

# Are adolescents chronically sleep-deprived? An investigation of sleep habits of adolescents in the Southwest of Germany

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## Abstract

**Background** Adolescent sleep receives increasing attention. Several studies have shown that adolescents generally do not sleep enough. This survey assessed adolescents' sleep patterns, and results were compared with sleep logs.

**Methods** A total of 818 students aged 12–18 attending three different school types were asked to complete a questionnaire, adapted from the 'School Sleep Habits Survey', and filled in a sleep protocol over 2 weeks. Information on sleep patterns and demographic data were obtained additionally.

**Results** A total of 601 students completed the questionnaire (i.e. 73.5% return rate), 55.1% female and 44.9% male. Average sleep duration during the week amounted to  $8.04 \pm 0.89$  h and  $9.51 \pm 1.65$  h on weekends. Sleep duration times on school days decreased from an average  $8.64 \pm 0.83$  h for the age category 12–13 years to  $7.83 \pm 0.72$  h for students above 16 years. 91.6% of all students slept less than 9.2 h per night during the week. Data from the 153 returned sleep logs showed even lower sleep times ( $7.75 \pm 0.82$  h for school nights).

**Conclusions** The main hypothesis that students sleep on average considerably less than the recommended 9 h during weekdays was confirmed. Bedtimes changed throughout the week with the latest on Friday and Saturday nights and the least sleep around midweek. There were no significant group differences regarding school type and environment (rural vs. urban). Interestingly, the majority reported only little daytime sleepiness and no impaired performance. Results regarding the consequences of chronic sleep deprivation in the literature are inconclusive. The impact on physiological parameters, especially metabolic functions, requires further investigations.

## Keywords

adolescents, sleep deprivation, sleep habits, sleep logs

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## Introduction

Adolescent sleep has received increasing attention in many countries over the past decade. Both cross-sectional and longitudinal studies have shown that sleep time on weekdays decreases from early to late adolescence while it increases on the weekend in

order to make up for the accumulated sleep loss (Klackenberg 1982; Strauch and Meier 1988; Wolfson and Carskadon 1998; Laberge *et al.* 2001; Giannotti *et al.* 2002; Iglowstein *et al.* 2003; Fredriksen *et al.* 2004; O'Brien & Mindell 2005; Spruyt *et al.* 2005; Yang *et al.* 2005). A cross-sectional survey by Brand and colleagues (2005) in Switzerland and a longitudinal

investigation by Strauch and Meier (1988) in Germany yielded similar results. Although there were some cultural differences in the area of sleep hygiene practices, school starting times and students' work loads the general trend remained the same (Tynjala *et al.* 1993; Ohayon *et al.* 2000; Takemura *et al.* 2002; Gau *et al.* 2004; LeBourgeois *et al.* 2004; Gaina *et al.* 2005; Lazaratou *et al.* 2005; Liu *et al.* 2005; Chen *et al.* 2006).

Results from the most recent surveys in Hungary, Italy and France confirmed the phase delay and reduced amount of sleep on weeknights for older adolescents (Violani *et al.* 2006; Viot-Blanc *et al.* 2006). A Swedish longitudinal study concluded that boys seemed to be sleeping even less than girls (Gillberg *et al.* 2006). Carskadon and colleagues (2006) and Viot-Blanc and colleagues (2006) provided data from a large telephone poll by the National Sleep Foundation. It was conducted throughout the USA and obtained information on sleep habits of 1602 11–17-year-old middle and high school students of various ethnic and socio-economic backgrounds. Again the results confirmed the worrisome trend towards chronic sleep deprivation in the older adolescents. Both Carskadon and colleagues (2006) demonstrated a relationship between insufficient sleep, poor performance, increased daytime sleepiness, reduced exercising and increased absenteeism at school.

An interesting report from Croatia, where students attended school in two shifts – morning or afternoon – showed that students acquire more sleep during the afternoon shifts despite the fact that they are going to sleep later at night (Koscek *et al.* 2006). This ties in with Carskadon (1990) and Carskadon and colleagues (1998), who found that students will not go to bed sooner with earlier school starting times, and that, without any curfews or schedules, adolescents will sleep for an average of 9.2 h, which therefore might be considered the physiologically optimal sleep duration.

Normal sleep is important for the development of children and adolescents (Anstead 2000; Dahl & Lewin 2002). Although inconsistent, evidence suggests that the consequences of sleep deprivation in children and adolescents are likely to manifest across several functional domains (Fallone *et al.* 2002; Fredriksen *et al.* 2004). Teenagers with low or irregular amounts of sleep have more sick days and an increased rate of injuries (Acebo *et al.* 1997). Students with insufficient sleep report decreased self-esteem, increased sleepiness and impaired mood, and exhibit more risk-taking behaviour (Owens 2001; Fallone *et al.* 2002; Fredriksen *et al.* 2004; Brand *et al.* 2005; O'Brien & Mindell 2005). There is a negative association between sleep duration and use of alcohol and tobacco, TV watching and playing video games and doctor's visits, whereas a healthy diet, amount of physical activity, effective stress management and

increased life appreciation correlate positively (Tynjala *et al.* 1993; Chen *et al.* 2006).

The objective of this study was to investigate the relationship between adolescents' sleep habits, the characteristics of students (age, gender, school type, environment) and daytime functioning (school performance) in a representative sample of Southwest Germany, and compare the results from the survey with the sleep logs. The area is typical for central Europe with a mix of urban and rural population from various ethnic backgrounds. In addition, we obtained data on family structure, drug consumption, time spent for hobbies and working and health problems. By surveying all school types we covered the different socio-economic subpopulations.

## Methods

### Subjects, procedure and instruments

The study was designed as a cross-sectional sampling. The targets of the survey were students from German secondary schools in the Southwest of Germany. After 4 years primary school, the German three-stream school system allocates students according to their grades and general performance to (i) a lower secondary school (*Hauptschule*), qualifying after year 9 for vocational school or apprenticeship; (ii) a secondary school (*Realschule*), which continues to year 10 and qualifies for further secondary education or apprenticeship; and (iii) grammar school (*Gymnasium*), finishing at year 13 with a high school certificate (*Abitur*) required for tertiary education.

Sample schools were selected randomly. The survey was conducted during normal class times from June to December 2005 with permission of the local Department of Education. As an incentive for the schools to participate, we gave a 20-min talk on sleep and learning to the students after the questionnaires were filled in. Study subjects below 16 years had to have their consent form signed by a legal guardian. Inclusion criteria were age between 12 and 18 years (grades 7–12) and the ability to understand the aim of the study and the questionnaire. A translated and slightly abbreviated version of the School Sleep Habits Survey (SSHS) (<http://www.sleepforscience.org>) was handed out to all students who agreed to participate. The rural subpopulation was asked to additionally complete a sleep diary over a fortnight, which was adapted from the 'Evening–Morning Protocol' by the German Society for Sleep Medicine. Both tools have been widely used and shown to be reliable and validated in a comparison with actigraph data (Wolfson *et al.* 2003; Gaina *et al.* 2005).

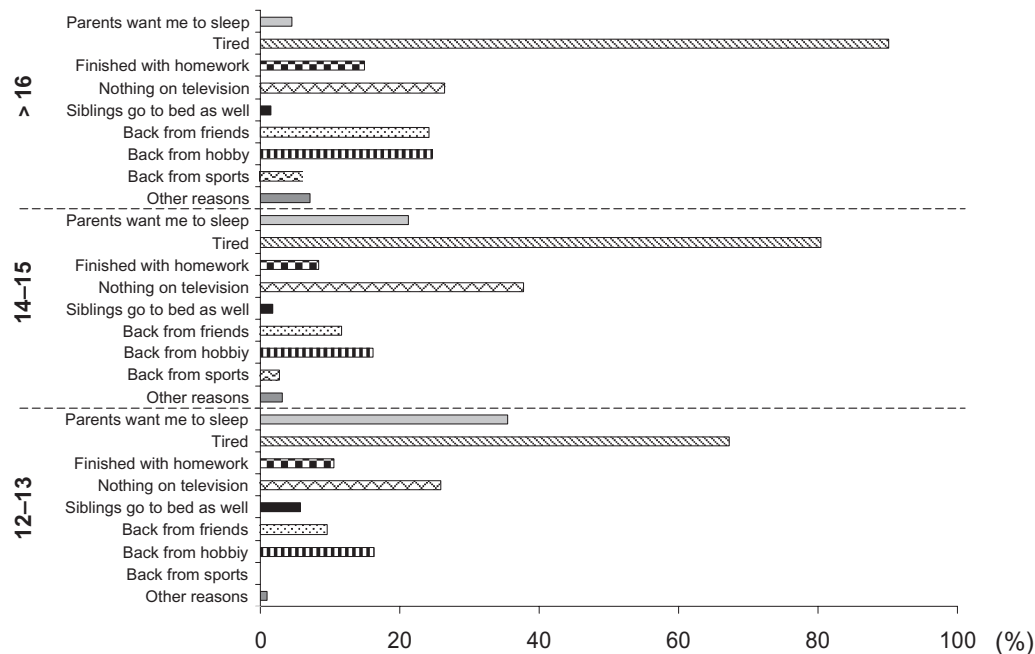


Figure 1. Reasons for going to bed ( $n = 597$ ). Data from questionnaires.

## Data analysis

Statistical analysis was mainly descriptive. Group comparisons were performed through multiple analyses of variance, including *post hoc* tests (Bonferroni). As the data were normally distributed, weekday and weekend sleep durations were compared with a dependent *t*-test. Sleep duration was defined as time in bed, for example, getting-up times minus bed times. The relation of sleep duration and daytime sleepiness and school performance was examined through Pearson's rank correlations.

## Results

### Description of population

Of the potential 881 students 601 (73.5%) agreed to participate and filled in the SSHS; 55.1% were female, 44.9% male, 286 students came from rural schools, 311 attended schools in Freiburg, which is a city of roughly 216 000 inhabitants. Age was normally distributed with a mean of  $15.4 \pm 1.7$  years and a median of 15 years. A total of 113 participants attended lower secondary school, 212 secondary school; and 272 were students at grammar schools. The ethnic background of students differed distinctly with the school types with 52.7% from

non-German backgrounds at the *Hauptschule*, 25.1% and only 14.1% at *Realschule* and *Gymnasium*, respectively.

A tenth of the population had chronic health problems, most of which were allergies, in particular asthma. Around 11% stated to have had treatment for psychiatric problems. 70.2% of the students drank alcohol, 20.2% smoked and 10.4% consumed illegal drugs (note: use could range from 'less than once a month' to 'more than 4 times weekly').

### Sleep duration

Reasons for going to bed changed from early to late adolescence. Although all students named 'being tired' as their main motivation, the younger children were still told by their parents to go to sleep. Watching television also played a major role for all adolescents, as did pursuing hobbies for the over 16-years old (refer to Fig. 1).

Bed times changed significantly with increasing age from  $2152 \pm 0045$  h for the 12-13-year-old children to  $2248 \pm 0042$  h for the 16 plus population ( $P = 0.000$ ) while getting-up times remained nearly the same owing to the early school starting times, which were usually between 0735 and 0750 h. Boys went to bed later on both school and non-school nights while the girls got up earlier during the week (Table 1).

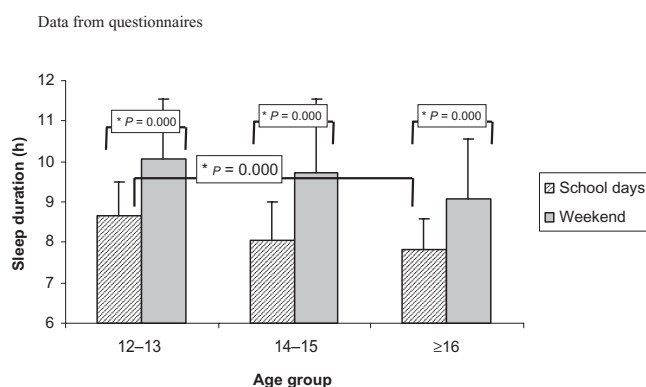
**Table 1.** Bed times and getting-up times during the week and on weekends ( $n = 597$ )

	Bed times (school nights) (Mean $\pm$ standard deviation)			Getting-up times (school days) (Mean $\pm$ standard deviation)		
	Age categories			Age categories		
	12–13	14–15	$\geq 16$	12–13	14–15	$\geq 16$
All	21:52 $\pm$ 0.45	22:33 $\pm$ 0.55	22:48 $\pm$ 0.42	06:31 $\pm$ 0.29	06:35 $\pm$ 0.28	06:38 $\pm$ 0.25
Girls	22:00 $\pm$ 0.40	22:20 $\pm$ 0.44	22:43 $\pm$ 0.43	06:24 $\pm$ 0.24	06:32 $\pm$ 0.25	06:34 $\pm$ 0.25
Boys	21:45 $\pm$ 0.49	22:51 $\pm$ 1.04	22:54 $\pm$ 0.44	06:39 $\pm$ 0.32	06:40 $\pm$ 0.32	06:44 $\pm$ 0.23

	Going-to-bed times (weekend) (Mean $\pm$ standard deviation)			Getting-up times (weekend) (Mean $\pm$ standard deviation)		
	Age categories			Age categories		
	12–13	14–15	$\geq 16$	12–13	14–15	$\geq 16$
All	23:34 $\pm$ 1.11	00:36 $\pm$ 1.35	01:24 $\pm$ 1.31	09:38 $\pm$ 1.23	10:18 $\pm$ 1.51	10:30 $\pm$ 1.35
Girls	23:24 $\pm$ 0.57	00:12 $\pm$ 1.16	01:17 $\pm$ 1.28	09:39 $\pm$ 1.09	10:08 $\pm$ 1.26	10:11 $\pm$ 1.25
Boys	23:47 $\pm$ 1.24	01:07 $\pm$ 1.45	01:34 $\pm$ 1.35	09:37 $\pm$ 1.38	10:32 $\pm$ 2.19	10:51 $\pm$ 1.42

Data from questionnaires.

**Figure 2.** Comparison of sleep duration for age groups ( $n = 587$ ). Data from questionnaires.

The mean for sleep duration on school nights was  $8.04 \pm 0.89$  h, which was significantly lower than on weekends with  $9.51 \pm 1.65$  h ( $P < 0.000$ ). The majority of students (91.6 %) slept less than 9.2 h with 7% even below 7 h. For the 12–13-year olds, sleep times were  $8.64 \pm 0.83$  h during the week and  $10.07 \pm 1.47$  h on the weekend,  $8.03 \pm 0.97$  h and  $9.71 \pm 1.82$  h, respectively for the students from 14 to 15 years of age, and finally for those over 16  $7.83 \pm 0.72$  h and  $9.09 \pm 1.45$  h. Especially, the 12–13-year-old boys slept significantly longer ( $P < 0.001$ ). Both the difference between the age groups and the time of the week, for example, school nights or weekend were significant (see Fig. 2), whereas the difference in sleep duration on weekends was not ( $P = 0.816$ ). There were no differences for sleep duration, going-to-bed and getting-up times between the rural and urban population or among the different school types. Table 2 summarizes the statistical analysis.

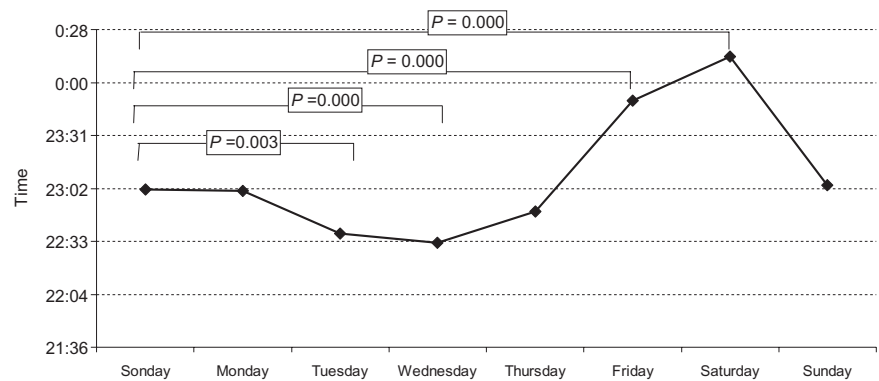
**Table 2.** Group comparisons ( $n = 583$ )

		Mean h (min)	SD h (min)	F value	P value
Age	12–13 years	8.64 (519)	0.83 (50)	13.994	0.000
	14–15 years	8.03 (482)	0.97 (58)		
	$\geq 16$ years	7.83 (470)	0.72 (44)		
Gender	Male	8.03	1.0	4.523	0.034
	Female	8.07	0.8		
Environment	Urban	8.07	0.9	0.058	0.810
	Rural	8.03	0.8		
School types	Hauptschule	8.04	1.0	0.476	0.621
	Realschule	8.24	1.0		
	Gymnasium	7.9	0.7		

Data from questionnaires, calculated by multiple analysis of variance (MANOVA) with *post hoc* tests,  $\alpha = 0.05$ .

### Sleep diary results

Of the 286 rural participants 153 (53.5 %) returned the sleep diaries. Mean sleep duration for the subpopulation was  $7.75 \pm 0.82$  h during the week and  $8.44 \pm 1.46$  h on weekends. Compared with the mean sleep times for the whole rural population of  $8.02 \pm 0.84$  h for school nights and  $9.31 \pm 1.49$  h for weekends, this was significantly shorter ( $P = 0.000$ ). With regards to bed times, students went to bed earlier around midweek and stayed up longest on Saturday nights (refer to Fig. 3). Therefore, sleep duration changed drastically across the week with the lowest values on Thursday night and the longest time in bed from Friday to Saturday.



**Figure 3.** Bed times across the week ( $n = 144$ ). Data from sleep diaries, rural population only.

### Consequences of sleep habits

Only 13.7% of the participants did not feel rested after sleep. 83.4% of the students considered themselves as 'good sleepers' compared with 16.6% 'bad sleepers'. 2.4% of the subjects said that they never woke during the night, 31.6% woke up only once. When asked how much sleep they thought they needed, students stated their subjective sleep requirement to be  $9.22 \pm 1.73$  h. Only 5, 3% of students would prefer to get up before 0745 h. Likewise, 53.4% would pick their bedtimes between 2215 and 0030 h, and 53.9% did not feel tired before 2215 h. With regards to napping, 27.8% never napped, 35.8% occasionally on schooldays, with differences between the age categories: 20% of the 12–13-year-old, 27.7% 14–15-year-old and 48.7% 16-year-old students of the above 35.8% (162) students napped.

We found no significant correlation between sleep duration and grades, and sleep duration and daytime sleepiness for the whole population, although more than 50% of the students stated that they had a 'few problems with daytime sleepiness'. However, for 14–15-year-old students, who slept less than 9 h, a small significant positive correlation of school-night sleep duration and daytime sleepiness was found ( $r = 0.230$ ,  $P = 0.001$ ). There was a weak tendency towards very good performance at school (average grade '1', i.e. the highest) and weekend sleep duration ( $r = 0.094$ ,  $P = 0.025$ ).

Students with alcohol, drug or nicotine consumption slept significantly less on schooldays ( $P = 0.000$  for alcohol and smoking,  $P = 0.002$  for drugs). 61.6% of the study subjects participated in sports activities outside school (team sports, dancing, swimming) and 45.9% had other hobbies (playing an instrument, being a member of youth groups). While sports

did not have an influence on sleep duration, the other activities showed a small negative correlation, for example, the more time spent with hobbies, the shorter the weeknight sleep duration ( $r = 0.151$ ,  $p = 0.013$ ). A third of the students (32.5%) also worked, which had no impact on sleep duration.

### Discussion

Adolescents sleep significantly less than the recommended 9 h, and sleep duration decreases with increasing age. This probably has both physiological and socio-psychological reasons. Relating the results to the reference values and generational trends from the longitudinal investigation by Iglowstein and colleagues (2003), we found that students in our sample had even shorter sleep durations, which might indicate that subsequent generations sleep less than earlier birth cohorts. However, that study did not differentiate between weekday and weekend sleep duration making it somewhat problematic to compare the results with our school-night sleep times. Additionally, the fact that we did not find differences for school types and urban/rural areas suggests physiological reasons for adolescent sleep habits. Carskadon and colleagues (1993) designate pubertal maturation as the major factor for the delayed phase preference in adolescents. Intrinsic regulatory mechanisms obviously change: the homeostatic system does not seem to alter during puberty, but circadian timing in adolescents shows a deferred onset of melatonin secretion resulting in later going-to-bed times.

These biological factors are confounded by psychosocial ones: an increased desire for independence, decreasing parental

control, more social opportunities, enhanced peer pressure, academic responsibilities, jobs and hobbies and the use of electronic devices (computer, mobile phones, etc.) (Carskadon 1990; Ohayon *et al.* 2000; Dahl & Lewin 2002). External constraints, such as parent control over bedtimes or specific cultural sleep practices also have a significant influence (Carskadon 1990; LeBourgeois *et al.* 2004). Parental influence on when their children should go to bed was only relevant in the youngest age group in our sample, while the older students determined their bedtimes more autonomously. There were some slight gender differences. Girls got up earlier during the week, presumably because they need more time for styling. Younger boys slept longer on school nights, which is probably due to their lower pubertal status compared with girls of the same age and was in line with findings from other studies (Carskadon *et al.* 1980; Laberge *et al.* 2001; Fallone *et al.* 2002).

As we defined time in bed as sleep duration, it can be assumed that the actual sleep duration was much lower. We can also deduce that adolescents in general underestimate their sleep duration. This was confirmed through the data from the sleep logs, which verified the survey results, and total sleep times calculated from the diaries were significantly lower than results from the survey – about 15 min less on school nights. As expected, there was a significant difference between week and weekend nights, and the older students slept about an hour less per night compared with the youngest. Students mostly slept through the night and judged their level of performance as ‘good’ to ‘moderate’, which compares with ‘no’ or ‘few problems with daytime sleepiness’ in the questionnaire. This underestimation of the consequences of sleep deprivation has been demonstrated in other studies (Van Dongen *et al.* 2003). Hansen and colleagues (2005) confirmed the accuracy of sleep diaries with actographic data from school nights. We can therefore reason that the sleep duration in our subsample is more realistic than the survey results. Return rate for the sleep diaries was lower than for the questionnaires and required a lot more effort from the study subjects. Consequently, the students, who handed in the diaries, were probably the academically ‘better’ and more conscientious ones. This might mean that sleep duration is even lower than the results from the sleep logs indicate.

It is interesting that in several studies, including our own, students stated their optimal sleep requirement as around 9 h. Obviously, the adolescents were aware that they do not get enough sleep. To compensate for the accumulating sleep debt, they slept longer on weekends and about one-third had a nap during the day. In fact, nearly half of those in the 16 plus age group stated that they nap on schooldays. The students

obviously adapted to the short school nights, seemed to have good quality sleep and, according to their grades in the previous school report, were able to maintain their performance levels during the week.

Sleep laboratory data suggest, that adolescents actually need more sleep than preadolescents, and daytime sleepiness is pronounced throughout the day even after sufficient sleep (Carskadon 1990; Sadeh *et al.* 2000). Both objective and subjective assessments demonstrated that teenagers suffer from sleepiness which impairs higher cognitive functions while routine performance is relatively maintained. There is inconclusive evidence concerning the effect on school grades (Fallone *et al.* 2002; Fredriksen *et al.* 2004; Taras & Potts-Datema 2005; Gibson *et al.* 2006). Our study could not find a connection between school performance and sleep duration. However, this was only based on subjective data and the opposite could well be the case if objective tests for sleepiness were to be applied. Smoking, alcohol and drug consumption were all related to less school-night sleep in our study sample, whereas out-of-school activities had little or no impact. The students seemed to be honest in answering these questions, probably because they were assured several times that the data would be kept strictly confidential.

In retrospect, some additional information on particular topics would have been interesting: travel times to school, time of out-of-school activities (i.e. late afternoon, evening, etc.), caffeine consumption and questions pertaining to the emotional status including any necessity for treatment. Also, students from the *Hauptschulen* were underrepresented due to the fact that recruitment there was difficult as many students refused participation and return rates were sometimes as low as 24%. Statistically, we accounted for that fact by using a multiple variance analysis.

This paper supports findings from various studies in other countries. Chronic sleep deprivation in adolescents is obviously a global problem: they do not sleep enough and the recommended 9 h of sleep are probably an unrealistic goal to achieve. The results regarding the consequences of chronic sleep deprivation in the literature are inconclusive. To some extent, the adolescents seem to have adapted to having short nights during school periods. They obviously compensate well enough to keep up a certain level of performance. Parents and other caregivers, health professionals and teachers need to be aware of these facts and should be educated on adolescent sleep patterns if necessary. When promoting a healthy lifestyle and school schedules that enable students to perform well and to reach their potential, adolescent sleep patterns, too, need to be considered.



### Key messages

- Over 90% of secondary school students sleep less than 9 h per night during the week.
- Students obviously compensate the accumulated sleep debt on weekends, but how well and how long can they do this?
- How and to what extent does daytime sleepiness affect the students' cognitive and emotional capacities?
- Teenagers might benefit from the inclusion of sleep topics in health education. Parents together with their children could develop a mutually satisfying sleep hygiene programme, for example, setting of bed times during the week, removing electronic devices from the bedrooms, providing the opportunity for catching-up on sleep on the weekends.
- The issue of sleep deprivation is also a political one, as school starting times, duration of commuting to school and back and school schedules have an impact on sleep duration, student performance and daytime sleepiness.

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