Sleep and academic performance in later adolescence: results from a large population-based study

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SUMMARY

The aim of the current study was to assess the association between sleep duration and sleep patterns and academic performance in 16–19 year-old adolescents using registry-based academic grades. A large population-based study from Norway conducted in 2012, the youth@hordaland-survey, surveyed 7798 adolescents aged 16–19 years (53.5% girls). The survey was linked with objective outcome data on school performance. Self-reported sleep measures provided information on sleep duration, sleep efficiency, sleep deficit and bedtime differences between weekday and weekend. School performance [grade point average (GPA)] was obtained from official administrative registries. Most sleep parameters were associated with increased risk for poor school performance. After adjusting for sociodemographic information, short sleep duration and sleep deficit were the sleep measures with the highest odds of poor GPA (lowest quartile). Weekday bedtime was associated significantly with GPA, with adolescents going to bed between 22:00 and 23:00 hours having the best GPA. Also, delayed sleep schedule during weekends was associated with poor academic performance. The associations were somewhat reduced after additional adjustment for non-attendance at school, but remained significant in the fully adjusted models. In conclusion, the demonstrated relationship between sleep problems and poor academic performance suggests that careful assessment of sleep is warranted when adolescents are underperforming at school. Future studies are needed on the association between impaired sleep in adolescence and later functioning in adulthood.

INTRODUCTION

The link between sleep and academic performance is an important research domain, particularly in the later adolescent years, as school performance is linked closely to subsequent educational and work attainment (De Ridder *et al.*, 2012). Sleep and academic performance may be related through several pathways and mechanisms. A direct effect of sleep has been shown in experimental studies in which sleep restriction has resulted in impaired learning and memory performance in early adolescence (Curcio *et al.*, 2006). Sleep may also impact upon academic performance indirectly through tardiness or school absence, which often accompanies sleep problems in this age group (Hysing *et al.*, 2015). Finally, there may be confounding factors, such as socioeconomic status (SES) known to be related to both sleep (Boe *et al.*, 2012) and school performance (Sirin, 2005), that might account for some of the association.

A meta-analysis including 17 studies of children and adolescents from 2010 confirmed a significant, but modest, association between sleep quality, sleep duration and sleepiness and academic performance (Dewald *et al.*, 2010). A similar conclusion was reached in a more recent review (Shochat *et al.*, 2014). However, there are several shortcomings in the existing literature. First, most studies have relied solely upon subjective reports of exposure (sleep)

and outcomes (academic performance), with the inherent risk of reporter bias. Secondly, most of the literature has included samples with a very wide age range, and not focused specifically on late adolescence, which is a particularly important transitional period involving substantial changes in sleep compared to prepuberty (Maslowsky and Ozer, 2014). Thirdly, a delayed sleep schedule, combined with increasing differences between weekday and weekend sleep, has been demonstrated in this age group, but thus far these specific sleep parameters have received little attention in relation to academic performance.

Based on these considerations, the main aim of the present study was to assess the association between a range of self-reported sleep variables and registry-based grade point average (GPA) among 16–19-year-old high school students. Based on the literature, we expected an association between sleep variables and GPA, with lower GPA among adolescent with short sleep duration and with a delayed sleep schedule. Secondly, we aimed to investigate if school absenteeism and sociodemographic factors could account for this association.

MATERIALS AND METHODS

Procedure

In this population-based study from 2012, we used data from the youth@hordaland-survey of adolescents in the county of Hordaland in western Norway. The general aim of the youth@hordaland-survey was to assess mental health, lifestyle, school performance and health service use in adolescents. All adolescents born between 1993 and 1995 (aged 16–19 years) attending secondary education were invited, through collaboration with Hordaland County, to participate. The data were collected from February to May 2012, with the majority collected in February. The adolescents received information about the study via their official school e-mail, and one school class (approximately 45 min) during regular school hours was allocated for them to complete the internet-based questionnaire. A teacher was present to organize the data collection and to ensure confidentiality. They could choose to complete the questionnaire at their own convenience if they were not present at school that day. Survey staff were available by telephone for both the adolescents and school personnel to answer queries related to the research.

Data from the youth@hordaland-survey were linked to official registers from Hordaland County, which included information on academic grades.

Sample

All adolescents born between 1993 and 1995 (n = 19 430) were invited to participate in the youth@hordaland study that took place during the first months of 2012, 10 220 of whom agreed, yielding a participation rate of 53%. Sleep variables were checked for validity of answers based on preliminary data analysis, resulting in 374 adolescents being omitted due to obvious invalid responses (e.g. negative sleep duration or sleep efficiency). Among the 9846 remaining adolescents in the 16–19-year age range, 2048 did not give consent to data linkage to the official school register or were not in high school, yielding a sample size of 7798 for the linked data set that is used in the present study.

Measures

Sleep variables

The adolescents' typical bedtime and rise-time were indicated in hours and minutes using a scroll-down menu with 5-min intervals, and were reported separately for weekend and weekdays. Typical time in bed (TIB) was calculated by subtracting bedtime from rise-time. Sleep onset latency (SOL) and wake after sleep onset (WASO) were indicated in hours and minutes using a scroll-down menu with 5-min intervals, and sleep duration was defined as TIB minus SOL and WASO. Sleep efficiency was calculated as sleep duration divided by TIB multiplied by 100 (reported as a percentage). Subjective sleep need was reported in hours and minutes, and sleep deficit was calculated separately for weekends and weekdays, subtracting total sleep duration from subjective sleep need. For the purpose of the present study, sleep duration was also split into six categories (<5, 5 to <6, 6 to <7, 7 to <8, 8 to <9, ≥9 h).

Academic performance and school absence

Academic grades were the official grades from the registers of Hordaland County. The registry data were linked to the youth@hordaland-survey for participants who consented to participate in the study as a whole (including school registry information), or consented specifically to the use of the registry information. The GPA was calculated, representing the average of the student's grades during the term. Secondary schools in Norway use a scale from 1 to 6, with 6 being the highest grade (outstanding competence) and 2 (low level of competence) as the lowest passing grade and 1 constituting failure. For analysis purposes, GPA was also dichotomized at the 25th percentile (lowest quartile) as an indicator of poor academic performance. The decision to use quartiles as the cutoff was that the Norwegian grading system is not easily transferable to settings in other countries and, as such, absolute cutoffs would make less sense than for sleep duration.

Official register-based data on school non-attendance were also provided by Hordaland County Council, and included both days and school-hours of absence during the last semester (6 months). A joint variable for school absence was also created, in which 6 h of non-attendance was equivalent to 1 day of absence, as specified by Norwegian school regulations.

Sociodemographics

Gender and date of birth were identified through personal identity number in the Norwegian National Population Register. Exact age was estimated by calculating the time interval between date of birth and date of participation. SES was assessed both by parental education and perceived family affluence. Maternal and paternal educations were reported separately, with three response options: 'primary school', 'secondary school' and 'college or university'. Perceived family affluence (i.e. how well off the adolescent perceived their family to be) was assessed by asking the adolescents how their family affluence is compared to most others. Response alternatives were (i) 'better family affluence', (ii) 'approximately like most others' and (iii) 'poorer family affluence'. A recent report from the second wave of the Bergen Child Study, when the children were aged 11–13 years, showed that the rating of family affluence correlated reasonably well ($r = 0.586$, $P < 0.001$) with information about taxable monetary income which was available for a subsample of 642 participants (Bøe *et al.*, 2014).

Ethics

The study was approved by the Regional Committee for Medical and Health Research Ethics (REC) in western Norway. In accordance with the regulations from the REC and Norwegian health authorities, adolescents aged 16 years and older can make decisions regarding their own health (including participation in health studies), and thus gave consent themselves to participate in the current study. Parents/guardians have the right to be informed, and in the current study all parents/guardians received written information about the study in advance.

Statistics

IBM SPSS version 22 for Mac (SPSS Inc., Chicago, IL, USA) was used for all analyses. Analysis of variance (ANOVA), independent-sample *t*-tests and chi-square tests were used to examine the association between academic grades and the demographic and sleep variables. Logistic regression analyses were used to assess the association between sleep variables (exposure) and poor academic performance (outcome: GPA dichotomized at the 25th percentile). We calculated both crude (unadjusted) odds ratios and adjusted for the following covariates entered simultaneously: age, gender, parental education and perceived family affluence. Finally, a fully adjusted model with additional adjustment for school non-attendance was conducted. To examine gender differences, estimated marginal means (EMM) were calculated for GPA in boys and girls separately for all sleep variables, adjusting for age, parental education and perceived family affluence. To examine possible age differences in these associations, EMM were also calculated separately for GPA in each age cohort. To adjust for multiple comparisons, Bonferroni corrections were performed by setting the significance cutoff at α divided by number of tests. In the current study, we performed a total of 15 tests at $\alpha = 0.05$, which means that we rejected the null hypothesis if the *P*-value was less than 0.0033.

Representativeness of the sample

Compared to national and regional statistics provided by the Norwegian Directorate for Education and Training (2014), the mean GPA of all mandatory courses in the current study [mean = 3.57, standard deviation (SD) = 0.99] was identical to the national GPA in 2012 in this age cohort (mean = 3.57, SD = 0.99; $P = 0.999$), but slightly lower than the GPA in Hordaland county (mean = 3.61, SD = 0.99; $P < 0.01$).

RESULTS

Demographic characteristics and GPA

In all, 7798 adolescents provided valid responses on the relevant sleep items in the linked sample. The mean age was 17 years, and the sample included more girls (53.5%) than boys (46.5%). Girls had significantly higher GPA than boys (GPA = 3.94 versus GPA = 3.73, respectively, $P < 0.001$). Age was not associated significantly with GPA. Adolescents whose parents had completed a college education had a significantly higher GPA than parents with less education (fathers: GPA = 4.09 versus GPA = 3.60, and mothers: GPA = 4.10 versus GPA = 3.73, respectively, both *P*s < 0.001). Adolescents with lower family affluence had lower GPA (3.69) compared to families with good or average (GPA = 3.86) family affluence ($P < 0.001$).

Sleep characteristics and GPA

There was a reverse J-shaped association between sleep duration and GPA. As detailed in Table 1, adolescents sleeping between 7 and 9 h had the highest GPA (4.0) compared with both longer sleep duration ($\geq$9 h: GPA = 3.9) and especially short sleep duration (<5 h: GPA = 3.5). There was a dose–response association between GPA and sleep efficiency, with adolescents having a sleep efficiency of $\geq$90% having the highest GPA (4.0) compared to adolescents with a sleep efficiency of <75% having a GPA of 3.5. Similarly, subjectively reported sleep deficit (sleep need − actual sleep) showed a similar graded association to GPA; adolescents with sleep deficit of $\geq$4 h had a GPA of 3.5, compared to a GPA of 4.0 in adolescents with a sleep deficit of <2 h.

Weekday bedtime was associated significantly with GPA, with adolescents going to bed between 22:00 and 23:00 hours having the best GPA (4.0). The later the bedtime during weekdays the lower the GPA but, of note, the GPA was lower for adolescents with a bedtime earlier than 22:00 hours relative to those going to bed between 22:00

Table 1 Sleep characteristics as risk factors for poor academic performance (defined as GPA in the lowest quartile)

		GPA		*Unadjusted model*		*Adjusted model**		*Fully adjusted model†*	
	%	*Mean*	*SD*	*OR*	*95% CI*	*OR*	*95% CI*	*OR*	*95% CI*
Sleep duration (h)									
<5:00	15.4	3.46	0.83	3.54	2.86–4.37	3.60	2.90–4.45	2.53	2.03–3.16
5:00–5:59	11.5	3.72	0.77	1.91	1.52–2.41	1.89	1.50–2.39	1.54	1.21–1.95
6:00–6:59	26.9	3.88	0.77	1.42	1.15–1.74	1.39	1.13–1.71	1.21	0.98–1.50
7:00–7:59	32.2	4.01	0.74	1.01	0.82–1.24	1.00	0.81–1.23	0.94	0.76–1.16
8:00–8:59	12.1	4.02	0.73	1.00	–	1.00	–	1.00	–
≥9:00	1.7	3.85	0.80	1.74	1.11–2.75	1.69	1.07–2.68	1.67	1.04–2.68
Sleep efficiency (%)									
≥90	56.6	3.97	0.76	1.00	–	1.00	–	1.00	–
85.0–89.9	12.9	3.89	0.76	1.22	1.03–1.45	1.24	1.04–1.49	1.16	0.98–1.39
75.0–84.9	12.9	3.75	0.79	1.59	1.36–1.85	1.67	1.42–1.97	1.45	1.23–1.72
<75	17.6	3.52	0.82	2.63	2.30–3.01	2.78	2.43–3.19	2.12	1.83–2.45
Sleep deficit (h)									
>4:00	19.2	3.48	0.80	3.18	2.75–3.68	3.36	2.90–3.90	2.65	2.27–3.09
3:00–3:59	11.1	3.80	0.78	1.68	1.39–2.03	1.73	1.43–2.10	1.47	1.21–1.80
2:00–2:59	16.5	3.90	0.77	1.31	1.10–1.56	1.36	1.14–1.62	1.24	1.03–1.49
<2:00	53.2	4.02	0.76	1.00	–	1.00	–	1.00	–
Weekday bedtime (hours)									
Before 22:00	3.8	3.84	0.84	1.72	1.31–2.27	1.72	1.30–2.27	1.74	1.31–2.33
22:00–22:59	27.7	4.01	0.76	1.00	–	1.00	–	1.00	–
23:00–23:59	42.1	3.89	0.77	1.28	1.11–1.47	1.21	1.05–1.39	1.09	0.94–1.26
00:00–00:59	19.4	3.69	0.79	2.04	1.74–2.38	1.89	1.61–2.21	1.61	1.37–1.91
01:00–01:59	4.8	3.51	0.80	2.98	2.35–3.77	2.69	2.12–3.41	2.19	1.71–2.81
02:00 or after	2.2	3.29	0.82	4.50	3.23–6.26	3.90	2.79–5.46	2.76	1.93–3.94
Bedtime difference (weekdays and weekends; h)									
<2:00	38.3	3.99	0.78	1.00	–	1.00	–	1.00	–
2:00–2:59	40.4	3.87	0.75	1.19	1.05–1.35	1.17	1.03–1.33	1.13	0.99–1.29
3:00–3:59	13.5	3.71	0.77	1.88	1.60–2.21	1.80	1.53–2.12	1.66	1.40–1.96
≥4:00	7.8	3.37	0.83	3.71	3.09–4.44	3.42	2.85–4.11	2.95	2.44–3.58

GPA, grade point average; SD, standard deviation; CI, confidence interval; OR, odds ratio.
*Adjusted for age, gender, parental education and family affluence.
†Additional adjustment for school non-attendance (official register-based).

and 23:00 hours. Similarly, large discrepancies between the adolescents' bedtime during weekends and weekdays were associated significantly with lower GPA (see Table 1 for details).

Sleep characteristics and poor academic performance

As detailed in Table 1, all sleep variables were associated significantly with increased risk odds of poor academic performance (defined as GPA in the lowest quartile) in a dose–response manner. Adjusting for sociodemographic information (age, gender, parental education and family affluence) did not (or only slightly) attenuate the associations. To examine if the associations could be explained by increased non-attendance at school, an additional adjustment was made for register-based school absence during the last 6 months. As indicated in the last column in Table 1, school non-attendance explained some of the variance; however, all sleep variables also remained significant risk factors for poor academic performance in the fully adjusted analyses.

Gender and age differences

Fig. 1 displays the EMM of the GPAs for boys and girls, by all sleep characteristics. Adjusted for confounders, girls had higher GPA than boys across all categories of sleep variables, and distinct dose–response associations were found for both genders. There were no significant interaction effects of gender and sleep variables, with the exception of gender × bedtime differences between weekdays and weekends ($F_{(4,7357)} = 2.55$, $P = 0.037$).

There were no significant interaction effects of age and any of the sleep variables on GPA (data not shown).

DISCUSSION

In this population-based study of Norwegian adolescents, poor sleep was related to lower academic performance. The associations were in a dose–response manner, and were present for sleep deficit, sleep efficiency, weekday bedtimes, delayed sleep schedule during weekends and sleep duration, with the latter having the highest odds of poor school

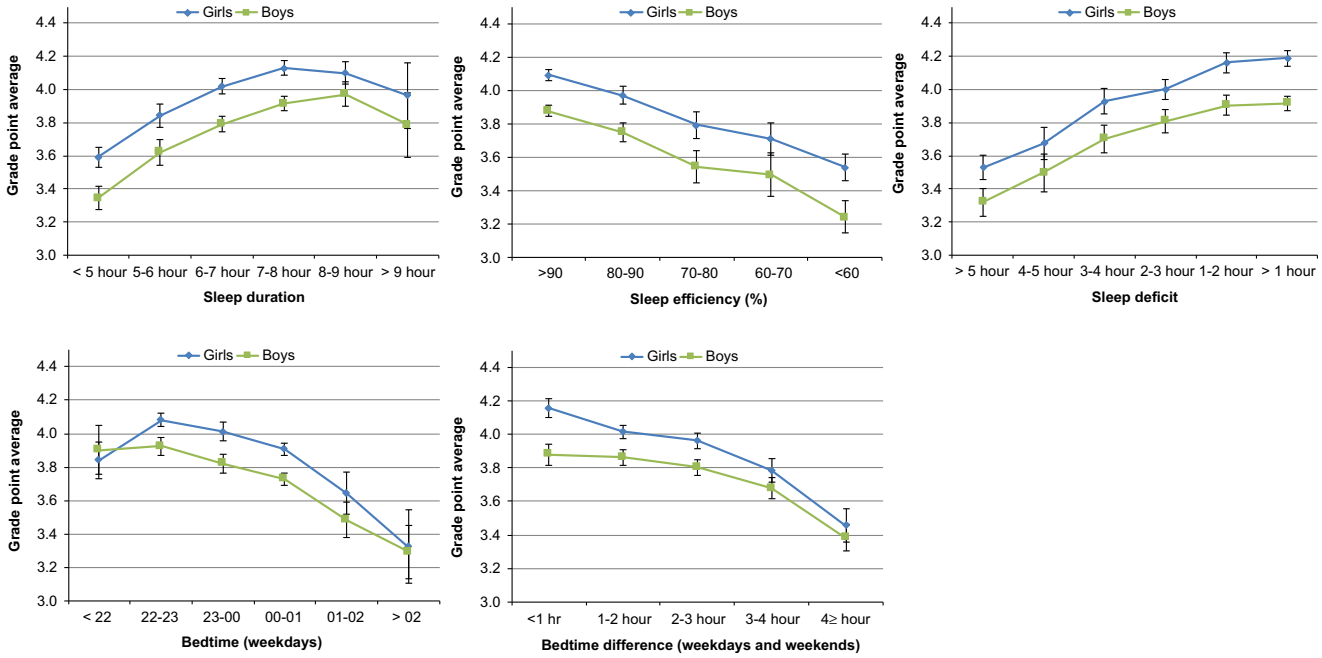

Figure 1. Estimated marginal means (EMM) of grade point average for boys and girls, by sleep characteristics. EMM are adjusted for age, parental education and perceived family affluence. Errors bars represent 95% confidence intervals.

performance as measured by GPA from official registries. Non-attendance at school accounted for some, but not all, the association.

The link between short sleep duration and impaired school performance is in accordance with previous studies in adolescents using subjective reports of academic functioning (Chung and Cheung, 2008; Loessl *et al.*, 2008). It also confirms the results from a small study of 750 Italian adolescents, where sleep complaints were related to academic functioning based on data from school registers (Lazaratou *et al.*, 2005). Most of the previous studies have used samples with a wide age range (Loessl *et al.*, 2008) or have been restricted to sampling from a couple of schools, which restricts generalizability (O'Brien and Mindell, 2005). One exception is the large-scale Hong Kong study, that supports the generalizability of the sleep debt and school functioning association based on self-reported school performance (Mak *et al.*, 2012). The present study confirms the generalizability due to a very large and representative sample, and extends the literature further by employing official register-based academic grades. Interestingly, the association between sleep and academic performance was not gender-specific. This is in contrast to a study conducted in Greece, which found that sleep debt among boys affected academic performance to a larger extent compared to girls' sleep debt (Lazaratou *et al.*, 2005). We do not know for certain why the current study found no gender-specific associations, although one cannot disregard possible methodological explanations, as the current study used a much more comprehensive questionnaire of sleep parameters, as well as objective data on GPA.

Weekday bedtime was associated significantly with GPA, with adolescents going to bed between 22:00 and 23:00 hours having the best GPA (4.0). Note that in Norway a relatively small number of late teens in the 16–19-year age group go to bed before 22:00 hours (3.8%). We also found that the later the bedtime, the lower the GPA. These findings are consistent with a prior study conducted in the United States (Asarnow *et al.*, 2014). It should also be noted that adolescents with a bedtime earlier than 22:00 hours had a lower GPA compared to those going to bed between 22:00 and 23:00 hours. Although we do not have data allowing us to explore this interesting finding further, this small group may, for example, comprise adolescents with somatic health problems. Also notable is that larger discrepancies between the adolescents' bedtime during weekends and weekdays, as well as low sleep efficiency, were associated significantly with lower GPA. Together these findings suggest that earlier bedtimes and encouraging regular bed- and wake-times across the week are likely to be important intervention targets. Indeed, moving bedtimes earlier by 20–30 min per week is a commonly used intervention for delayed sleep phase problems, and regularizing bed- and wake-times are core interventions within stimulus control (Bootzin and Nicassio, 1978).

By controlling for potential confounders, we aimed to identify possible mechanisms which may be involved in the association between poor sleep and poor academic performance. School absence accounted for some of the associations between poor sleep and poor academic functioning. However, there was still a significant association when missed school hours and days were accounted for. This

suggests that other factors besides missed school classes may be present. We expected that the adolescents' family SES might have been a confounder. While family SES in the current study was related negatively to school performance, in line with expectations (Sirin, 2005), controlling for sociodemographics only slightly attenuated the associations. There may also be other confounders that we have not considered in the present study. One example is chronic illness and learning disabilities that could be related to both sleep and academic performance. Mental health problems comprise another possible confounder of this association. While this was beyond the scope of the present study, future research should focus on identifying other possible confounders and pathways by which sleep may be related to academic performance. Finally, it should be noted that girls overall had a significantly higher GPA compared to boys, irrespective of sleep variables. This is also in line with previous research showing that girls have better academic performance in general in this age group.

Strengths and limitations

The present study is based on a broad and detailed assessment of sleep. The measures add to earlier epidemiological studies with the inclusion of SOL and wake-time during the night. When defining what constitutes a 'sleep deficit', we used the respondents' perceived sleep need as the norm. On average, this variable was in accordance with expert recommended sleep duration (Carskadon *et al*., 1980), suggesting that normative sleep data would have given comparable results. A major strength of the study is the use of data from administrative registries on academic performance, reducing the risk of mono-informant bias.

There are limitations that should be noted. Data stem from one county in Norway, and although the distribution of urban and rural areas reflects Norway a whole, the possible limited generalizability must be taken into account. Also, attrition from the study could affect generalizability. In the present study, only adolescents who attended high school (due to the outcome measures being academic grades) were included. Official data show that in 2012, 92% of all adolescents in Norway aged 16–18 attended high school [The Directorate of Integration and Diversity (IMDi), 2012], which would make our actual eligible population an estimated 17 875. Nevertheless, there is a large attrition to the study. In the present study, we conducted representativity analyses on the GPA of the sample, and these indicated that the academic performance was representative for the region and the country as a whole. Based on previous research from the former waves of the Bergen Child Study (the same population as the current study), non-participants have also been shown to have more psychological problems than participants (Stormark *et al*., 2008), and it is therefore likely that the prevalence of mental health problems or, in this case, sleep problems, could be underestimated.

The sleep measure was based on the general pattern of sleep, and the grades are the GPA of the past semester. Thus, stability of the assessed variables is expected, and therefore variations and changes in sleep and consequent impact on changes school achievement may not be inferred from the present study.

The cross-sectional nature of the study does not allow for causal inferences. We cannot exclude the alternative hypothesis that academic performance leads to sleep problems through distress or stress related to poor results, or that late-night studying may be at the expense of sleep (Gillen-O'Neel *et al*., 2013). Secondly, all sleep data were obtained by self-report. Although self-reported sleep parameters, including SOL and WASO, typically differ from those obtained from objective assessments (Lauderdale *et al*., 2008), recent studies have shown that such self-report sleep assessments can be recommended for the characterization of sleep parameters in both clinical and population-based research (Zinkhan *et al*., 2014). Also, the accuracy of self-reported SOL and WASO are generally better among adolescents than in older adults (Dillon *et al*., 2015), and a recent study of young adolescents in Hong Kong found good agreement between actigraphy-measured and questionnaire-reported sleep durations (Kong *et al*., 2011).

CONCLUSION

In summary, the results underscore the importance of sleep for academic functioning. If adolescents are not able to perform according to their own academic potential this may have important short-term consequences for their GPA, but again may give rise to a range of negative adult functional outcomes. Academic performance is an important marker for future work affiliation and health. Future studies should investigate further how the association between sleep and school impacts upon future educational status and work affiliation.

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AUTHOR CONTRIBUTIONS

BS and MH were involved in acquisition of data. BS and MH were responsible for conception and design of the study, conducted the statistical analysis and drafted the manuscript. AH, SL and KG gave critical revision of the manuscript for important intellectual content. BS and MH had full access to all the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis. All authors read and approved the final manuscript.

CONFLICT OF INTEREST

None reported.

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