).**Conclusions**: This study indicates that SIESTA is effective at improving sleep hygiene, perceived sleep problems, and depressive symptoms in adolescents with ADHD. However, to maintain long-term effects, booster sessions may be beneficial.

Keywords ADHD · Sleep · Adolescence · RCT · CBT

Introduction

Attention-deficit/hyperactivity disorder (ADHD) is a common neurodevelopmental disorder [1] associated with difficulties across different domains of functioning, such as educational underachievement, interpersonal-, and internalizing problems, externalizing behaviors, and sleep problems [2]. Sleep problems in particular are often overlooked in ADHD even though they significantly impair daily life and are likely to increase into adulthood [3]. Adolescence is an especially important developmental period, as then, sleep problems often emerge or worsen [4]. Sleep

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undergoes significant changes during adolescence, affecting both sleep pressure and circadian rhythms, due to the natural maturation of sleep regulatory systems and changing environmental and social demands [5]. Reviews show adolescents with ADHD consistently report more subjectively experienced sleep problems than their neurotypical peers, such as lower sleep satisfaction and daytime sleepiness. When assessing sleep with daily diaries, the most consistently impaired aspects of sleep include a longer sleep onset latency and lower sleep efficiency. Studies using objective measures, show more inconsistent results [4, 6, 7]. However, only few studies are available. Moreover in adolescents with ADHD, sleep problems may causally contribute to ADHD and co-occurring psychiatric symptoms, such as depression and anxiety [8]. Therefore, sleep is an important intervention target for adolescents with ADHD [9].

Although no ADHD-adapted sleep intervention is currently available for adolescents, there is evidence of effectiveness in reducing sleep problems (i.e., symptoms of insomnia, sleep onset delay, and nighttime awakenings) in children and adults with ADHD [10, 11]. In adolescents with ADHD, only one non-randomized pilot trial examined the effectiveness of a transdiagnostic sleep intervention in 14 adolescents (TranS-C-Youth; [12]). Results showed that sleep (i.e., sleep quality, sleep habits, and sleep-wake behavior), ADHD symptoms, and daily life functioning improved [13]. However, due to lack of a control group it remains inconclusive whether positive effects were related to the intervention. Therefore, in this study we tested the effectiveness of SIESTA – Sleep IntervEntion as Symptom Treatment for ADHD – an ADHD-adapted Cognitive Behavioral Therapy (CBT) sleep hygiene intervention for adolescents, using a randomized controlled design (RCT). SIESTA builds on the promising qualitative feedback of adolescents with ADHD in our pilot study [14], which indicated that both adolescents and parents reported positive effects such as improved sleep hygiene, feeling more awake, and falling asleep faster.

SIESTA targets individually determined sleep problems by changing sleep hygiene practices, targeting difficulty with planning and organization, and circadian rhythm problems [4]. Adolescents with ADHD often have inadequate sleep hygiene [4]. Sleep hygiene includes various factors such as sleep practices (e.g., winding down in the evening), sleep environment (e.g., a cluttered bedroom), and physiological influences (e.g., caffeine use), which are associated with sleep problems [15, 16]. Therefore, improving sleep hygiene is a core goal of SIESTA. Second, adolescents with ADHD often have difficulties with planning and organization [17]. These difficulties might lead to later bedtimes, e.g., by finishing homework later, resulting in a shorter total sleep time [17, 18]. Consequently, SIESTA includes a focus on improving planning. Third, ADHD is associated with a shift in circadian rhythm, contributing to later bedtimes, which can lead to insufficient sleep due to early school start times [19]. Hence SIESTA incorporates the importance of sufficient daylight to evoke earlier sleep onset times. However, SIESTA does not target sleep problems that require more intensive interventions (e.g., chronic insomnia or narcolepsy).

The context, structure, and mode of SIESTA are also adapted to the needs of adolescents with ADHD and have been further refined following qualitative feedback from adolescents and parents in our pilot study (e.g., more structure, examples, reduction of cognitive load). First, they are more likely to drop out of treatment or have difficulties with compliance, due to ADHD symptoms as well as difficulties with (intrinsic) motivation [20]. Hence, to support autonomy SIESTA is individually tailored and adolescents choose their own sleep goals and motivational interviewing is used throughout SIESTA. Second, executive functioning (EF) deficits (e.g., difficulties with inhibition, working memory) are common [21], which can contribute to challenges during treatment. Therefore, SIESTA is highly structured, focuses on one major goal at a time, utilizes multiple small steps, and includes visual aids. Lastly, during adolescence the need for autonomy increases, indicating a primary focus on the adolescents themselves [22]. However, some caregiver involvement is desirable as especially adolescents with ADHD may still require some support transitioning to autonomous sleep self-regulation [18].

This study examines the effectiveness of SIESTA next to treatment as usual for ADHD (SIESTA+TAU), compared to TAU only in the short- and middle-long term (+-4 months follow-up). We hypothesize that SIESTA+TAU will improve sleep hygiene, sleep problems, and objective and subjective sleep parameters more than TAU only. Moreover, we hypothesize that it will have a positive effect on secondary outcomes (e.g., ADHD/depressive symptoms).

Methods

Participants

Inclusion criteria were (1) age 13 to 17 years, (2) attending secondary education, (3) having an IQ≥80, verified by the subtests Vocabulary and Matrix reasoning from the Wechsler Intelligence Scale for Children (WISC; [23]) or the Wechsler Adult Intelligence Scale (WAIS; [24]), (4) having a prior diagnosis of ADHD, (5) fulfilling ADHD criteria at time of screening, verified by the Kiddie Schedule for Affective Disorders and Schizophrenia – Present & Lifetime Version DSM-5 (K-SADS-PL DSM-5; [25]), (6) experiencing sleep

problems assessed in a sleep interview with adolescents and caregiver(s) based on the criteria outlined in the DSM-5 [1] and the ICSD-3 [26]. Specifically, sleep problems were defined as: occurring on at least three days per week and persisting for a minimum of three months; characterized by either sleep onset latency > 20 min, time awake after sleep onset > 30 min, or a total sleep duration < 7 h, in conjunction with at least one inadequate sleep hygiene practice (e.g., caffeine or media use before bedtime) and distress reported by either the adolescent or their caregiver(s). Many adolescents use ADHD medication and although this has been suggested to impact sleep, it likely is not the primary contributor to their sleep problems [27]. Nevertheless to rule out medication change effects, if applicable, participants had to maintain (8) a stable use of ADHD medication for at least four weeks prior to participation. From pre- to post-test participants were further instructed to maintain a stable use of ADHD medication, which was thoroughly evaluated through interviews with adolescents and parents.

Exclusion criteria included (1) specific self- or caregiver-reported sleep disorders, i.e., restless legs syndrome, sleep breathing disorders, and narcolepsy, (2) caregiver-reported comorbid disorders including autism, conduct disorder, and depressive disorder but only in case of current suicide risk or active suicidality, as for these disorders more intense or other interventions may be indicated; the latter two were verified by the K-SADS-PL DSM-5 [25], (3) substance abuse (excluding nicotine) as indicated by the Substance use disorders and addictive disorders subscale of the Measurements in the Addictions for Triage and Evaluations-Youth [28], (4) experiencing an acute crisis situation at home, because a more intense intervention would be necessary, (5) presenting with physical or medical conditions or medication use directly influencing sleep patterns, (6) participation in cognitive behavioral sleep interventions within the preceding six months, (7) using melatonin (unless with a washout period of at least two weeks prior to pre-test). From pre- to post-test participants were further instructed not to start using melatonin, which was thoroughly evaluated through interviews with adolescents and parents. Of the 106 screened adolescents, 15 were excluded (Fig. 1).

Study design

This study was approved by the Ethical Committee Research of UZ/KU Leuven (S64197), registered at ClinicalTrials.gov (NCT04723719), followed JARS and CONSORT guidelines (Supplement 1) [30, 31], and a published protocol paper describes methods in more detail [32]. DB, BB, AR, SB, MD, and SVDO were blinded throughout the study, participants and clinicians were not blinded given the nature of the intervention. SIESTA+TAU was compared to TAU only. An independent researcher was responsible for randomization, using a computerized random schedule. Allocation was stratified for ADHD medication use (yes/no) and for five locations across Flanders, with a 1:1 ratio SIESTA+TAU versus TAU using permuted block sizes of two; 47 adolescents were allocated to the SIESTA+TAU and 45 to the TAU group (Fig. 1). Sample size was determined based on power analysis; a CBT sleep study in adolescents without ADHD showed a large effect on sleep and medium effect on ADHD symptoms [33]; therefore a moderate to large effect size was anticipated [32]. Using G*power, at least 40 participants per condition were necessary (power 0.8/alpha 0.05); to account for potential drop-outs an additional 15% was recruited, resulting in 92 participants [32].

Procedure

Recruitment took place across Flanders (Belgium). Participants in the SIESTA study were recruited through clinics, ADHD organizations, social media, and a network of clinicians. To improve accessibility, clinicians traveled to five different locations to provide the intervention, minimizing the need for adolescents to travel long distances. After signing informed assent and consent forms, screening for inclusion took place. This included the sleep interview with the adolescent and caregiver(s), the WISC/WAIS with the adolescent, and the K-SADS with the caregiver(s), and both filling out questionnaires [32]. If participants met inclusion criteria, the study protocol started (Fig. 1). Pre-, post-, and follow-up test measurement included actigraphy, sleep diaries, and questionnaires for adolescents, caregiver(s), and teachers. Participants of TAU were offered SIESTA after completion of follow-up measurements. Screening was in five waves (2021–2023) with recruitment in January-March or September-October. These time periods were chosen to conduct the measurements and provide SIESTA during regular school weeks, as sleep during holidays and exam-periods may not be representative.

Intervention

Participants in the SIESTA+TAU group received SIESTA, an ADHD-adapted CBT sleep intervention for adolescents, consisting of seven individual weekly one-hour sessions with the adolescent and two separate one-hour sessions with the caregiver(s) (Supplement 2: content of the sessions), next to their TAU for ADHD. SIESTA focuses on sleep hygiene while addressing the unique challenges faced by adolescents with ADHD. They often experience motivational difficulties [20], thus an important part of SIESTA is motivational interviewing. To support adolescents' increasing autonomy, adolescents formulate their own goals to

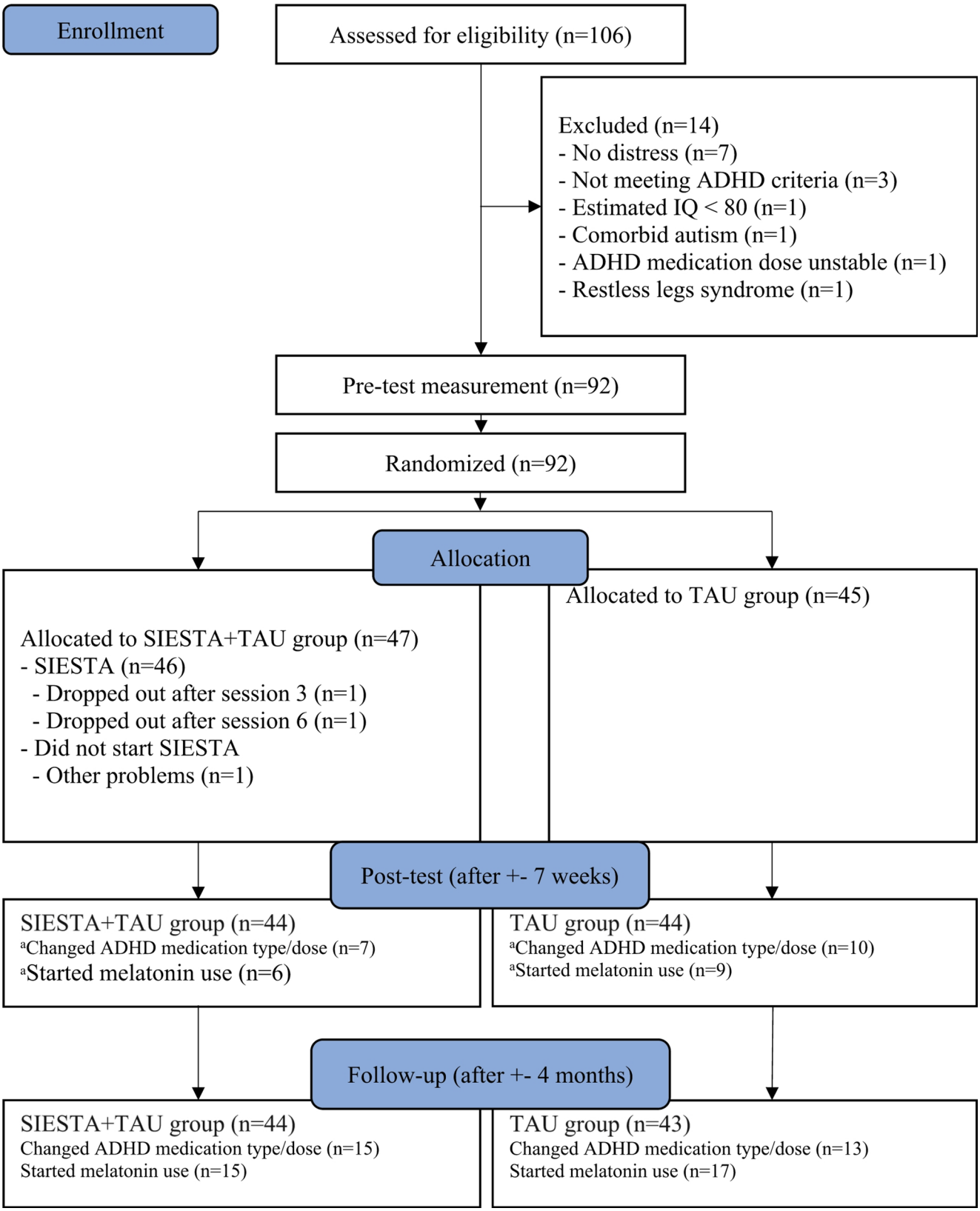

Fig. 1 RCT CONSORT flow diagram. *Note*. [a]Although explicitly instructed not to

work on. The sleep problems addressed in the intervention are quite heterogeneous and thus vary depending on the primary goal chosen by each adolescent. About 50% of the participants in SIESTA selected a goal related to improving sleep onset latency, suggesting that difficulty falling asleep is a commonly targeted problem in SIESTA. Special attention is given to working with adolescents with ADHD, e.g., goals are made feasible, the sessions vary in methods used (quiz, infographic), adjusted in pace and speech, and challenges with memory and follow-through are anticipated. SIESTA includes a workbook that records all experiments and steps, utilizing infographics and concise text to maintain engagement and help them remember the techniques they learned. For clinicians, there is a trainer manual outlining session goals and additional information on sleep and techniques used [34].

Treatment integrity and fidelity

SIESTA was administered by nine licensed clinical psychologists. The number of participants they provided the intervention to ranged from one to 17 participants (*Mdn* = 2). All psychologists received a one-day training and initially provided SIESTA to pilot study or TAU group participants (if they wanted the intervention after follow-up test, which 37 did). Weekly supervision was provided by two supervisors, BB (co-developer of SIESTA and registered supervisor for the Dutch Cognitive Behavior Therapy Association) and AR (registered behavior therapist and CBT for insomnia (CBT-I) specialist at Leuven's University Hospital). Sessions were recorded and 10% were randomly selected for integrity coding by two trained clinical psychology master students. The coding used a 3-point scale (1 = not addressed, 2 = somewhat addressed, and 3 = fully addressed) to assess the coverage of each session's components. The average agreement between scorers and clinicians was 96.2%, the average protocol adherence was 91.2%.

Serious adverse events of SIESTA

Serious adverse events (SAE) were monitored during SIESTA, SAE were spontaneously reported in sessions 1–2 and explicitly asked from session 3 onwards (from then on an established working relationship). Documented events were reported immediately to the Ethical Committee Research at UZ/KU Leuven. For each event, the description, timing, severity, relationship to the study, and outcome were recorded.

Treatment as usual for ADHD

Treatment as usual for ADHD was assessed in both groups at post-test and follow-up by caregiver- and adolescent-reported questions (i.e., whether they had sessions with any health care providers and what these sessions were about). Furthermore, they were asked whether their ADHD medication type and/or dose changed, and whether any melatonin was used, although they were instructed not to, from pre- to post-test.

Primary outcome measures

As sleep is a multifaceted domain, a mixed methods approach was chosen to comprehensively assess sleep (Supplement 3: more information on all outcomes).

Self-reported sleep hygiene was assessed with the revised Adolescent Sleep Hygiene Scale (ASHSr) [35]. Moreover, adolescents filled out the Chronic Sleep Reduction Questionnaire (CSRQ), measuring chronic sleep deprivation [36], and two subscales of the School Sleep Habits Survey (SSHS), assessing daytime sleepiness and sleep/wake problem behaviors. Caregivers completed the Children Sleep Habits Questionnaire (CSHQ) [37].

Sleep parameters were measured using wrist actigraphy (using the Motionwatch 8 (CamNtech) and accompanying MotionWare software; [38]) and sleep diaries (using an ecological assessment app (mPath); [39]) for one week. They included total sleep time (TST; time asleep between sleep onset and sleep offset), sleep onset latency (SOL; time from lights out to sleep onset), sleep efficiency (SE; percentage of time asleep while in bed), and number of awakenings (NoA; number of times awake after sleep onset and before sleep offset).

Secondary outcome measures

The Disruptive Behavior Disorder Rating Scale (DBDRS) was filled out by caregivers to assess inattentive and hyperactive/impulsive, and ODD symptoms [40]. Anxiety symptoms were evaluated using the self-reported SCARED-R [41], depressive symptoms with the self-reported Child Depression Inventory 2 (CDI-2) [42]. Regarding functional outcomes, caregiver-adolescent conflict was evaluated with the Conflict Behavior Questionnaire (CBQ) [43]. To assess adolescents' academic functioning, caregivers completed the Homework Problems Checklist (HPC) [44] and teachers the Classroom Performance Scale (CPS) [45].

Satisfaction for SIESTA

Adolescents and caregivers of the SIESTA+TAU group reported their satisfaction with SIESTA using Likert-scale and open-ended questions (see Supplement 4 for more info).

Statistical analysis

Differences in treatment as usual between groups were compared using Chi-Square tests. Statistical analyses were conducted using R Statistical Software (v4.3.1; [46]), using an intent-to-treat approach. Imputation for missing items was performed using predictive mean matching using the mice package [47] with five donor pools that were pooled using Rubin's Rules [48, 49]. In case of missingness larger than 30%, completer analyses were conducted [48]. To assess the possible influence of the five waves of assessment, intraclass correlations (ICC) were computed [50].

To test for significant differences between the groups, a linear mixed effects model was used, using the lme function of the nlme package [51]. In contrast to the planned model (fixed effect: interaction between time and condition; random intercept per participant/wave) [31], baseline differences on pre-test outcomes were controlled for in the final model, with pre-test being included as a fixed effect. Taking baseline differences into account is advised to reduce the chance of biased estimates of the intervention effect [52]. However, no testing for baseline differences was done as "perfect" randomization could result in any differences being due to chance and instead focus should be on adjusting for potential confounding variables (such as pre-test measures), irrespective of their statistical significance at baseline, to ensure more internally valid and precise effect estimates [53]. Effect sizes were computed using partial eta squared (0.01: small effect, 0.06: medium effect, 0.14: large effect). Multiple testing was accounted for by the Benjamini, Krieger, and Yekutieli (BKY) correction [54]. For exploratory within-group effects, post-hoc paired samples t-tests and repeated measures ANOVAs were conducted. Covariate analyses were conducted by including changes in ADHD medication or melatonin use as covariates in the statistical models.

Results

Participants included 92 adolescents (53% female), most used ADHD medication (80%). (demographics see Table 1; Supplement 5: caregiver demographics).

Differences between groups

There were no significant differences between groups in amount of sessions of treatment as usual for ADHD (pre-post: χ^2 (1, N=33)=0.14, p=.71; post-follow-up: χ^2 (1, N=46)=0.06, p=.80), (although instructed not to

Table 1 Demographic characteristics of participants

Characteristic		SIESTA+TAU (n=47)	TAU (n=45)
		M (SD)	M (SD)
Age in years		14.45 (1.54)	14.27 (1.30)
Pubertal development (PDS)		2.89 (0.91)	2.88 (0.92)
IQ		99.64 (12.66)	106.44 (14.52)
		% (n)	% (n)
Gender	Female	48.9 (23)	57.7 (26)
	Male	51.0 (24)	42.2 (19)
ADHD presentation[a]	Inattentive	53.2 (25)	44.4 (20)
	Hyperactive-Impulsive	2.1 (1)	8.8 (4)
	Combined	44.7 (21)	46.6 (21)
School type	General education	63.8 (30)	71.1 (32)
	Vocational education	12.8 (6)	4.4 (2)
	Artistic education	6.4 (3)	8.8 (4)
	Technical education	17.0 (8)	15.5 (7)
ADHD medication	Total	78.7 (37)	80.0 (36)
	Methylphenidate	70.2 (33)	77.8 (35)
	Dextroamphetamine	6.4 (3)	2.2 (1)
	Atomoxetine	2.1 (1)	0 (0)
Family composition	Biological / legal parents	74.5 (35)	66.7 (30)
	Single biological / legal parent	17.0 (8)	20.0 (9)
	Newly composed / co-parenting	6.4 (3)	13.3 (6)
	Foster family	2.1 (1)	0.0 (0)

Note. [a]ADHD presentation based on K-SADS-PL DSM-5; PDS = Pubertal Developmental Scale [29]

from pre- to post-test) ADHD medication change (pre-post: χ^2 (1, N=17)=0.82, p=.37; post-follow-up: χ^2 (1, N=28)=0.10, p=.75), nor melatonin use (pre-post: χ^2 (1, N=15)=0.88, p=.35; post-follow-up: χ^2 (1, N=32)=0.35, p=.56) (Supplement 6).

Data attrition

Missingness in primary (pre: 0-14.1%, post: 3.3–17.4%, follow-up test 6.5–18.5%) and secondary outcomes (pre: 0-1.1%, post: 3.3%, follow-up test: 7.6–9.8%) was limited, based on both adolescent- and caregiver report (Supplement 7). Missing items for actigraphy measures ranged from 2.2 to 3.3% at pre-test, 10.9–13% at post-test, and 15.2–18.5% at follow-up. Missingness of teacher-report was 30.4% at pre-, 51.1% at post-, and 65.2% at follow-up test, therefore completer analysis was used.

Intraclass correlation

Wave did not explain a significant amount of variance in primary and secondary outcome analyses (ranging from 0 −2%), thus was not included as a level.

Primary outcomes

Means, standard deviations, and results from the analyses are reported in Table 2. The following interaction effects were significant from pre- to post intervention: The SIESTA+TAU group improved on the ASHSr (large effect), CSRQ (large effect), and sleep-wake problem behaviors of the SSHS (small effect), significantly more than the TAU group. At follow-up one interaction remained significant (ASHSr, medium effect). There were no significant interaction effects on self-reported daytime sleepiness, the CSHQ, actigraphy, and sleep diary outcomes; exploratory within group analysis showed that both groups improved on the sleep diary, there was no change over time on actigraphy (Supplement 8).

Secondary outcomes

There was a significant interaction for depressive symptoms (*B(SE)* = -3.09 (1.11); p=.007; η_p^2 = 0.09; medium effect), the SIESTA+TAU group showed a significantly stronger decrease of depressive symptoms from pre- to post-test compared to TAU, there were no other significant interactions (Supplement 9). Exploratory within group analyses showed that on most outcomes either both groups significantly improved (DBDRS-ADHD, CDI-2, HPC) or there was no effect over time (DBDRS-ODD, CBQ, CPS). On the SCARED only the within group analysis of the SIESTA+TAU group was significant (Supplement 10).

Covariate analyses

Covariate analyses, including ADHD medication change and melatonin use, showed the same interaction effects from pre- to post-test and follow-up test, except for sleep-wake problem behaviors (SSHS) which was no longer significant (Supplements 11–12).

Satisfaction for SIESTA

Satisfaction scores of both adolescents and caregivers were generally positive (Means of 3.68–4.57 / 5; Supplement 5). Adolescents mostly reported improvement on falling asleep faster (n=23) and caregivers mostly reported improvement of their adolescent's awareness of sleep processes and sleep hygiene (n=25). Regarding persisting challenges, adolescents mostly reported no challenges because everything they worked on improved (n=14) and caregivers mostly reported that their adolescent was still going to bed too late (n=7) (Supplement 13).

Serious adverse events of SIESTA

One SAE was reported during SIESTA which the Ethical Committee Research of UZ/KU Leuven considered unrelated to SIESTA.

Discussion

This RCT is the first to investigate the effect of a CBT intervention targeting sleep hygiene, SIESTA+TAU, as compared to TAU only for adolescents with ADHD and co-occurring sleep problems. SIESTA+TAU improved on sleep hygiene and perceived sleep problems (chronic sleep deprivation) more than TAU only in the short term (large effects), and more than TAU on sleep-wake problems although this effect was only small, and not significant after covarying for ADHD medication change and melatonin use. The beneficial effect of SIESTA+TAU over TAU on sleep hygiene remained at four months follow-up (medium effect). On secondary outcomes, depressive symptoms improved more in SIESTA+TAU than in TAU only (medium effect).

Large effects were found for improvement in sleep hygiene for SIESTA+TAU as compared to TAU only. This is particularly relevant as targeting this is the main focus of SIESTA and sleep hygiene is an important contributor to sleep problems in adolescents [15]. Furthermore, the SIESTA+TAU group improved significantly more on

Table 2 Means, standard deviations, estimated coefficients, standard errors, and effect sizes for primary outcomes

		Pre-test	Post-test	Follow-up	Pre- to post-test			Pre- to follow-up		
Outcome per treatment group		*M* (*SD*)	*M* (*SD*)	*M* (*SD*)	*B* (*SE*)	*p*	η_p^2	*B* (*SE*)	*p*	η_p^2
Self-reported sleep hygiene (ASHSr Total)	SIESTA+TAU	4.23 (0.51)	4.55 (0.47)	4.47 (0.54)	0.42 (0.09)	**<0.001**	0.21	−0.23 (0.08)	**0.005**	0.09
	TAU	4.30 (0.43)	4.18 (0.48)	4.34 (0.49)						
Self-reported chronic sleep deprivation (CSRQ Total)	SIESTA+TAU	41.83 (7.17)	36.25 (7.50)	36.21 (6.49)	-5.05 (1.34)	**<0.001**	0.15	2.46 (1.51)	0.11	0.03
	TAU	38.79 (7.43)	39.36 (7.50)	36.85 (7.66)						
Self-reported daytime sleepiness (SSHS)	SIESTA+TAU	13.35 (3.56)	12.46 (2.24)	12.74 (2.74)	−0.87 (0.50)	0.08	0.03	0.74 (0.61)	0.23	0.02
	TAU	12.47 (2.63)	13.02 (3.15)	12.59 (2.96)						
Self-reported sleep-wake problem behaviors (SSHS)	SIESTA+TAU	21.77 (4.82)	19.52 (5.43)	19.51 (5.53)	-1.82 (0.88)	**0.04**	0.05	1.18 (1.10)	0.29	0.02
	TAU	20.78 (5.34)	20.77 (4.78)	19.71 (5.49)						
Caregiver-rated sleep problems (CSHQ Total)	SIESTA+TAU	52.69 (5.71)	49.03 (5.59)	49.00 (5.92)	-2.85 (1.48)	0.07	0.06	1.21 (1.39)	0.39	0.01
	TAU	52.19 (7.55)	51.95 (7.94)	50.85 (6.67)						
TST Actigraph	SIESTA+TAU	8.11 (0.76)	8.03 (0.64)	8.20 (0.61)	−0.17 (0.12)	0.17	0.02	0.22 (0.18)	0.22	0.02
	TAU	7.94 (0.95)	8.07 (0.65)	8.11 (0.72)						
SOL Actigraph	SIESTA+TAU	0.56 (0.45)	0.54 (0.37)	0.40 (0.32)	0.09 (0.08)	0.30	0.02	−0.31 (0.16)	0.09	0.10
	TAU	0.74 (0.66)	0.51 (0.38)	0.56 (0.52)						
SE Actigraph	SIESTA+TAU	0.92 (0.05)	0.92 (0.04)	0.94 (0.03)	−0.01 (0.01)	0.33	0.02	0.03 (0.01)	0.07	0.06
	TAU	0.90 (0.08)	0.92 (0.04)	0.92 (0.05)						
NoA Actigraph	SIESTA+TAU	40.79 (7.95)	39.95 (8.05)	40.70 (6.58)	−0.17 (1.59)	0.92	0.00	−0.92 (1.81)	0.61	0.00
	TAU	37.75 (9.30)	39.18 (8.71)	39.08 (8.48)						
TST Sleep diary	SIESTA+TAU	7.57 (0.96)	7.62 (0.84)	7.78 (0.82)	0.05 (0.15)	0.74	0.00	−0.05 (0.21)	0.82	0.00
	TAU	7.47 (0.98)	7.68 (0.71)	7.72 (0.78)						
SOL Sleep diary	SIESTA+TAU	1.06 (0.72)	0.77 (0.64)	0.64 (0.39)	−0.06 (0.14)	0.65	0.01	−0.22 (0.18)	0.23	0.03
	TAU	1.16 (0.79)	0.90 (0.49)	0.88 (0.58)						
SE Sleep diary	SIESTA+TAU	0.84 (0.09)	0.87 (0.07)	0.89 (06)	0.00 (0.02)	0.79	0.01	0.02 (0.02)	0.37	0.02
	TAU	0.83 (0.09)	0.87 (0.05)	0.86 (0.08)						
NoA Sleep diary	SIESTA+TAU	0.55 (0.65)	0.30 (0.39)	0.19 (0.22)	0.02 (0.08)	0.81	0.00	−0.17 (0.11)	0.14	0.04
	TAU	0.43 (0.37)	0.26 (0.36)	0.29 (0.44)						

Note. Significant *p* values after the BKY correction in bold

subjectively perceived sleep problems. However, despite positive subjective findings, no significant differences were found on sleep parameters (i.e., total sleep time or sleep efficiency) assessed with actigraphy and sleep diaries.

Noteworthy, within-group analyses on sleep diaries showed an improvement of sleep parameters in both groups. This might indicate a self-monitoring effect (i.e., due to monitoring of sleep perceiving less time to fall asleep and longer sleep times) [55]. Interestingly, only in the SIESTA+TAU group, this rating was corroborated with a subjective experience of less sleep problems. This highlights the importance of subjective perception in sleep research, i.e., sleep diary and actigraphy changes might not accurately represent changes of perceived sleep problems [26, 56, 57], e.g., falling asleep faster in under two hours might already be fast for some individuals, while for others 20 min is already long. Previous CBT-I research in adolescents without ADHD also found more pronounced effects on sleep questionnaires, in contrast to sleep parameters [58].

Of interest, significant interaction effects were found for depressive symptoms, with SIESTA+TAU reporting a significantly larger decrease in depressive symptoms than TAU only. Depressive symptoms often emerge in adolescence, are highly impairing [59] and relate to sleep problems [60]. Targeting sleep as in SIESTA may break this vicious cycle between sleep and depression in ADHD [61]. Surprisingly, we did not find an effect on ADHD symptoms or other secondary outcomes. Studies in childhood did find changes in ADHD symptoms and other outcomes after intervention [11], and a sleep extension/restriction study found that sleep extension reduced ADHD, ODD symptoms, and improved functional outcomes in adolescents with ADHD. Although speculative, it may be for effects on more distal outcomes beyond sleep and depression, a marked change of objective sleep duration and efficiency (e.g. by including bedtime restriction or chronotherapy) is necessary [8]. Thus, while subjective improvements were associated with reductions in depressive symptoms, future interventions should explore whether improvements in objective sleep parameters can further enhance benefits for both ADHD symptoms and overall functioning.

Limitations

Despite the strengths of this study, i.e., including a large percentage of females (53%), a relatively melatonin-free sample (often not in sleep research), intensive supervised clinicians, limited drop-out, and general satisfaction among participants, certain limitations should be considered. First, even though we recruited in three languages (Dutch, English, and French; in Belgium the majority of global minority members are French speaking immigrants from, e.g., Morocco [62]) and provided SIESTA in diverse rural and urban locations across Flanders, the sample primarily consisted of highly educated families. Second, although we specifically instructed adolescents not to change medication from pre- to post test, 18% changed their dose and 16% started melatonin from pre-to post and respectively 30% and 34% from pre to follow-up. However, covariate analyses showed largely similar results.

Future directions

Although we found small to large effects on subjective perception of sleep, future research should identify which subgroups (e.g., age, puberty, gender, comorbidity) benefit most from SIESTA and explore the reasons why. Second, after our study started, the non-controlled pilot study on a transdiagnostic intervention for adolescents with ADHD was published, with promising results on different sleep variables [13]. Future research could compare the ADHD specific SIESTA to non-ADHD-adapted CBT-I such as TranS-C to determine whether ADHD adaptations are indeed beneficial. Moreover, given the potential interplay of homeostatic sleep drive and circadian rhythms in ADHD-related sleep problems [7], integrating biological targets into future iterations of SIESTA - potentially by adapting ADHD-specific elements from SIESTA into a CBT-I or Trans-C framework - may be a crucial next step in optimizing sleep outcomes for adolescents with ADHD. Lastly, the relatively short duration of our follow-up limits the possibility to draw conclusions regarding sustainability of the intervention effects. The reduced findings at follow-up and approximately one-third of adolescents (re-)starting melatonin use, indicate that adolescents might find it difficult to maintain their sleep plan and that booster sessions or, e.g., booster text-messages might be useful [63].

Clinical implications

ADHD can be a lifelong condition, with sleep problems occurring across the life-span. Sustained management strategies of sleep may need to be integrated into a comprehensive ADHD treatment plan. SIESTA could be part of such a plan, with clinicians playing a key role in reminding and reinforcing the learned tools in SIESTA throughout different life stages, fostering holistic care for individuals with ADHD [64].

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Data availability Data is available upon reasonable request.

Declarations

Competing interests Bianca E. Boyer is a co-developer and author of treatment manuals "Plan My Life", "Solution Focused Treatment" and "My Sleep Plan"; she receives royalties for the sales of all interventions. Marina Danckaerts is participating in a Takeda-sponsored clinical trial in ADHD. Saskia Van der Oord declares an honorarium and reimbursement for travel expenses from MEDICE for a lecture on non-pharmacological treatment of ADHD. On behalf of the other authors, the corresponding author states that there is no conflict of interest.

References

1. American Psychiatric Association (2013) APA - DSM - Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition, Text Revision (DSM-5-TR)
2. Faraone SV, Banaschewski T, Coghill D et al (2021) The world federation of ADHD international consensus statement: 208 Evidence-based conclusions about the disorder. Neurosci Biobehav Rev 128:789–818. https://doi.org/10.1016/j.neubiorev.2021.01.022
3. Becker SP (2019) The triple threat of sleep, adolescence, and ADHD. Sleep and ADHD: an evidence-based guide to assessment and treatment. Elsevier Academic, San Diego, CA, US, pp 257–293
4. Marten F, Keuppens L, Baeyens D et al (2023) Sleep parameters and problems in adolescents with and without ADHD: A systematic review and meta-analysis. JCPP Adv
5. D'Ambrosio C, Redline S (2014) Sleep across the lifespan. Impact of sleep and sleep disturbances on obesity and cancer. Springer, New York, NY, pp 1–23. https://doi.org/10.1007/978-1-4614-9527-7_1
6. Marten F, Keuppens L, Baeyens D et al (2025) Co-occurring mental health problems in adolescents with ADHD and sleep problems. Sleep Med 126:107–113
7. Lunsford-Avery JR, Carskadon MA, Kollins SH, Krystal AD (2025) Sleep physiology and neurocognition among adolescents with attention-deficit/hyperactivity disorder. J Am Acad Child Adolesc Psychiatry 64:276–289. https://doi.org/10.1016/j.jaac.2024.03.005
8. Becker SP, Tamm L, Epstein JN, Beebe DW (2020) Impact of sleep restriction on affective functioning in adolescents with attention-deficit/hyperactivity disorder. J Child Psychol Psychiatry 61:1160–1168. https://doi.org/10.1111/jcpp.13235
9. Cortese S, Fusetto Veronesi G, Gabellone A et al (2024) The management of sleep disturbances in children with attention-deficit/hyperactivity disorder (ADHD): an update of the literature. Expert Rev Neurother 24:585–596. https://doi.org/10.1080/14737175.2024.2353692
10. Jernelöv S, Larsson Y, Llenas M et al (2019) Effects and clinical feasibility of a behavioral treatment for sleep problems in adult attention deficit hyperactivity disorder (ADHD): a pragmatic within-group pilot evaluation. BMC Psychiatry 19:226. https://doi.org/10.1186/s12888-019-2216-2
11. Sciberras E, Mulraney M, Mensah F et al (2020) Sustained impact of a sleep intervention and moderators of treatment outcome for children with ADHD: a randomised controlled trial. Psychol Med 50:210–219. https://doi.org/10.1017/S0033291718004063
12. Harvey AG (2016) A transdiagnostic intervention for youth sleep and circadian problems. Cogn Behav Pract 23:341–355. https://doi.org/10.1016/j.cbpra.2015.06.001
13. Becker SP, Duraccio KM, Sidol CA et al (2021) Impact of a behavioral sleep intervention in adolescents with ADHD: feasibility, acceptability, and preliminary effectiveness from a pilot open trial. J Atten Disord 26:1051–1066. https://doi.org/10.1177/10870547211056965
14. Keuppens L, Marten F, Baeyens D et al (2024) A pilot study of a cognitive-behavioral sleep intervention specifically for adolescents with ADHD and sleep problems: A qualitative and quantitative evaluation. Cogn Behav Pract 31:367–382. https://doi.org/10.1016/j.cbpra.2023.12.001
15. Martin CA, Hiscock H, Rinehart N et al (2020) Associations between sleep hygiene and sleep problems in adolescents with ADHD: A cross-sectional study. J Atten Disord 24:545–554. https://doi.org/10.1177/1087054718762513
16. Van Dyk TR, Becker SP, Byars KC (2019) Rates of mental health symptoms and associations with self-reported sleep quality and sleep hygiene in adolescents presenting for insomnia treatment. J Clin Sleep Med 15:1433–1442. https://doi.org/10.5664/jcsm.7970
17. Boyer BE, Geurts HM, Van der Oord S (2018) Planning skills of adolescents with ADHD. J Atten Disord 22:46–57. https://doi.org/10.1177/1087054714538658
18. Maskevich S, Shen L, Drummond SPA, Bei B (2021) What time do you plan to sleep tonight? An intense longitudinal study of adolescent daily sleep self-regulation via planning and its associations with sleep opportunity. J Child Psychol Psychiatry 63:900–911. https://doi.org/10.1111/jcpp.13540
19. Coogan AN, McGowan NM (2017) A systematic review of circadian function, chronotype and chronotherapy in attention deficit hyperactivity disorder. ADHD Atten Deficit Hyperact Disord 9:129–147. https://doi.org/10.1007/s12402-016-0214-5
20. Sibley MH, Graziano PA, Kuriyan AB et al (2016) Parent–teen behavior therapy + motivational interviewing for adolescents with

ADHD. J Consult Clin Psychol 84:699–712. https://doi.org/10.1037/ccp0000106
21. Martel MM, Levinson CA, Lee CA, Smith TE (2017) Impulsivity symptoms as core to the developmental externalizing spectrum. J Abnorm Child Psychol 45:83–90. https://doi.org/10.1007/s10802-016-0148-6
22. Evans SW, Van der Oord S, Rogers EE (2019) Academic functioning and interventions for adolescents with ADHD. In: Becker SP (ed) ADHD in adolescents: development, assessment, and treatment. Guilford Press, New York, p 426
23. Wechsler D (2014) Wechsler intelligence scale for children. WISC-V), Pearson
24. Wechsler D (2008) Wechsler adult intelligence Scale–Fourth edition. WAIS-IV)
25. Kaufman J, Birmaher B, Axelson D et al (2016) The KSADS-PL DSM-5. Kennedy Krieger Institute, Baltimore, MD
26. American Academy of Sleep Medicine (2014) International Classification of Sleep Disorders-Third Edition
27. Wiggs KK, Breaux R, Langberg JM et al (2023) Examining daily stimulant medication use and sleep in adolescents with ADHD. https://doi.org/10.1007/s00787-023-02204-w. Eur Child Adolesc Psychiatry
28. Schippers G, Broekman T (2013) MATE-U 2.1 a-handleiding En protocol voor de MATE-jeugd. Beta Boeken, Nijmegen
29. Petersen AC, Crockett L, Richards M, Boxer A (1988) A self-report measure of pubertal status: reliability, validity, and initial norms. J Youth Adolesc 17:117–133. https://doi.org/10.1007/BF01537962
30. Appelbaum M, Cooper H, Kline RB et al (2018) Journal Article reporting standards for quantitative research in psychology: the APA publications and communications board task force report. Am Psychol 73:3–25. https://doi.org/10.1037/amp0000191
31. Schulz KF, Altman DG, Moher D, CONSORT Group (2010) CONSORT 2010 statement: updated guidelines for reporting parallel group randomised trials. BMJ 340:c332. https://doi.org/10.1136/bmj.c332
32. Keuppens L, Marten F, Baeyens D et al (2023) Sleep intervention as symptom treatment for ADHD (SIESTA)-Blended CBT sleep intervention to improve sleep, ADHD symptoms and related problems in adolescents with ADHD: protocol for a randomised controlled trial. BMJ Open 13:e065355. https://doi.org/10.1136/bmjopen-2022-065355
33. de Bruin EJ, Bögels SM, Oort FJ, Meijer AM (2018) Improvements of adolescent psychopathology after insomnia treatment: results from a randomized controlled trial over 1 year. J Child Psychol Psychiatry 59:509–522. https://doi.org/10.1111/jcpp.12834
34. Beerts E, Boyer BE, Kuin M et al SIESTA - Sleep intervention as symptom treatment for ADHD: Een flexibel behandelprotocol voor slaapproblemen Bij Jongeren Met ADHD. Werkboek voor jongeren
35. Storfer-Isser A, Lebourgeois MK, Harsh J et al (2013) Psychometric properties of the adolescent sleep hygiene scale. J Sleep Res 22:707–716. https://doi.org/10.1111/jsr.12059
36. Meijer AM (2008) Chronic sleep reduction, functioning at school and school achievement in preadolescents. J Sleep Res 17:395–405. https://doi.org/10.1111/j.1365-2869.2008.00677.x
37. Owens JA, Spirito A, McGuinn M (2000) The children's sleep habits questionnaire (CSHQ): psychometric properties of a survey instrument for school-aged children. Sleep 23:1043–1051
38. CamNtech Ltd MotionWatch
39. Mestdagh M, Verdonck S (2019) M-path
40. Oosterlaan J, Baeyens D, Scheres A et al (2008) VvGK6-16. Vragenlijst voor Gedragsproblemen Bij kinderen Van 6 tot En Met 16 Jaar. Harcourt Test, Amsterdam
41. Muris PEHM, Bodden D, Hale WW et al (2007) SCARED-NL. Vragenlijst over angst En bang-zijn Bij kinderen En adolescenten. Boom Uitgevers
42. Kovacs M, Bodden D, Braet C, Stikkelbroek Y (2016) CDI-2 Screeningsvragenlijst voor depressie Bij kinderen En Jongeren. Hogrefe, Amsterdam
43. Prinz RJ, Foster S, Kent RN, O'Leary KD (1979) Multivariate assessment of conflict in distressed and nondistressed mother-adolescent dyads. J Appl Behav Anal 12:691–700. https://doi.org/10.1901/jaba.1979.12-691
44. Anesko KM, Schoiock G, Ramirez R, Levine FM (1987) The homework problem checklist: assessing children's homework difficulties. Behav Assess 9:179–185
45. Brady CE, Evans SW, Berlin KS et al (2012) Evaluating school impairment with adolescents using the classroom performance survey. Sch Psychol Rev 41:429–446. https://doi.org/10.1080/02796015.2012.12087498
46. R Core Team (2023) R Statistical Software
47. van Buuren S, Groothuis-Oudshoorn K (2011) Mice: multivariate imputation by chained equations in R. J Stat Softw 45:1–67. https://doi.org/10.18637/jss.v045.i03
48. Kleinke K (2017) Multiple imputation under violated distributional assumptions: A systematic evaluation of the assumed robustness of predictive mean matching. J Educ Behav Stat 42:371–404. https://doi.org/10.3102/1076998616687084
49. Rubin DB, Schenker N (1991) Multiple imputation in health-care databases: an overview and some applications. Stat Med 10:585–598. https://doi.org/10.1002/sim.4780100410
50. Peugh JL (2010) A practical guide to multilevel modeling. J Sch Psychol 48:85–112. https://doi.org/10.1016/j.jsp.2009.09.002
51. Lindstrom MJ, Bates DM (1988) Newton-raphson and Em algorithms for linear mixed-effects models for repeated-measures data. J Am Stat Assoc 83:1014–1022. https://doi.org/10.2307/2290128
52. Twisk J, Bosman L, Hoekstra T et al (2018) Different ways to estimate treatment effects in randomised controlled trials. Contemp Clin Trials Commun 10:80–85. https://doi.org/10.1016/j.conctc.2018.03.008
53. de Boer MR, Waterlander WE, Kuijper LD et al (2015) Testing for baseline differences in randomized controlled trials: an unhealthy research behavior that is hard to eradicate. Int J Behav Nutr Phys Act 12:1–8. https://doi.org/10.1186/s12966-015-0162-z
54. Benjamini Y, Krieger AM, Yekutieli D (2006) Adaptive linear step-up procedures that control the false discovery rate. Biometrika 93:491–507. https://doi.org/10.1093/biomet/93.3.491
55. Mairs L, Mullan B (2015) Self-monitoring vs. implementation intentions: A comparison of behaviour change techniques to improve sleep hygiene and sleep outcomes in students. Int J Behav Med 22:635–644. https://doi.org/10.1007/s12529-015-9467-1
56. Benz F, Riemann D, Domschke K et al (2023) How many hours do you sleep? A comparison of subjective and objective sleep duration measures in a sample of insomnia patients and good sleepers. J Sleep Res 32:e13802. https://doi.org/10.1111/jsr.13802
57. Harvey AG, Dong L, Hein K et al (2021) A randomized controlled trial of the transdiagnostic intervention for sleep and circadian dysfunction (TranS-C) to improve serious mental illness outcomes in a community setting. J Consult Clin Psychol 89:537–550. https://doi.org/10.1037/ccp0000650
58. Harvey AG, Hein K, Dolsen EA et al (2018) Modifying the impact of eveningness chronotype (night-owls) in youth: A randomized controlled trial. J Am Acad Child Adolesc Psychiatry 57:742–754. https://doi.org/10.1016/j.jaac.2018.04.020

59. Mei F, Wang Z (2024) Trends in mental health: A review of the most influential research on depression in children and adolescents. Ann Gen Psychiatry 23:36. https://doi.org/10.1186/s12991-024-00520-2
60. Sivertsen B, Harvey AG, Lundervold AJ, Hysing M (2014) Sleep problems and depression in adolescence: results from a large population-based study of Norwegian adolescents aged 16–18 years. Eur Child Adolesc Psychiatry 23:681–689. https://doi.org/10.1007/s00787-013-0502-y
61. Touchette E, Fréchette-Boilard G, Petit D et al (2024) Longitudinal study of childhood sleep trajectories and adolescent mental health problems. SLEEP Adv 5:zpae013. https://doi.org/10.1093/sleepadvances/zpae013
62. Statistiek Vlaanderen (2023) Bevolking Naar Herkomst. Statistiek Vlaanderen
63. Dolsen EA, Dong L, Harvey AG (2023) Transdiagnostic sleep and circadian intervention for adolescents plus text messaging: randomized controlled trial 12-month follow-up. J Clin Child Adolesc Psychol 52:750–762. https://doi.org/10.1080/15374416.2021.1978295
64. DuPaul GJ, Evans SW, Mautone JA et al (2020) Future directions for psychosocial interventions for children and adolescents with ADHD. J Clin Child Adolesc Psychol 49:134–145. https://doi.org/10.1080/15374416.2019.1689825