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Self-reported sleep patterns and quality amongst adolescents: cross-sectional and prospective associations with anxiety and depression

Faith Orchard,[1] Alice M. Gregory,[2] Michael Gradisar,[3] and Shirley Reynolds[1]

[1]School of Psychology and Clinical Language Sciences, University of Reading, Reading, UK; [2]Department of Psychology, Goldsmiths, University of London, London, UK; [3]College of Education, Psychology and Social Work, Flinders University, Adelaide, SA, Australia

Background: Sleep problems are common in adolescence, and frequently comorbid with both anxiety and depression. Research studies have suggested a bidirectional relationship between sleep and psychopathology, which includes evidence that sleep interventions can alleviate symptoms of anxiety and depression. However, little is known about the nature of sleep problems amongst adolescents with anxiety and depression, and whether specific sleeping difficulties are involved in the longitudinal relationship between sleep, anxiety and depression. **Method:** The sample was derived from the Avon Longitudinal Study of Parents and Children (ALSPAC), a population-based, prospective, birth cohort study of children born in 1991–1992. Data were explored from a subset of participants who took part in a clinical assessment at age 15, on self-report sleep patterns and quality, and diagnostic outcomes of anxiety and depression (N = 5,033). Subsequent diagnostic and symptom severity data on anxiety and depression at ages 17, 21 and 24 were also examined. **Results:** Cross-sectional and longitudinal analyses were conducted to explore the relationship between sleep problems, anxiety and depression. Results revealed that adolescents aged 15 with depression experience difficulties with both sleep patterns and sleep quality, whereas adolescents with anxiety only reported problems with sleep quality. A range of sleep variables at age 15 predicted the severity of anxiety and depression symptoms and the diagnoses of anxiety and depressive disorders at age 17, 21 and 24 years. **Conclusions:** The results provide further insight into the nature of sleep problems amongst adolescents with anxiety and depression, and the prospective relationship between sleep disturbance and future psychopathology. These data suggest that targeting sleep difficulties during adolescence may have long-term mental health benefits. **Keywords:** Adolescence; longitudinal studies; sleep; depression; anxiety.

Introduction

Healthy sleep is characterised by getting enough sleep, at appropriate times and in the absence of any sleep disturbance (Paruthi et al., 2016). During adolescence, a multitude of social, biological and psychological factors make sleep particularly vulnerable (e.g. Crowley et al., 2018). Two bioregulatory sleep processes undergo dynamic developmental changes during this stage of life. Firstly, older adolescents (e.g. 14 years olds) take longer to build sleep homeostatic pressure compared to younger adolescents (e.g. 11 years), resulting in increased biological alertness in the late evening to early morning (e.g. 10:30 P.M. to 2:30 A.M.) (Taylor et al., 2005). The second biological process is a delay in the timing of the adolescent endogenous circadian rhythm, with sleep timing signalled later in the evening by this 'biological clock'. This circadian phase delay is seen across humans and non-human mammals (Hagenauer & Lee, 2013), substantiating the biological basis of this developmental change. Whilst it is feasible for adolescents to minimise and regularise this tendency to fall asleep late and wake late, the cessation of parent-set bedtimes (Short et al., 2011) and increased vocational, social and cultural demands (Crowley et al., 2007; Crowley et al., 2018; Gradisar et al., 2011) leave millions of adolescents at risk for a range of inter-related 'sleep problems', including an extended latency to sleep onset, and restricted sleep duration on school nights in particular (Morrison et al., 1992; Short, et al., 2013).

The impact of poor sleep quality in adolescents is wide-reaching (e.g. Owens, 2014), with growing evidence that poor-quality and insufficient sleep is linked to cognitive, emotional and behavioural dysregulation (Gregory & Sadeh, 2016; Palmer & Alfano, 2017; Sadeh et al., 2003). Inadequate sleep in adolescence is associated with reduced executive functioning (Beebe, 2011), poorer academic performance and reduced learning capacity (Curcio et al., 2006; Gaultney, 2010; Lo et al., 2016), and increased prevalence of affective disorders (e.g. Roberts & Duong, 2014). Sleep disturbance is one of the most common symptoms of adolescent depression (Goodyer et al., 2017; Orchard et al., 2017), and has been linked to the severity of a depressive episode (Liu et al., 2007) and the risk of suicidal behaviour and self-harm (McCall et al., 2010; Singareddy et al., 2013). Similarly, high proportions of young people with anxiety have also reported

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experiencing one or more sleep-related problems (Alfano et al., 2007; Chase & Pincus, 2011). Recent longitudinal data suggest that the relationship between sleep problems and psychopathology may be bidirectional. Although, a meta-analysis showed a stronger direction of effect from sleep problems to depression in adolescents, rather than the onset of sleep problems following depression (Lovato & Gradisar, 2014). Specifically, they found that depression appeared to be worse when adolescents spent more time awake in bed (e.g. taking longer to fall asleep). This meta-analysis identified ten studies that examined the longitudinal relationship between sleep and depression. The studies included self-report and biological measures of sleep, as well as measures of symptom severity and diagnostic status of depression. This has enabled the examination of the perception of problems vs objective measurement, and symptom variance vs clinical utility. However, none of these studies examined more than one follow-up time point.

Multiple mechanisms linking sleep, anxiety and depression in young people have been proposed (Blake et al., 2018; Gregory & Sadeh, 2016; Palagini et al., 2019), and these are all likely to contribute to this complex relationship. For example, the natural shift towards later bedtimes and potential problems with sleep onset latency can result in less sleep on weeknights, due to a set time to rise for school (Crowley et al., 2018). This chronic sleep restriction may result in a variety of daytime symptoms, many of which overlap with depression symptoms, including reduced positive emotions, reduced motivation, poor concentration and fatigue/tiredness (Dahl, 1999; Lo, et al., 2016; Talbot et al., 2010).

Another potential mechanism linking sleep and mood is a late chronotype (i.e. the mid-point of sleep on free days; Zavada et al., 2005). During adolescent development (10–20 years), the mid-point of sleep dramatically drifts later and begins to reverse again during the mid-20s (Kuula et al., 2019). Numerous studies have shown an association between eveningness/ a later chronotype/ later circadian timing and depression symptoms or a depressive disorder (Bauducco et al., 2020). Whilst there could be biological and/or social reasons for these associations, these mechanisms need to be further elucidated given that a later chronotype and an increase in depression symptoms are prevalent during adolescence across the world (Gradisar et al., 2011; Olds et al., 2010).

There is growing evidence that the treatment of disrupted sleep has positive consequences for other mental health difficulties including psychotic experiences (Bradley et al., 2018; Freeman et al., 2017) and depression and anxiety symptoms (Gee et al., 2018; Luik et al., 2017). These findings have led researchers and clinicians to develop an interest in adapting adolescent-specific sleep interventions, with a view to improving both sleep and symptoms of anxiety and depression (e.g. Clarke & Harvey, 2012; Orchard, et al, 2019).

The present study used data from a large longitudinal study of adolescents in the United Kingdom, the Avon Longitudinal Study of Parents and Children (ALSPAC). Drawing on available data of sleep, anxiety and depression, across multiple time points in adolescence and early adulthood, two aims were identified. The first aim was to examine cross-sectional sleep habits at age 15 years and to compare self-reported sleep quality and sleep patterns of those who met diagnostic criteria for an anxiety disorder and/or depression to those with no anxiety or depression. The second aim was to test the longitudinal association between sleep patterns and quality at 15 years and (a) diagnoses of anxiety and depression in late adolescence and early adulthood, and (b) symptoms of anxiety and depression in early adulthood.

Methods

Cohort study numbers

Pregnant women resident in Avon, United Kingdom, with expected dates of delivery 1st April 1991 to 31st December 1992 were invited to take part in the study. The initial number of pregnancies enrolled is 14,541. Of these initial pregnancies, there was a total of 14,676 foetuses, resulting in 14,062 live births and 13,988 children who were alive at 1 year of age.

When the oldest children were approximately 7 years of age, an attempt was made to bolster the initial sample with eligible cases who had failed to join the study originally. As a result, when considering variables collected from the age of seven onwards (and potentially abstracted from obstetric notes) there are data available for more than the 14,541 pregnancies mentioned above. The number of new pregnancies not in the initial sample (known as Phase I enrolment) that are currently represented on the built files and reflecting enrolment status at the age of 24 is 913 (456, 262 and 195 recruited during Phases II, III and IV, respectively), resulting in an additional 913 children being enrolled. The phases of enrolment are described in more detail in the initial cohort profile papers and in a recent update (Boyd et al., 2013; Fraser et al., 2012; Northstone, et al., 2019). The total sample size for analyses using any data collected after the age of seven is therefore 15,454 pregnancies, resulting in 15,589 foetuses. Of these, 14,901 were alive at 1 year of age.

Participants

The present study examined data obtained from a subset of participants who took part in a clinical assessment examining both sleep and mental health diagnoses at age 15 years (between October 2006 and November 2008). Of these 5,525 participants, 432 did not attend the sleep assessment session, and a further 37 participants did not complete the diagnostic interview. Data were also removed from 23 participants who withdrew consent. This left a total sample of $N = 5,033$ with diagnostic and sleep data at age 15. Participants were 53% female and 98% white.

Ethical approval for the study was obtained from the ALSPAC Ethics and Law Committee and the Local Research Ethics Committees. Informed consent for the use of data collected via questionnaires and clinics was obtained from

participants following the recommendations of the ALSPAC Ethics and Law Committee at the time.

Measures

The present study included measures on sleep at age 15, diagnostic outcomes at ages 15, 17 and 24, and symptomatology at age 21. Please note that the study website contains details of all the data that are available through a fully searchable data dictionary and variable search tool (http://www.bristol.ac.uk/alspac/researchers/our-data/).

Sleep. Participants completed a sleep questionnaire as part of the Teen Focus Clinic at age 15 years that assessed various aspects of their sleep.

Sleep patterns: Initial questions explored sleep patterns on school days and on weekends, and participants were asked to report on their sleep in the last 2 weeks. The variables for analysing sleep patterns (sleep onset time and wake-up time) were measured using a modified version of the School Sleep Habits Survey (Wolfson et al., 2003). The main modification that was relevant to the present analyses was the addition of questions to establish sleep onset latency and sleep onset time, specifically asking; 'What time do you USUALLY start trying to go to sleep?' and 'How long does it USUALLY take for you to fall asleep?'. These additional items also made it possible to compute total sleep time (TST), which was assessed by calculating the difference between adolescents' sleep onset time and sleep offset time. This method can provide a more accurate measurement of sleep quantity as opposed to estimating the amount of sleep one obtains (Matricciani, 2013). Finally, chronotype was defined as the mid-point between sleep onset and sleep offset on free days (i.e. weekends), based on work by Zavada et al. (2005), and expressed as clock time (i.e. the later the mid-point of sleep and the later the chronotype).

Sleep quality: Perceptions of sleep quality were examined with a range of questions. These included sleep onset latency (mins) on school nights and weekends (Ohayon et al., 2017), and how many times a night participants usually woke up on a four-point scale (1 = *never*; 2 = *once*; 3 = *two or three times*; 4 = >*three times*). Additionally, problems with daytime sleepiness were examined on a five-point Likert scale (1 = *no problem*; 2 = *a little problem*; 3 = *more than a little problem*; 4 = *a big problem*; 5 = *a very big problem*). Ease of getting up was also examined on a four-point Likert scale (1 = *very easy*; 2 = *easy*; 3 = *not easy*; 4 = *hard*). Finally, participants were asked how often they believed they got enough sleep on a five-point Likert scale (1 = *always*; 2 = *usually*; 3 = *sometimes*; 4 = *rarely*; 5 = *never*).

Anxiety and depression diagnoses. Anxiety and depression diagnoses were assessed at focus clinics at ages 15, 17 and 24 years.

Diagnostic assessment at age 15: Anxiety and depression diagnoses were assessed at the Teen Focus Clinic at age 15 years, using the Development and Well-Being Assessment (DAWBA; Goodman et al., 2000). This assessment is a self-report measure that enquires about psychiatric symptoms and generates International Classification of Diseases – 10th Revision diagnoses (World Health Organization; WHO, 1992).

For the purpose of the cross-sectional analyses, participants were grouped, on the basis of the DAWBA outcome, into one of three groups: no diagnosis of anxiety or depression (n = 4,921), met diagnostic criteria for one or more anxiety disorders (n = 74), and met diagnostic criteria for depression (n = 78). Adolescents with comorbid anxiety and depression (n = 22) were included in the depressed group. This decision was made for two reasons, (a) the numbers of comorbid participants were too small to analyse independently, and (b) depression is more commonly comorbid with anxiety, than *vice versa* (Cummings et al., 2014); hence, the 'depressed' group will be more generalisable. In order to ensure that this did not result in the depressed group showing differences due to being *more severe*, sensitivity analyses were conducted without comorbid participants.

Externalising disorders were also assessed using the DAWBA. Participants with externalising disorders were not removed from the three groups. Thus, differences between the three groups are more likely to be explained by the presence of anxiety and depression only.

Diagnostic assessment at age 17 and 24: Anxiety and depression diagnoses were assessed on a subset of participants using the Clinical Interview Schedule – Revised (CIS-R; Lewis et al., 1992) at the Teen Focus Clinic at age 17 years (n = 5,081) and the Focus@24 Clinic at age 24 years (n = 4026). The CIS-R is a psychiatric interview designed to assess symptoms of depression and anxiety in non-clinical populations, and is administered by non-clinicians. At age 17, n = 3,528 participants also had sleep and diagnostic data available at age 15 and hence could be included in the longitudinal analyses, and at age 24, n = 2,853 participants also had sleep and diagnostic data at age 15. Frequencies of participants with anxiety and depression at ages 17 and 24 are summarised in Table 1, along with the percentages of adolescents in each of the diagnostic groups at age 15, to demonstrate how many adolescents had persistent vs new diagnoses.

When participants were 22 years and older, data were collected and managed using REDCap electronic data capture tools hosted at University of Bristol (Harris et al., 2019; Harris et al., 2009). REDCap (Research Electronic Data Capture) is a secure, web-based software platform designed to support data capture for research studies, providing (a) an intuitive interface for validated data capture; (b) audit trails for tracking data manipulation and export procedures; (c) automated export procedures for seamless data downloads to common statistical packages; and (d) procedures for data integration and interoperability with external sources.

Anxiety and depression symptoms. Anxiety and depression symptoms were measured by self-report questionnaires at age 21 (n = 3,463). Of these participants, n = 2,459 also had sleep and diagnostic data available at age 15, and hence could be included in the longitudinal analyses.

Anxiety symptoms were measured using the Generalised Anxiety Disorder Assessment (GAD-7; Spitzer et al., 2006), a seven-item questionnaire that is used to measure the severity

Table 1 Percentages of anxiety and depression diagnoses at ages 17 and 24, and percentages of age 15 adolescents with persistent vs. new diagnoses

	Diagnostic data at age 17 (N = 3,528)		Diagnostic data at age 24 (N = 2,853)	
Diagnostic groups at age 15	Anxiety (n = 317; 9%)	Depression (n = 259, 7%)	Anxiety (n = 270; 9%)	Depression (n = 291; 10%)
No anxiety/ depression	8.1%	6.8%	8.7%	9.5%
Anxiety	35.8%	20.8%	37.8%	37.8%
Depression	40.0%	30.9%	30.0%	26.0%

of generalised anxiety disorder. The individual is asked to rate the severity of each item over the past two-week period. Responses are scored on a four-point Likert scale from 'not at all' to 'nearly every day'. The measure has been found to have good reliability and validity (Löwe et al., 2008; Ruiz et al., 2011; Spitzer et al., 2006). Total scores are computed to give a measure of severity and can vary from 0 to 21.

Depression symptoms were measured using the adult version of the Short Mood and Feelings Questionnaire (SMFQ; Angold et al., 1995), a 13-item questionnaire that is used to measure the severity of depression over the past two-week period. Responses are scored on a three-point Likert scale from 'not true' to 'true'. The measure has been found to have good reliability and validity (Angold et al., 1995; Messer et al., 1995). Total scores are computed to give a measure of severity and can vary from 0 to 26.

Data preparation and analytic plan

Continuous data were screened in relation to the assumptions of parametric tests (Tabachnick & Fidell, 2007). Where assumptions were violated, confirmatory analyses were conducted by running analyses with 1,000 bootstrap samples. All results were consistent, suggesting that the original analyses were robust to the violations of assumptions. For simplicity and comparability with other research, results based on the original (non-bootstrapped) analyses are presented below.

For cross-sectional analyses, continuous sleep variables were analysed using multiple analysis of variance (MANOVA), with diagnostic group as the independent variable, with three levels (no depression or anxiety, depressed and anxious). For prospective analyses, multiple regression models and multiple logistic regression models were conducted investigating how well sleep patterns and sleep quality at age 15 predicted symptoms of anxiety and depression at 21, and diagnoses of anxiety and depression at ages 17 and 24, after controlling for age 15 anxiety and depression.

Results

Cross-sectional between-group differences in sleep patterns at age 15

Between-group differences for sleep patterns were examined using a MANOVA where the independent variable was diagnostic group (depressed, anxious and no anxiety/depression) and the dependent variables were sleep onset time and wake-up time on school days and weekends, total sleep time on school days and weekends, and chronotype. Mean sleep times, between-subjects analyses and Bonferroni-corrected pairwise comparisons are presented in Table 2.

There was a significant main effect of group on sleep patterns, $V = 0.01$, $F(8, 9570) = 7.11$, $p < .001$, $\eta^2 = .01$. Between-subjects effects revealed significant group differences for sleep onset time on school days and weekends, wake-up time on school days, total sleep time on school days and weekends, and chronotype. There was no significant difference for wake-up time on weekends. Corrected pairwise comparisons for sleep onset times indicated that the depressed group reported going to sleep significantly later than the no anxiety/depression group (35 min later) and the anxious group (33 min later) on school nights and that the depressed group reported going to sleep significantly later than the no anxiety/depression group on weekends (30 min later). Corrected pairwise comparisons did not reveal significant differences for wake-up times.

Corrected pairwise comparisons for total sleep time revealed that the depressed group had significantly less sleep on school nights than the no anxiety/depression group and the anxious group (42 min less and 34 min less; respectively) and that the depressed group also had significantly less sleep on weekends than the no anxiety/depression group and the anxious group (31 min less and 36 min less; respectively). Corrected pairwise comparisons did not reveal significant differences for chronotype.

To ensure that differences between the depressed and anxiety groups were not being driven by the depressed group including participants with comorbid anxiety and depression, sensitivity analyses were conducted without comorbid participants, and the results did not change.

Cross-sectional between-group differences in subjective sleep quality

Group differences between perceived sleep quality variables were examined using a MANOVA where the independent variable was diagnostic group (depressed, anxious and no anxiety/depression) and the dependent variables were seven sleep quality items: sleep onset latency (school nights and weekends), night wakening, ease to get up (school days and weekends), daytime sleepiness and frequency of sufficient sleep. Mean sleep ratings, between-group analyses and Bonferroni-corrected pairwise comparisons are presented in Table 3.

There was a significant main effect of group, $V = 0.04$, $F(14, 9344) = 13.92$, $p < .001$, $\eta^2 = .02$, with significant between-group differences for all subjective sleep quality variables. Corrected pairwise comparisons revealed many characteristics specific to individual disorders and across both disorders, compared to adolescents with no anxiety/depression.

Adolescents with anxiety and depression took significantly longer to fall asleep on school nights and weekends compared to adolescents with no anxiety/depression. Depressed adolescents also reported longer sleep onset latency than the anxious group on school nights. Adolescents reported more difficulty getting up on school days if they were depressed (35% reported that it was 'hard' to get up) or anxious (31% reported that it was 'hard' to get up), compared to adolescents with no anxiety/depression (18% reported that it was 'hard' to get up). But only depressed adolescents reported significantly worse problems on weekends when compared to adolescents with no anxiety/depression (11%, compared to 3%).

Table 2 Subjective sleep patterns amongst those with and without anxiety and depression diagnoses at age 15 (n = 4,790)

Mean (SD)	No depression or anxiety (n = 4,658)	Anxiety (n = 65)	Depression (n = 67)	F (2, 4787)
Sleep onset time (hr:min)				
School nights	22:58 (77.78)[a]	23:00 (79.28)[a]	23:33 (112.95)[b]	17.84***
Weekend nights	00:01 (109.85)[a]	00:13 (111.79)[ab]	00:31 (131.55)[b]	7.58**
Wake-up time (hr:min)				
School days	07:05 (49.05)	06:59 (60.20)	06:57 (66.08)	3.02*
Weekend days	09:42 (131.25)	09:59 (146.98)	09:41 (163.62)	1.53
Total sleep time (hr:min)				
School nights	08:07 (0.82)[a]	07:59 (0.84)[a]	07:25 (1.27)[b]	24.05***
Weekend nights	09:41 (1.27)[a]	09:46 (1.46)[a]	09:10 (1.78)[b]	5.40**
Chronotype (hr:min)	04:52 (1.03)	05:07 (1.08)	05:07 (1.19)	3.48*

*p < .05; **p < .01; and ***p < .001; Superscript letters have been used to indicate significant differences, where letters are the same across variables there is no difference, and where letters differ (i.e. *a* and *b*) this denotes between-group Bonferroni-corrected significance.

Table 3 Subjective sleep quality amongst those with and without anxiety and depression diagnoses at age 15 (n = 4,680)

Mean (SD)	No depression or anxiety (n = 4,548)	Anxiety (n = 67)	Depression (n = 65)	F (2, 4677)
Sleep onset latency (min)				
School nights	21.02 (16.28)[a]	29.76 (27.23)[b]	37.60 (35.67)[c]	39.24*
Weekend nights	17.38 (14.12)[a]	21.94 (17.07)[b]	26.03 (21.62)[b]	14.89*
Number of times wakes at night	1.83 (1.15)[a]	2.07 (1.13)[ab]	2.55 (1.17)[b]	18.83*
Ease to get up				
School days	2.71 (0.83)[a]	3.01 (0.86)[b]	3.06 (0.90)[b]	10.21*
Weekend days	2.04 (0.70)[a]	2.22 (0.78)[ab]	2.35 (0.84)[b]	8.75*
Daytime sleepiness	1.72 (0.73)[a]	2.18 (1.00)[b]	2.58 (1.07)[c]	55.92*
Frequency of enough sleep	2.38 (0.84)[a]	2.87 (1.09)[b]	3.14 (0.90)[b]	36.59*

*p < .001; Superscript letters have been used to indicate significant differences, where letters are the same across variables there is no difference, and where letters differ (i.e. *a* and *b*) this denotes between-group Bonferroni-corrected significance; 'Ease to get up' measured on 4-point scale where 1 = easy and 4 = hard; 'Daytime sleepiness' measured on a 5-point scale from 1 = no problem to 5 = very big problem; 'Frequency of enough sleep' measured on 5-point scale where 1 = always and 5 = never.

Adolescents also reported more problems with daytime sleepiness if they had depression (19% reported 'big' or 'very big' problem) or anxiety (10% reported 'big' or 'very big' problem), compared to adolescents with no anxiety/depression (3% reported 'big' or 'very big' problem). Depressed adolescents reported significantly more daytime sleepiness than anxious adolescents. Night-time waking was significantly worse for depressed participants than young people who were anxious or not depressed/anxious. Finally, adolescents were less likely to think that they get enough sleep if they were depressed (38% reported 'rarely' or 'never' getting enough sleep) or anxious (31% reported 'rarely' or 'never' getting enough sleep), compared to adolescents with no anxiety/depression (11% reported 'rarely' or 'never' getting enough sleep).

To ensure that differences between the depressed and anxious groups were not being driven by participants with comorbidity in the depressed group, sensitivity analyses were conducted without comorbid participants. The only difference that did not persist was depressed participants reporting more problems with daytime sleepiness than anxious participants.

Prospective relationship between sleep habits at 15 years and diagnoses of anxiety and depression at 17 and 24 years

To test the hypothesis that sleep patterns and sleep quality would significantly predict a diagnosis of depression or anxiety at age 17 and 24, we conducted multiple logistic regression models with diagnostic status as the dependent variable. Due to issues with multicollinearity, and to reduce the number of models being analysed, the only sleep pattern variables included in prospective analyses were total sleep time (school and weekend nights) and chronotype.

Four models were analysed for each age (i.e. 17 and 24): (1) sleep patterns predicting anxiety diagnoses, (2) sleep quality predicting anxiety diagnoses, (3) sleep patterns predicting depression diagnoses and (4) sleep quality predicting depression diagnoses. Diagnoses of anxiety and depression at age 15 were entered as a predictor in the first step, and sleep variables were entered in the second step. This was to establish whether sleep habits at age 15 predicted diagnoses of anxiety or depression, over and above the presence of these difficulties at age 15.

As expected, diagnoses of anxiety and depression at 15 years were significant predictors of diagnoses at 17 and 24 in the first step of all models conducted ($p < .001$). To simplify the reporting of results, these first steps of the models are not included in the tables. Sleep variable statistics for logistic regression models at age 17 can be found in Table 4, and sleep variable statistics for logistic regression models at age 24 can be found in Table 5.

Less total sleep time on school nights at age 15 was a significant predictor of anxiety and depression at ages 17 and 24. Total sleep time on weekends and chronotype was not significant predictors of future anxiety or depression. Three sleep quality variables measured at 15 years consistently predicted anxiety and depression diagnoses at age 17 and 24: daytime sleepiness, night-time waking and perception of getting enough sleep. Sleep onset latency was also a significant predictor of age 24 anxiety diagnoses only.

Prospective relationship between sleep habits at 15 years and symptoms of anxiety and depression at 21 years

To test the hypothesis that sleep patterns and sleep quality would significantly predict symptoms of depression or anxiety at age 21, we conducted hierarchical multiple regression models with symptoms of anxiety or depression as the dependent variable. Due to issues with multicollinearity, and to reduce the number of models being analysed, the only sleep pattern variables included in prospective analyses were total sleep time (school and weekend nights) and chronotype.

Four models were analysed: (1) sleep patterns predicting anxiety symptoms, (2) sleep quality predicting anxiety symptoms (3) sleep patterns predicting depression symptoms and (4) sleep quality predicting depression symptoms. Diagnoses of anxiety and depression at age 15 were entered as a predictor in the first step, and sleep variables were entered in the second step. This was to establish whether sleep habits at age 15 predicted symptoms of anxiety or depression, over and above the presence of these difficulties at age 15.

As expected, diagnoses of anxiety and depression at 15 years were significant predictors of symptoms at age 21 in the first step of all models conducted ($p < .001$). To simplify the reporting of results, these first steps of the model are not included in tables. Sleep variable statistics for linear regression models at age 21 can be found in Table 6.

Less total sleep time on school nights at age 15 was a significant predictor of both anxiety and depression symptoms at age 21. Total sleep time on weekends and chronotype was not significant predictors. Four of the sleep quality variables measured at 15 years predicted anxiety and depression symptoms at age 21: sleep onset latency on school nights, daytime sleepiness, night-time waking and perception of getting enough sleep.

Discussion

This study addressed cross-sectional and longitudinal relationships between self-reported sleep patterns and sleep quality at age 15 and subsequent symptoms and diagnoses of anxiety and depression. The first research question addressed whether there would be differences between diagnostic groups at age 15 in sleep patterns and sleep quality. Some significant between-group differences were identified for sleep patterns, including sleep onset time (during the school week and at the weekend) and total sleep time (school days and weekend). Specifically, adolescents with depression had later sleep onset time on school nights, and less total sleep on school nights and weekends, than the anxiety and the no anxiety/depression groups. Adolescents with depression also had later sleep onset time on weekends than the participants with no anxiety or depression. Although the depressed group included comorbid participants with anxiety diagnoses, sensitivity analyses without these participants revealed no change in results.

For sleep quality, adolescents with depression reported greater difficulties than adolescents with no anxiety/depression on all variables (i.e. time to fall asleep on school nights and weekends, difficulty getting up on school nights and weekends, waking in the night, daytime sleepiness and not getting enough sleep). Adolescents with depression also reported greater difficulties falling asleep on school days, and with daytime sleepiness, than adolescents with anxiety. Finally, adolescents with an anxiety disorder did not report any sleep problems to be worse than the depressed group but did report worse sleep quality on most indices than the adolescents with no anxiety/depression. Sensitivity analyses without comorbid participants in the depressed group revealed that depressed adolescents no longer differed from anxiety participants on daytime sleepiness.

The second research question addressed whether sleep patterns and sleep quality at age 15 would predict symptoms and diagnoses of anxiety and depression later in adolescence (age 17) and in early adulthood (age 21 and 24). The first analysis examined whether *sleep patterns* at 15 years predicted anxiety and depression diagnoses at ages 17 and 24. Anxiety and depression diagnosis at age 17 and 24 was significantly predicted by less total sleep time on school nights at age 15, but not by weekend total sleep time or chronotype. This finding is consistent with the literature which hypothesises that low total sleep time on school nights would predict future anxiety and depression, because late sleep onset and fixed waking times on school days create chronic sleep restriction during adolescence, and that

Table 4 Summary of sleep variables at age 15 in logistic regression models predicting anxiety and depression diagnoses at age 17 (n = 3,347)

Age 15	Anxiety at 17 years	b	Odds ratio (95% CI)	R^2	Model
Sleep patterns	TST school	−0.28***	0.76 (0.64–0.89)	.02 (Cox&Snell)	$X^2(3) = 26.65$***
	TST weekend	−0.06	0.94 (0.85–1.05)	.05 (Nagelkerk)	
	Chronotype	0.10	1.11 (0.97–1.26)		
Sleep quality	SOL school	0.01	1.01 (1.00–1.02)	.04 (Cox&Snell)	$X^2(7) = 74.38$***
	SOL weekend	0.00	1.00 (0.99–1.01)	.09 (Nagelkerk)	
	Ease getting up school	0.06	1.06 (0.90–1.25)		
	Ease getting up weekend	0.05	1.05 (0.88–1.26)		
	Daytime sleepiness	0.40***	1.49 (1.26–1.77)		
	Night waking	0.15**	1.16 (1.05–1.29)		
	Perception of enough sleep	0.19*	1.20 (1.02–1.42)		
Age 15	Depression at 17 years	b	Odds ratio (95% CI)	R^2	Model
Sleep patterns	TST school	−0.36***	0.70 (0.59–0.84)	.02 (Cox&Snell)	$X^2(3) = 26.49$***
	TST weekend	−0.04	0.96 (0.86–1.08)	.04 (Nagelkerk)	
	Chronotype	0.03	1.03 (0.89–1.19)		
Sleep quality	SOL school	1.01	1.01 (1.00–1.02)	.04 (Cox&Snell)	$X^2(7) = 103.11$***
	SOL weekend	−0.00	1.00 (0.99–1.01)	.10 (Nagelkerk)	
	Ease getting up school	−0.06	0.94 (0.79–1.12)		
	Ease getting up weekend	0.17	1.19 (0.98–1.44)		
	Daytime sleepiness	0.51***	1.67 (1.39–1.00)		
	Night waking	0.21**	1.23 (1.11–1.38)		
	Perception of enough sleep	0.31*	1.36 (1.14–1.63)		

Step 1 age 15 anxiety and depression not included in table; SOL, sleep onset latency; TST, total sleep time; *$p < .05$; **$p < .01$; and ***$p < .001$.

adolescents with delayed sleep are particularly vulnerable (Crowley et al., 2018). However, it does not support the hypothesis that a late chronotype may be a mechanism linking sleep and mental health (e.g. Bauducco et al., 2020).

The second analysis examined whether *sleep quality* at 15 years predicted depression and anxiety diagnoses at 17 and 24 years. Analyses revealed significant predictors to be daytime sleepiness, night waking and perception of whether sleep quantity was enough. These predictors were the same for each diagnosis and at 17 and 24 years. Whilst a model proposed by Lovato and Gradisar (2014) emphasises sleep onset latency and wake after sleep onset as predicting later depression, their model also found self-reported sleep quality to be the third predictor of depression. Although there is a consensus about objective measures of sleep quality (Ohayon et al., 2017), there is not yet a consensus about subjective measures. Conceptually, daytime sleepiness and night wakings are likely to also be perceived as reflecting inadequate sleep and poor-quality sleep. Thus, these aspects of sleep quality hold promise for future research, particularly when investigating links with anxiety and depression. In contrast, anxiety diagnoses at age 24 were predicted by sleep onset latency on school nights. This may not be surprising as sleep onset latency on school nights may be more prone to problems with pre-sleep arousal or worries, which could, in turn, be associated with the development of anxiety, although this would not explain why this finding was not also present at age 17.

Finally, *sleep patterns* and *sleep quality* at age 15 were examined as predictors of anxiety and depression symptoms at age 21. The same variables were predictive of both anxiety and depression symptoms, and were, overall, consistent with results from the models predicting diagnoses. Total sleep time on school nights was the only significant sleep pattern predictor of symptoms of anxiety and depression. Significant sleep quality predictors mirrored those found in the diagnostic analyses, whereby daytime sleepiness, night waking and perception of whether sleep quantity was enough, significantly predicted symptoms. However, as in the model of predicting anxiety diagnoses at 24, sleep onset latency on school nights was also a significant predictor of symptoms of both anxiety and depression at age 21. This slight discrepancy between the models of diagnostic outcomes compared to symptoms may be reflective of the greater variance that can be examined when analysing continuous variables compared to categorical variables. This finding also strengthens the likelihood that sleep onset latency on school nights is an important factor in influencing mental health outcomes later in life, as predicted by Lovato and Gradisar (2014).

Anxious participants reported challenges with sleep quality but did not report any sleep patterns to be worse than adolescents with no anxiety/depression. Similar results have been reported when comparing objective and subjective measures of sleep amongst anxious children. Alfano et al. (2015) reported that parent and child reported sleep

Table 5 Summary of sleep variables at age 15 in logistic regression models predicting anxiety and depression diagnoses at age 24 (n = 2,719)

Age 15	Anxiety at 24 years	*B*	Odds ratio (95% CI)	R^2	Model
Sleep patterns	TST school	−0.30**	0.74 (0.62–0.88)	.02 (Cox&Snell)	$X^2(3) = 15.64$**
	TST weekend	−0.02	0.99 (0.88–1.10)	.03 (Nagelkerk)	
	Chronotype	−0.01	0.99 (0.86–1.15)		
Sleep quality	SOL school	0.01**	1.01 (1.00–1.02)	.04 (Cox&Snell)	$X^2(7) = 73.78$***
	SOL weekend	−0.00	1.00 (0.99–1.01)	.08 (Nagelkerk)	
	Ease getting up school	0.08	1.08 (0.91–1.29)		
	Ease getting up weekend	0.09	1.09 (0.90–1.32)		
	Daytime sleepiness	0.34***	1.40 (1.17–1.67)		
	Night waking	0.15**	1.17 (1.05–1.30)		
	Perception of enough sleep	0.22*	1.25 (1.05–1.49)		
Age 15	Depression at 24 years	*B*	Odds ratio (95% CI)	R^2	Model
Sleep patterns	TST school	−0.20*	0.82 (0.69–0.97)	.01 (Cox&Snell)	$X^2(3) = 10.80$*
	TST weekend	−0.04	0.97 (0.87–1.08)	.02 (Nagelkerk)	
	Chronotype	0.07	1.07 (0.93–1.23)		
Sleep quality	SOL school	0.01	1.01 (1.00–1.02)	.03 (Cox&Snell)	$X^2(7) = 51.57$***
	SOL weekend	0.00	1.00 (0.99–1.01)	.06 (Nagelkerk)	
	Ease getting up school	−0.01	0.99 (0.83–1.17)		
	Ease getting up weekend	0.06	1.07 (0.89–1.28)		
	Daytime sleepiness	0.32***	1.38 (1.16–1.64)		
	Night waking	0.12*	1.13 (1.02–1.26)		
	Perception of enough sleep	0.22*	1.25 (1.05–1.48)		

Step 1 age 15 anxiety and depression not included in table; SOL: sleep onset latency; TST: total sleep time; *p < .05; **p < .01; and ***p < .001.

problems were worse in anxious compared to control children, but no between-group differences were found for actigraphy-based sleep patterns. Furthermore, research examining objective measures of sleep in depressed and anxious young people found that anxious participants had less slow-wave sleep than depressed participants (Forbes et al., 2008), which may explain the presence of tiredness even in the absence of quantity disturbance. Anxious young people reported that these difficulties were only present on school nights, which may indicate heightened anxiety or worry related to school (e.g. worries about academic performance or social interactions) is interfering with good quality sleep. Alternatively, heightened anxiety may increase dysfunctional beliefs about sleep (e.g. Gregory et al., 2009), and this would be consistent with the finding that adolescents with anxiety did not report different sleep patterns from those with no anxiety or depression. To help better understand the data on sleep difficulties in anxious young people, future research would benefit from using objective measures of sleep (e.g. actigraphy or polysomnography) as well as assessing beliefs and biases about sleep.

Although difficulties with sleep patterns were not characteristic in young people who had anxiety disorders at 15 years, they seem to be a potential risk factor for the development of both anxiety and depression. This may indicate a potential benefit to treating early sleep difficulties in adolescence, irrespective of existing psychological disorders. There is not only growing interest in the effectiveness of sleep interventions on sleep but also on anxiety and depression (e.g. Gee et al., 2018; Luik et al., 2017). The findings of this study also suggest that treatment of sleep should be examined for prevention of future anxiety or depression. Prevention activities may be well suited to delivery in schools, where large numbers of young people with early sleep problems are likely to be present. To date, the evidence seems to suggest that interventions are most effective at improving short-term anxiety and depression when they use CBT-I programmes (rather than sleep education), and when they target at-risk participants (i.e. presenting with symptoms of anxiety and depression) (Blake & Allen, 2019).

Young people with anxiety and/or depression may also benefit from treatment that targets sleep difficulties either by including sessions on sleep in a multi-modal intervention (e.g. Clarke et al., 2015), or even by targeting only sleep problems (e.g. Gee et al., 2018; Orchard et al., 2019). Importantly, given the robust findings that sleep quality predicted later anxiety and depression, robust randomised controlled trials of sleep programmes in adolescents should include measures of sleep quality as well as anxiety and depression symptoms.

This study improved on previous research in the field by addressing a number of questions (a) exploring both cross-sectional and prospective relationships between sleep, and anxiety and depression, (b) exploring both sleep patterns and perceived sleep quality, (c) considering prospective relationships with categorical and continuous approaches to

Table 6 Summary of sleep variables at age 15 in multiple regression models predicting anxiety and depression symptoms at age 21 (n = 2,363)

Age 15	Anxiety at 21 years	F	df	R^2	ΔR^2	B	$SE\ B$	β
Sleep patterns	TST school	23.10***	4, 2348	0.04	0.01***	−0.54	0.13	−0.10***
	TST weekend					−0.02	0.08	−0.00
	Chronotype					0.16	0.11	0.04
Sleep quality	SOL school	26.05***	8, 2246	0.09	0.06***	0.03	0.01	0.11***
	SOL weekend					−0.01	0.01	−0.04
	Ease getting up school					0.07	0.12	0.01
	Ease getting up weekend					0.07	0.13	0.01
	Daytime sleepiness					0.70	0.14	0.12***
	Night waking					0.35	0.08	0.09***
	Perception of enough sleep					0.54	0.13	0.10***
Age 15	Depression at 21 years							
Sleep patterns	TST school	18.50***	4, 2358	0.03	0.02***	−0.68	0.16	−0.10***
	TST weekend					−0.01	0.10	−0.00
	Chronotype					0.23	0.13	0.04
Sleep quality	SOL school	19.60***	8, 2256	0.07	0.05***	0.03	0.01	0.10**
	SOL weekend					−0.01	0.01	−0.03
	Ease getting up school					0.13	0.15	0.02
	Ease getting up weekend					−0.01	0.16	−0.00
	Daytime sleepiness					0.80	0.17	0.11***
	Night waking					0.33	0.10	0.07**
	Perception of enough sleep					0.52	0.16	0.08**

Step 1 age 15 anxiety and depression not included in table; SOL: sleep onset latency; TST: total sleep time; *$p < .05$; **$p < .01$; and ***$p < .001$.

mental health measurement, and (d) at multiple time points across adolescence and in adulthood. The analysis of this cohort dataset enabled access to a large sample and the ability to examine individuals with and without diagnoses of anxiety and depression, established with diagnostic assessments. There are however some important limitations. Firstly, participants were mostly White British, limiting the extent to which the study can be generalised to other demographic groups. Secondly, the diagnostic groups were small at age 15, with depression and anxiety identified in approximately 1% of the sample, and this is lower than reported *point prevalence* of depression and anxiety in young people (2.6% and 6.5% respectively; Polanczyk, Salum, Sugaya, Caye, & Rohde, 2015). The relative scarcity of participants who met diagnostic criteria at 15 years may be an artefact of the DAWBA, which has been noted to be a conservative measurement of depression and anxiety (Angold et al., 2012). At age 17 and 24, when anxiety and depression were assessed using the CIS-R, rates of anxiety and depression were higher (at 17 years, 9.0% anxiety and 7.3% depression; at 24 years, 9.5% anxiety and 10.2% depression). However, this limitation is somewhat alleviated by the inclusion of prospective models predicting severity of anxiety and depression symptoms reported with self-report questionnaires, especially as these models provide internal replication for the majority of findings.

It is also important to note a couple of limitations related to the measurement of sleep. Sleep was measured subjectively, and thus could be influenced by reporting and memory biases. However, the longitudinal relationships indicate that even if sleep problems reported at age 15 are not objective, these subjective ratings are related to future mental health problems and therefore warrant further investigation or intervention. Secondly, not all facets of sleep were assessed. One key area that was not measured was 'wake after sleep onset' (WASO). This may be important because WASO may reduce total sleep time values, and therefore, total sleep time may have been overestimated. Finally, diagnoses of depression and some anxiety disorders do include assessment of sleep difficulties, meaning that there is some overlap in measurement.

Although there were significant differences in sleep between young people who had anxiety disorders and depression, the predictors of future anxiety and depression in adolescence and adulthood were largely the same across the two difficulty areas. This fits with research examining other predictors, such as genetics, where strong genetic overlap is often flagged between depression and anxiety (Nivard et al., 2015), as well as sleep phenotypes (Barclay & Gregory, 2013). The data from this study do imply that managing the amount, quality and perception of sleep during adolescence may have long-term implications for the development of anxiety and depression later in adolescence and in early adulthood. Future work should begin to examine this, providing support for sleep behaviours in adolescence, and conducting long-term follow-ups to examine the resulting effect on the development of anxiety and depression.

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Correspondence

Faith Orchard, School of Psychology and Clinical Language Sciences, University of Reading, Reading RG6 6AL, UK; Email: f.orchard@reading.ac.uk

Key points

- Sleep problems are common in adolescence, and frequently co-occur with depression and anxiety.
- Adolescents with depression reported problems with sleep patterns and sleep quality, and adolescents with anxiety reported problems with sleep quality only.
- Sleep quality and total sleep time at age 15 were predictive of anxiety and depression diagnoses and symptoms at ages 17, 21 and 24 years.
- Adolescents with anxiety and depression may benefit from additional support with sleep habits.
- Future research should address whether providing support with sleep habits in adolescence may prevent anxiety and depression from developing later in life.

References

Alfano, C.A., Ginsburg, G.S., & Kingery, J.N. (2007). Sleep-related problems among children and adolescents with anxiety disorders. *Journal of the American Academy of Child & Adolescent Psychiatry*, *46*, 224–232.

Alfano, C.A., Patriquin, M.A., & De Los Reyes, A. (2015). Subjective–objective sleep comparisons and discrepancies among clinically-anxious and healthy children. *Journal of Abnormal Child Psychology*, *43*, 1343–1353.

Angold, A., Costello, E.J., Messer, S.C., Pickles, A., Winder, F., & Silver, D. (1995). The development of a short questionnaire for use in epidemiological studies of depression in children and adolescents. *International Journal of Methods in Psychiatric Research*, *5*, 237–249.

Angold, A., Erkanli, A., Copeland, W., Goodman, R., Fisher, P.W., & Costello, E.J. (2012). Psychiatric diagnostic interviews for children and adolescents: A comparative study. *Journal of the American Academy of Child & Adolescent Psychiatry*, *51*, 506–517.

Barclay, N.L., & Gregory, A.M. (2013). Sleep in childhood and adolescence: age-specific sleep characteristics, common sleep disturbances and associated difficulties. In S.L. Andersen & D.S. Pine (Eds.), *The neurobiology of childhood* (pp. 337–365). New York: Springer.

Bauducco, S., Richardson, C., & Gradisar, M. (2020). Chronotype, circadian rhythms, and mood. *Current Opinion in Psychology*, *34*, 77–83.

Beebe, D.W. (2011). Cognitive, behavioral, and functional consequences of inadequate sleep in children and adolescents. *Pediatric Clinics*, *58*, 649–665.

Blake, M.J., & Allen, N.B. (2019). Prevention of internalizing disorders and suicide via adolescent sleep interventions. *Current Opinion in Psychology*, *34*, 37–42.

Blake, M.J., Trinder, J.A., & Allen, N.B. (2018). Mechanisms underlying the association between insomnia, anxiety, and depression in adolescence: Implications for behavioral sleep interventions. *Clinical Psychology Review*, *63*, 25–40.

Boyd, A., Golding, J., Macleod, J., Lawlor, D.A., Fraser, A., Henderson, J., … & Davey Smith, G. (2013). Cohort profile: the 'children of the 90s'—the index offspring of the Avon Longitudinal Study of Parents and Children. *International Journal of Epidemiology*, *42*, 111–127.

Bradley, J., Freeman, D., Chadwick, E., Harvey, A.G., Mullins, B., Johns, L., … & Waite, F. (2018). Treating sleep problems in young people at ultra-high risk of psychosis: A feasibility case series. *Behavioural and Cognitive Psychotherapy*, *46*, 276–291.

Chase, R.M., & Pincus, D.B. (2011). Sleep-related problems in children and adolescents with anxiety disorders. *Behavioral Sleep Medicine*, *9*, 224–236.

Clarke, G., & Harvey, A.G. (2012). The complex role of sleep in adolescent depression. *Child and Adolescent Psychiatric Clinics*, *21*, 385–400.

Clarke, G., McGlinchey, E.L., Hein, K., Gullion, C.M., Dickerson, J.F., Leo, M.C., & Harvey, A.G. (2015). Cognitive-behavioral treatment of insomnia and depression in adolescents: A pilot randomized trial. *Behaviour Research and Therapy*, *69*, 111–118.

Crowley, S.J., Acebo, C., & Carskadon, M.A. (2007). Sleep, circadian rhythms, and delayed phase in adolescence. *Sleep Medicine*, *8*, 602–612.

Crowley, S.J., Wolfson, A.R., Tarokh, L., & Carskadon, M.A. (2018). An update on adolescent sleep: New evidence informing the perfect storm model. *Journal of Adolescence*, *67*, 55–65.

Cummings, C.M., Caporino, N.E., & Kendall, P.C. (2014). Comorbidity of anxiety and depression in children and adolescents: 20 years after. *Psychological Bulletin*, *140*, 816.

Curcio, G., Ferrara, M., & De Gennaro, L. (2006). Sleep loss, learning capacity and academic performance. *Sleep Medicine Reviews*, *10*, 323–337.

Dahl, R.E. (1999). The consequences of insufficient sleep for adolescents. *Phi Delta Kappan*, *80*, 354–359.

Forbes, E.E., Bertocci, M.A., Gregory, A.M., Ryan, N.D., Axelson, D.A., Birmaher, B., & Dahl, R.E. (2008). Objective sleep in pediatric anxiety disorders and major depressive disorder. *Journal of the American Academy of Child & Adolescent Psychiatry*, *47*, 148–155.

Fraser, A., Macdonald-Wallis, C., Tilling, K., Boyd, A., Golding, J., Davey Smith, G., … & NESS, A. (2012). Cohort profile: The Avon Longitudinal Study of Parents and Children: ALSPAC mothers cohort. *International Journal of Epidemiology*, *42*, 97–110.

Freeman, D., Sheaves, B., Goodwin, G.M., Yu, L.-M., Nickless, A., Harrison, P.J., … & Wadekar, V. (2017). The effects of improving sleep on mental health (OASIS): A randomised controlled trial with mediation analysis. *The Lancet Psychiatry*, *4*, 749–758.

Gaultney, J.F. (2010). The prevalence of sleep disorders in college students: Impact on academic performance. *Journal of American College Health*, *59*, 91–97.

Gee, B., Orchard, F., Clarke, E., Joy, A., Clarke, T., & Reynolds, S. (2018). The effect of non-pharmacological sleep interventions on depression symptoms: A meta-analysis of randomised controlled trials. *Sleep Medicine Reviews*, *43*, 118–128.

Goodman, R., Ford, T., Richards, H., Gatward, R., & Meltzer, H. (2000). The development and well-being assessment: Description and initial validation of an integrated assessment of child and adolescent psychopathology. *Journal of Child Psychology and Psychiatry*, *41*, 645–655.

Goodyer, I.M., Reynolds, S., Barrett, B., Byford, S., Dubicka, B., Hill, J., … & Roberts, C. (2017). Cognitive behavioural therapy and short-term psychoanalytical psychotherapy versus a brief psychosocial intervention in adolescents with unipolar major depressive disorder (IMPACT): a multicentre, pragmatic, observer-blind, randomised controlled superiority trial. *The Lancet Psychiatry*, *4*, 109–119.

Gradisar, M., Gardner, G., & Dohnt, H. (2011). Recent worldwide sleep patterns and problems during adolescence: A review and meta-analysis of age, region, and sleep. *Sleep Medicine*, *12*, 110–118.

Gregory, A.M., Cox, J., Crawford, M.R., Holland, J., Haravey, A.G., & Team, S. (2009). Dysfunctional beliefs and attitudes about sleep in children. *Journal of Sleep Research*, *18*, 422–426.

Gregory, A.M., & Sadeh, A. (2016). Annual research review: Sleep problems in childhood psychiatric disorders–a review of the latest science. *Journal of Child Psychology and Psychiatry*, *57*, 296–317.

Hagenauer, M.H., & Lee, T.M. (2013). Adolescent sleep patterns in humans and laboratory animals. *Hormones and Behavior*, *64*, 270–279.

Harris, P.A., Taylor, R., Minor, B.L., Elliott, V., Fernandez, M., O'Neal, L., … & Duda, S.N. (2019). The REDCap consortium: Building an international community of software partners. *Journal of Biomedical Informatics*, *95*, 103208.

Harris, P.A., Taylor, R., Thielke, R., Payne, J., Gonzalez, N., & Conde, J.G. (2009). Research electronic data capture (REDCap) – A metadata-driven methodology and workflow process for providing translational research informatics support. *Journal of Biomedical Informatics*, *42*, 377–381.

Kuula, L., Gradisar, M., Martinmäki, K., Richardson, C., Bonnar, D., Bartel, K., … & Pesonen, A. (2019). Using big data to explore worldwide trends in objective sleep in the transition to adulthood. *Sleep Medicine*, *62*, 69–76.

Lewis, G., Pelosi, A.J., Araya, R., & Dunn, G. (1992). Measuring psychiatric disorder in the community: A standardized assessment for use by lay interviewers. *Psychological medicine*, *22*, 465–486.

Liu, X., Buysse, D.J., Gentzler, A.L., Kiss, E., Mayer, L., Kapornai, K., … & Kovacs, M. (2007). Insomnia and hypersomnia associated with depressive phenomenology and comorbidity in childhood depression. *Sleep*, *30*, 83–90.

Lo, J.C., Ong, J.L., Leong, R.L., Gooley, J.J., & Chee, M.W. (2016). Cognitive performance, sleepiness, and mood in partially sleep deprived adolescents: The need for sleep study. *Sleep*, *39*, 687–698.

Lovato, N., & Gradisar, M. (2014). A meta-analysis and model of the relationship between sleep and depression in adolescents: Recommendations for future research and clinical practice. *Sleep Medicine Reviews*, *18*, 521–529.

Löwe, B., Decker, O., Muller, S., Brahler, E., Schellburg, D., Herzog, W., & Herzberg, P.Y. (2008). Validation and standardisation of the GAD-7. *Medical Care*, *46*, 266–274.

Luik, A.I., Bostock, S., Chisnall, L., Kyle, S.D., Lidbetter, N., Baldwin, N., & Espie, C.A. (2017). Treating depression and anxiety with digital cognitive behavioural therapy for insomnia: a real world NHS evaluation using standardized outcome measures. *Behavioural and Cognitive Psychotherapy*, *45*, 91–96.

Matricciani, L. (2013). Subjective reports of children's sleep duration: Does the question matter? A literature review. *Sleep Medicine*, *14*, 303–311.

McCall, W.V., Blocker, J.N., D'Agostino, R., Jr, Kimball, J., Boggs, N., Lasater, B., & Rosenquist, P.B. (2010). Insomnia severity is an indicator of suicidal ideation during a depression clinical trial. *Sleep Medicine*, *11*, 822–827.

Messer, S.C., Angold, A., Costello, E.J., Loeber, R., Van Kammen, W., & Stouthamer-Loeber, M. (1995). Development of a short questionnaire for use in epidemiological studies of depression in children and adolescents: Factor composition and structure across development. *International Journal of Methods in Psychiatric Research*, *5*, 251–262.

Morrison, D.N., McGee, R., & Stanton, W.R. (1992). Sleep problems in adolescence. *Journal of the American Academy of Child & Adolescent Psychiatry*, *31*, 94–99.

Nivard, M., Dolan, C., Kendler, K., Kan, K.-J., Willemsen, G., Van Beijsterveldt, C., … & Bartels, M. (2015). Stability in symptoms of anxiety and depression as a function of genotype and environment: A longitudinal twin study from ages 3 to 63 years. *Psychological Medicine*, *45*, 1039–1049.

Northstone, K., Lewcock, M., Groom, A., Boyd, A., Macleod, J., Timpson, N.J., & Wells, N. (2019). The Avon Longitudinal Study of Parents and Children (ALSPAC): An updated on the enrolled sample of index children in 2019. *Wellcome Open Research*, *4*, 51.

Ohayon, M., Wickwire, E.M., Hirshkowitz, M., Albert, S.M., Avidan, A., Daly, F.J., … & Gozal, D. (2017). National Sleep Foundation's sleep quality recommendations: First report. *Sleep Health*, *3*, 6–19.

Olds, T., Blunden, S., Petkov, J., & Forchino, F. (2010). The relationships between sex, age, geography and time in bed in adolescents: A meta-analysis of data from 23 countries. *Sleep Medicine Reviews*, *14*, 371–378.

Orchard, F., Pass, L., Chessell, C., Moody, A., Ellis, J., & Reynolds, S. (2019). Adapting Brief CBT-I for Depressed Adolescents: A case illustration of the sleeping better program. *Cognitive and Behavioral Practice*.

Orchard, F., Pass, L., Marshall, T., & Reynolds, S. (2017). Clinical characteristics of adolescents referred for treatment

of depressive disorders. *Child and Adolescent Mental Health*, *22*, 61–68.
Owens, J. (2014). Insufficient sleep in adolescents and young adults: an update on causes and consequences. *Pediatrics*, *134*, e921–e932.
Palagini, L., Domschke, K., Benedetti, F., Foster, R.G., Wulff, K., & Riemann, D. (2019). Developmental pathways towards mood disorders in adult life: Is there a role for sleep disturbances? *Journal of Affective Disorders*, *243*, 121–132.
Palmer, C.A., & Alfano, C.A. (2017). Sleep and emotion regulation: An organizing, integrative review. *Sleep Medicine Reviews*, *31*, 6–16.
Paruthi, S., Brooks, L.J., D'Ambrosio, C., Hall, W.A., Kotagal, S., Lloyd, R.M., ... & Quan, S.F. (2016). Recommended amount of sleep for pediatric populations: a consensus statement of the American Academy of Sleep Medicine. *Journal of Clinical Sleep Medicine*, *12*, 785–786.
Polanczyk, G.V., Salum, G.A., Sugaya, L.S., Caye, A., & Rohde, L.A. (2015). Annual Research Review: A meta-analysis of the worldwide prevalence of mental disorders in children and adolescents. *Journal of Child Psychology and Psychiatry*, *56*, 345–365.
Roberts, R.E., & Duong, H.T. (2014). The prospective association between sleep deprivation and depression among adolescents. *Sleep*, *37*, 239–244.
Ruiz, M., Zamorano, E., García-Campayo, J., Pardo, A., Freire, O., & Rejas, J. (2011). Validity of the GAD-7 scale as an outcome measure of disability in patients with generalized anxiety disorders in primary care. *Journal of Affective Disorders*, *128*, 277–286.
Sadeh, A., Gruber, R., & Raviv, A. (2003). The effects of sleep restriction and extension on school-age children: What a difference an hour makes. *Child Development*, *74*, 444–455.
Short, M.A., Gradisar, M., Lack, L.C., Wright, H.R., & Chatburn, A. (2013). Estimating adolescent sleep patterns: parent reports versus adolescent self-report surveys, sleep diaries, and actigraphy. *Nature and Science of Sleep*, *5*, 23.
Short, M.A., Gradisar, M., Wright, H., Lack, L.C., Dohnt, H., & Carskadon, M.A. (2011). Time for bed: parent-set bedtimes associated with improved sleep and daytime functioning in adolescents. *Sleep*, *34*, 797–800.
Singareddy, R., Krishnamurthy, V.B., Vgontzas, A.N., Fernandez-Mendoza, J., Calhoun, S.L., Shaffer, M.L., & Bixler, E.O. (2013). Subjective and objective sleep and self-harm behaviors in young children: a general population study. *Psychiatry Research*, *209*, 549–553.
Spitzer, R.L., Kroenke, K., Williams, J.B., & Löwe, B. (2006). A brief measure for assessing generalized anxiety disorder: The GAD-7. *Archives of Internal Medicine*, *166*, 1092–1097.
Tabachnick, B.G., & Fidell, L.S. (2007). *Experimental designs using ANOVA*. Pacific Grove, CA: Thomson/Brooks/Cole.
Talbot, L.S., McGlinchey, E.L., Kaplan, K.A., Dahl, R.E., & Harvey, A.G. (2010). Sleep deprivation in adolescents and adults: changes in affect. *Emotion*, *10*, 831.
Taylor, D.J., Jenni, O.G., Acebo, C., & Carskadon, M.A. (2005). Sleep tendency during extended wakefulness: Insights into adolescent sleep regulation and behavior. *Journal of Sleep Research*, *14*, 239–244.
WHO (1992). *The ICD-10 classification of mental and behavioural disorders: Clinical descriptions and diagnostic guidelines* (vol. *1*). Geneva, Switzerland: World Health Organization.
Wolfson, A.R., Carskadon, M.A., Acebo, C., Seifer, R., Fallone, G., Labyak, S.E., & Martin, J.L. (2003). Evidence for the validity of a sleep habits survey for adolescents. *Sleep*, *26*, 213–216.
Zavada, A., Gordijn, M.C., Beersma, D.G., Daan, S., & Roenneberg, T. (2005). Comparison of the Munich Chronotype Questionnaire with the Horne-Östberg's morningness-eveningness score. *Chronobiology International*, *22*, 267–278.

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