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Sleep duration, positive attitude toward life, and academic achievement: The role of daytime tiredness, behavioral persistence, and school start times

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A B S T R A C T

Sleep timing undergoes profound changes during adolescence, often resulting in inadequate sleep duration. The present study examines the relationship of sleep duration with positive attitude toward life and academic achievement in a sample of 2716 adolescents in Switzerland (mean age: 15.4 years, SD = 0.8), and whether this relationship is mediated by increased daytime tiredness and lower self-discipline/behavioral persistence. Further, we address the question whether adolescents who start school modestly later (20 min; $n = 343$) receive more sleep and report better functioning.

Sleeping less than an average of 8 h per night was related to more tiredness, inferior behavioral persistence, less positive attitude toward life, and lower school grades, as compared to longer sleep duration. Daytime tiredness and behavioral persistence mediated the relationship between short sleep duration and positive attitude toward life and school grades. Students who started school 20 min later received reliably more sleep and reported less tiredness.

During adolescence, bedtime shifts to later in the evening, due to both biological maturation and environmental factors such as decreased parental influence on children's bedtimes, an increase in academic obligations and workload, and social activities (Carskadon, Acebo, & Jenni, 2004; Crowley, Acebo, & Carskadon, 2007). Despite going to bed later, adolescents are usually required to wake up just as early or even earlier than they did during mid- and late childhood, due to early school start times, resulting in sleep deprivation in most adolescents (National Sleep Foundation, 2006).

Insufficient sleep during adolescence is associated with a host of negative outcomes, including emotional, cognitive, and behavioral problems (Fallone, Owens, & Deane, 2002; Fredriksen, Rhodes, Reddy, & Way, 2004; O'Brien & Mindell, 2005). In a recent study on more than 15,000 adolescents, later bedtimes were related to a higher risk of depression and suicidal ideation (Gangwisch et al., 2010). Further, sufficient sleep is important for learning and cognitive performance, which is particularly relevant for adolescents striving to meet academic demands at school. Experimentally induced sleep restriction/deprivation impairs verbal processing and abstract reasoning of children and adolescents (Randazzo, Muehlbach, Schweitzer, & Walsh, 1998) and school-based surveys indicate that adolescents who sleep less than others achieve lower school grades (Chung & Cheung, 2008; Dewald, Meijer, Oort, Kerkhof, & Bogels, 2010; Wolfson & Carskadon, 2003).

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One possible mediator of the effect of short sleep is excessive daytime tiredness, which is a frequent condition in adolescence (Fallone et al., 2002). Higher levels of daytime tiredness are associated with short sleep duration (O'Brien & Mindell, 2005), compromised well-being (Brand, Gerber, Beck, et al., 2010), and lower academic achievement (Chung & Cheung, 2008; Dewald et al., 2010). A further possible pathway through which short sleep and daytime tiredness affect well-being and academic performance is via students' diminished ability to persist in achieving goals and to engage efficiently on school work. Behavioral persistence and self-discipline have been shown to play an important role in academic performance (Andersson & Bergman, 2011; Duckworth & Seligman, 2005; Fortier, Vallerand, & Guay, 1995; Tangney, Baumeister, & Boone, 2004). Dweck (1986) differentiated between individuals with mastery goals and individuals with performance goals. Individuals with mastery goals believe that their abilities are malleable and therefore seek challenges and show high persistence to improve their skills. By contrast, individuals with performance goals believe that their abilities are fixed traits. Thus, their motivation is not oriented toward improving skills but directly toward gaining positive and avoiding negative judgments. They therefore avoid challenges and show low persistence when facing obstacles. Independent of intellectual ability, individuals with mastery goals learn new tasks easier and display higher achievement in the end, when compared to individuals with performance goals (Dupeyrat & Mariné, 2005). Beyond the impact on academic achievement, behavioral persistence can be important for general well-being, as it aids adolescents in exercising regularly, eating a healthy diet (Gillison, Standage, & Skevington, 2011; Wills, Isasi, Mendoza, & Ainette, 2007), and refraining from risky or problematic behaviors such as substance use, early sexual behavior, and delinquency (Cooper, Wood, Orcutt, & Albino, 2003).

While both sleep duration and behavioral persistence are important for well-being and achievement, few studies examine the relationship of short sleep and tiredness with behavioral persistence. One study found that a delayed sleep schedule was correlated with low self-control, a tendency to postpone tasks, and poor time management (Digdon & Howell, 2008), which can be considered indicators of behavioral persistence. Additionally, better-rested children tend to report higher achievement motivation, indicating a relationship between daytime tiredness and motivation (Meijer, Habekothé, & Van den Wittenboer, 2000).

The first aim of the present study was to examine the association of sleep duration with well-being and academic achievement. Based on recommendations for adolescent sleep made by the National Sleep Foundation, a sleep duration of less than 8 h is considered as insufficient. In comparison, borderline sufficient sleep duration is 8–8:59 h for this age, and an optimal sleep duration is considered to be 9 h or more (National Sleep Foundation, 2006).

The second aim of the study was to examine the potentially mediating roles of daytime tiredness and behavioral persistence in the relationship of sleep duration with well-being and academic achievement. We expected shorter sleep duration to be associated with more daytime tiredness, which in turn was expected to be associated with lower levels of behavioral persistence. Finally, we expected more daytime tiredness and lower behavioral persistence to be associated with compromised well-being and impaired academic achievement.

The third aim of the study was to examine the role of school start times taking advantage of the variation in school start times between the schools that participated on the study. Specifically, we compared sleep duration, daytime tiredness, behavioral persistence, and well-being of students at a school with modestly delayed start time (i.e., 8:00 am) with students at the five other schools that started 20 min earlier (i.e., at 7:40 am). There is evidence that later school start times are associated with longer sleep duration as well as improved health and well-being of adolescents (Owens, Belon, & Moss, 2010; Wahlstrom, 2002; Wolfson, Spaulding, Dandrow, & Baroni, 2007). Delay of school start times by 1 h or more has been shown to result in an extension of sleep time on school nights, less daytime sleepiness, depressive symptoms, and tardiness due to oversleeping (Wahlstrom, 2002; Wolfson et al., 2007). Despite these favorable findings, delaying school start times by 1 h or more can also raise opposition from local communities due to effects on family life and has thus not been widely introduced (Eliasson, Eliasson, King, Gould, & Eliasson, 2002; Wahlstrom, 2010). On the other hand, knowledge on effects of more modest delays of school start times is limited. An exception is a recent intervention study that found that a modest delay of school start time by 30 min resulted in increased sleep duration, less daytime sleepiness and improved alertness, mood and health (Owens et al., 2010). We compare sleep duration, daytime tiredness, behavioral persistence, and well-being of students at the school that starts modestly delayed (i.e., 20 min later) with students at the early starting schools.

In general, it is well-known that children and adolescents from families of lower socio-economic status (SES) and/or immigration status are at increased risk for mental health problems, poor school achievement, as well as poor sleep (Buckhalt, 2011; Vazsonyi, Trejos-Castillo, & Huang, 2006). Moreover, it has been argued that the role of insufficient sleep for adolescent's health, well-being, and school achievement is amplified by low SES of their families (Buckhalt, 2011). For the present work we studied lower track secondary school students in northwestern Switzerland with a large proportion of students of immigration status who are generally of lower socio-economic status (Swiss Federal Office of Statistics, 2011) than adolescents of higher track secondary schools or adolescents from the host country.

Method

Procedure

Participants were recruited from 8th and 9th grade classes of all six lower track secondary schools of a mid-size city in northwestern Switzerland, which were located in close proximity (i.e., the maximum distance between the most distant schools was 2 miles). Lower track secondary school qualifies for vocational training. The students were informed of the

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purpose of the study and provided consent to participation. The study was carried out in the spring of 2010 and 2011 in accordance to the ethical standards required by the University of Basel and by the Ethics Committee of both Cantons of Basel, which are laid down in the Declaration of Helsinki (World Medical Association, 2011).

Participants completed an online questionnaire during regular school classes while being supervised by an informatics teacher. The questionnaire assessed sleep habits, daytime tiredness, behavioral persistence, and attitude toward life along with school climate and satisfaction with various aspects of the school. Additionally, school grades in mathematics and German language were obtained from the school database and were linked with the questionnaire data.

Participants

Of 3323 students attending six lower track secondary schools (i.e., $n = 1686$ students during year 2010 and $n = 1637$ during year 2011), 2716 (81.7%) agreed to participate and were included in the present study. Six hundred and seven students were not included because they did not complete the questionnaire or because school grades could not be linked to the questionnaire data. Among the included students, 1397 (51.4%) were male and they were between 13; 5 and 18; 7 years old, with a mean age of 15; 5 years (SD = 0; 10 years). 1431 students (52.7%) were in the 8th grade and 1285 students (47.3%) were in 9th grade. Approximately two thirds of the sample (65.4%) indicated a different language than German or Swiss German as their native language. There was a high number of students ($n = 1140$, 42.0%) with a native language from the immigration regions of Turkey (Turkish or Kurdish: $n = 473$), former Yugoslavia (Serbian, Croatian, Bosnian, or Albanian: $n = 552$), and Portugal (Portuguese: $n = 115$), who are on average from families of lower socio-economic status than the average Swiss family, or immigrant families from Germany or France (Swiss Federal Office of Statistics, 2011). It is noteworthy that a large number of adolescents with immigration status is common in lower track secondary schools in Swiss cities. Most of the participants ($n = 2650$; 97.6%) were attending general public school where a high level of German language skills is required. They were therefore expected to possess sufficient German language skills to understand the questions presented in the questionnaire. A small minority of 66 students (2.4%) were allocated in a special foreign language class for students with insufficient German skills where learning German is one of the main goals. We assume that teachers supported these students when they needed help in completing the questionnaire.

Measures

Sleep habits

To assess sleep habits, students were asked to indicate their usual bedtime and rise time on school days and weekends. The six answer categories for school night bedtime were 'before 9:30 pm', '9:30–9:59 pm', '10–10:29 pm', '10:30–10:59 pm', '11–11:29 pm' and 'after 11:30 pm'. The answer categories for rise time on school days were 'before 6 am', '6–6:29 am', '6:30–6:59 am' and '7 am or later'. Usual weekend bedtime and rise time were assessed with six answer categories, which were 'before 10 pm', '10–10:59 pm', '11–11:59 pm', '0–0:59 am', '1–2 am' and 'after 2 am' for bedtime and 'before 8 am', '8–8:59 am', '9–9:59 am', '10–10:59 am', '11–12 am' and 'after 12 pm' for rise time. To estimate sleep duration the mean point of each answer category was used and the difference between bedtime and rise time was taken (e.g., bedtime '10–10:29 pm' and rise time '6–6:29 am' resulted in the difference between 10:15 pm and 6:15 am, which is an estimated sleep duration of 8 h). The average total sleep duration was calculated as the weighted average of school night and weekend sleep duration, using the formula: $[(5 \times \text{school night sleep duration}) + (2 \times \text{weekend sleep duration})]/7$.

Daytime tiredness

Daytime tiredness was measured with two items (e.g., "At school I am often so tired that I almost fall asleep") using a 6-point scale ranging from 1 (don't agree at all) to 6 (completely agree; Cronbach's alpha = 0.80). Higher mean scores reflect higher levels of daytime tiredness.

Behavioral persistence

Behavioral persistence was measured with four items (e.g., "I often quit when I am facing the first difficulty") from a questionnaire designed to measure volitional control of students (Fend & Prester, 1986), using a 6-point scale ranging from 1 (don't agree at all) to 6 (completely agree; Cronbach's alpha = 0.72). The scale was coded such that higher mean scores reflect higher behavioral persistence.

Positive attitude toward life

Positive attitude toward life was measured with two items (e.g., "I am satisfied with how my life plans are getting fulfilled") from the Berne Questionnaire on Adolescent Subjective Well-being (Grob, Little, Wanner, Wearing, & EURONET, 1996), using a 6-point scale ranging from 1 (don't agree at all) to 6 (completely agree; Cronbach's alpha = 0.78).

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School grades

After completion of the term, schools provided final school grades for mathematics and German language from the school database, which were then matched with the questionnaire data. Swiss school grades range from 1 (lowest) to 6 (highest). Grades <4 are considered failing grades, while grades of 4–6 are considered satisfactory to excellent.

Statistical analysis

We performed analysis of covariance (ANCOVA) and planned contrasts to compare the variables of interest between students sleeping less than 8 h, 8–8:59 h and 9 h or more, as well as between students from early starting schools and from late starting schools. Analyses were conducted separately for males and females controlling for age and native language. Effect sizes were calculated following Cohen (1988), with $d = 0.20$ indicating small, $d = 0.50$ indicating medium, and $d = 0.80$ indicating large effect sizes. The role of daytime tiredness and behavioral persistence in mediating the association of sleep duration with well-being and academic achievement was tested using structural equation modeling (SEM) in AMOS 20 (Arbuckle & Wothke, 1999). Total sleep duration was entered as an observed variable, while daytime tiredness, behavioral persistence positive attitude toward life, and academic achievement were entered as latent variables with two indicators each. The indicators of behavioral persistence were formed by parceling two items together per indicator; the indicators of the latent construct of academic achievement were the Mathematics and Language (German) school grades; the indicators for daytime tiredness and positive attitude toward life were the items of these scales. Structural equation modeling was conducted applying the multi-group approach specifying separate models for males and females, which constrained factor loadings of latent constructs equal across gender. A model with path coefficients constrained to be invariant was compared to a model with the path coefficients allowed to be unequal across groups by using χ2-difference test. Further, to ascertain robustness of the findings across grade levels and assessment waves, models for 8th ($n = 1431$) and 9th grade students ($n = 1285$), were compared as well as models for students assessed in spring 2010 ($n = 1308$) and 2011 ($n = 1408$). To evaluate the goodness of fit, the comparative fit index (CFI; >0.95 indicates a good fit (McDonald & Ho, 2002)) and the root-mean square error of approximation (RMSEA; <0.05 indicates an excellent fit (Browne & Cudeck, 1989)) were considered.

Results

Descriptive statistics

On average, participants' sleep duration was 8:36 h (SD = 0:48 h), the average estimated bedtime on school nights was 10:29 pm, and the average estimated rise time on school days was 6:29 am. On weekends, average estimated bedtime and rise time were considerably later (00:48 am and 10:46 am, respectively). In Table 1, means and standard deviations of the study variables are shown separately for male and female students. Compared to males, female students reported earlier bed- and rise times on school days and earlier bedtimes on weekends. They were higher in daytime tiredness, lower in behavioral persistence, and had better grades in German language, but they achieved worse grades in math. No gender difference was found regarding positive attitude toward life.

Table 2 shows the results of the analysis of covariance and planned contrasts, comparing daytime tiredness, behavioral persistence, positive attitude toward life, and academic achievement of students sleeping less than 8 h, between 8 and 8:59 h, as well as 9 h or more. Male and female students sleeping less than 8 h were more tired than their counterparts sleeping 8–8:59 h, who in turn were more tired than those sleeping 9 h or more. Behavioral persistence and positive attitude toward life were higher in male and female students who sleep 8 h or more than among those who sleep less than 8 h. However, there was no difference in behavioral persistence and positive attitude toward life between those sleeping 8–8:59 h and the ones sleeping more than 9 h. Finally, male and female students sleeping less than 8 h had lower Mathematics and German grades than their counterparts sleeping more. No significant advantage in school grades could be found in students sleeping more than 9 h compared to those in the intermediate category sleeping 8–8:59 h. Effect sizes (Cohen's d) of the comparisons of longer sleep duration with the group with a sleep duration below 8 h were small to medium with regard to daytime tiredness ($d = 0.33$–0.50), small with regard to behavioral persistence ($d = 0.17$–0.28) and positive attitude toward life ($d = 0.20$–0.36), and very small for school grades ($d = 0.07$–0.22).

Table 3 presents means and standard deviations for sleep variables, daytime tiredness, and behavioral persistence, and positive attitude toward life comparing students from early and late starting schools separately for males and females. Students attending the school with a later school start time reported a school night sleep duration that was on average 16 min longer than that of students attending the earlier starting schools. The increase in sleep duration on school nights was entirely due to differences in rise times on school days: students at the later starting school got up 27 min later than students at the earlier starting schools; while bedtime on school nights were only 11 min later. The effects of school start time on weekday sleep duration were remarkably similar across males and females. Weekend sleep duration, bedtimes, and rise times were not different between early and late starting students. Further, students from early starting schools reported significantly more daytime tiredness than students from late starting schools. No differences were found for behavioral persistence and positive attitude toward life.

Fig. 1 presents structural equation models that were used to test whether the relation of sleep duration with positive attitude toward life and academic achievement was mediated by daytime tiredness and behavioral persistence. The fit for

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Table 1
Descriptive statistics.

	Male ($N = 1397$)		Female ($N = 1319$)		p
	Mean N	*SD %*	*Mean N*	*SD %*	
Age (years)	15.49	0.83	15.39	0.78	0.002
Native language (% German)	471	33.7	470	35.6	0.29
Academic achievement					
Mathematics grade	4.27	0.87	4.08	0.86	<0.001
German grade	4.29	0.68	4.48	0.62	<0.001
Total sleep duration (h)	8.56	0.77	8.56	0.80	0.87
Sleep duration school nights (h)	8.08	0.81	7.93	0.85	<0.001
Bedtime school nights	10:35 pm	45 min	10:23 pm	44 min	<0.001
Before 9.30 pm	55	3.9	97	7.4	<0.001
9.30–9.59 pm	225	16.1	287	21.8	
10.00–10.29 pm	446	31.9	428	32.4	
10.30–10.59 pm	295	21.1	259	19.6	
11.00–11.29 pm	199	14.2	158	12.0	
After 11.30 pm	177	12.7	90	6.8	
Rise time school days	6:40 am	30 min	6:19 am	31 min	<0.001
Before 6.00 am	78	5.6	264	20.0	<0.001
6.00–6.29 am	398	28.5	606	45.9	
6.30–6.59 am	681	48.7	375	28.4	
7.00 am or later	240	17.2	74	5.6	
Sleep duration weekends (h)	9.79	1.33	10.15	1.29	<0.001
Bedtime weekends	1:00 am	1 h 19 min	0:36 am	1 h 20 min	<0.001
Before 10.00 pm	17	1.2	29	2.2	<0.001
10.00–10.59 pm	90	6.4	136	10.3	
11.00–11.59 pm	256	18.3	293	22.2	
0.00–0.59 am	258	18.5	301	22.8	
1.00–2.00 am	368	26.3	337	25.5	
After 2.00 am	408	29.2	223	16.9	
Rise time weekends	10:47 am	1 h 19 min	10:45 am	1 h 12 min	0.42
Before 8.00 am	40	2.9	25	1.9	0.002
8.00–8.59 am	103	7.4	87	6.6	
9.00–9.59 am	224	16.0	225	17.1	
10.00–10.59 am	369	26.4	384	29.1	
11.00–12.00 am	375	26.8	399	30.3	
After 12.00 am	286	20.5	199	15.1	
Daytime tiredness	3.27	1.49	3.56	1.39	<0.001
Behavioral persistence	3.73	1.00	3.59	1.03	<0.001
Positive attitude toward life	4.72	1.05	4.76	0.98	0.23

models with factor loadings constrained to be invariant across gender was good ($\chi^2(60) = 145.2$, $p < .001$, CFI = 0.986, RMSEA = 0.023). The models revealed that short sleep was related to more daytime tiredness, which in turn was related to lower behavioral persistence. More daytime tiredness and lower behavioral persistence were predictive of less positive attitude toward life. Moreover, behavioral persistence was a moderately strong predictor of academic achievement. To a modest degree, short sleep duration also directly predicted less positive attitude toward life. A χ^2-difference test revealed that the relation between daytime tiredness and behavioral persistence was stronger for female students than for males, as

Table 2
Association between sleep duration and academic achievement, daytime tiredness, behavioral persistence, and attitude toward life.

	Total sleep duration						Contrasts					
	<8 h		8–8:59 h		≥9 h		<8 h *vs.* 8–8:59 h		<8 h *vs.* ≥9 h		8–8:59 h *vs.* ≥9 h	
	Mean	*SE*	*Mean*	*SE*	*Mean*	*SE*	*d*	*p*	*d*	*p*	*d*	*p*
Math	4.16	0.05	4.32	0.03	4.27	0.04	0.19	0.007	0.15	0.009	−0.05	0.40
	3.99	0.05	4.08	0.03	4.16	0.05	0.12	0.15	0.22	0.01	0.11	0.15
German	4.24	0.04	4.33	0.03	4.27	0.03	0.15	0.04	0.07	0.52	−0.08	0.15
	4.44	0.04	4.52	0.02	4.46	0.03	0.16	0.04	0.08	0.64	−0.08	0.11
Daytime tiredness	3.69	0.08	3.20	0.06	3.04	0.07	−0.33	<0.001	−0.44	<0.001	−0.12	0.07
	3.98	0.08	3.51	0.05	3.30	0.07	−0.35	<0.001	−0.50	<0.001	−0.15	0.02
Behavioral persistence	3.58	0.06	3.80	0.04	3.74	0.05	0.23	0.001	0.17	0.04	−0.05	0.36
	3.39	0.06	3.63	0.04	3.70	0.05	0.23	0.001	0.28	<0.001	0.07	0.28
Positive attitude toward life	4.53	0.06	4.75	0.04	4.80	0.05	0.20	0.002	0.26	0.001	0.06	0.43
	4.53	0.06	4.81	0.04	4.88	0.05	0.27	<0.001	0.36	<0.001	0.09	0.23

Note. Upper values are for males (<8 h: $n = 316$; 8–8:59 h: $n = 684$; ≥9 h: $n = 397$), lower values for females (<8 h: $n = 313$; 8–8:59 h: $n = 631$; ≥9 h: $n = 375$). Math = Mathematics grade; German = German grade (higher values indicate better grades). All values are adjusted for age and native language.

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Table 3
Sleep duration, bed and rise times, daytime tiredness, behavioral persistence, and attitude toward life in early and late starting schools.

	Early school start time $n = 2373$		Late school start time $n = 343$		*d*	*P*
	Mean	*SD*	*Mean*	*SD*		
Total sleep duration (h)	8.54	0.77	8.76	0.75	0.29	<0.001
	8.55	0.80	8.66	0.78	0.15	0.09
Sleep duration school nights (h)	8.04	0.80	8.32	0.86	0.34	<0.001
	7.90	0.85	8.14	0.89	0.27	0.001
Bedtime school nights	10:34 pm	45 min	10:41 pm	46 min	0.16	0.04
	10:22 pm	43 min	10:37 pm	46 min	0.35	<0.001
Rise time school days	6:37 am	28 min	7:01 am	32 min	0.80	<0.001
	6:15 am	27 min	6:45 am	35 min	0.93	<0.001
Sleep duration weekends	9.77	1.36	9.86	1.14	0.06	0.44
	10.17	1.30	9.98	1.21	−0.15	0.08
Bedtime weekends	0:59 am	1 h 19 min	1:08 am	1 h 16 min	0.13	0.11
	0:34 am	1 h 20 min	0:50 am	1 h 14 min	0.21	0.02
Rise time weekends	10:45 am	1 h 19 min	10:59 am	1 h 14 min	0.19	0.02
	10:44 am	1 h 12 min	10:49 am	1 h 13 min	0.07	0.43
Daytime tiredness	3.32	1.49	2.92	1.40	−0.28	<0.001
	3.59	1.40	3.33	1.34	−0.19	0.03
Behavioral persistence	3.73	1.01	3.71	0.91	−0.03	0.74
	3.60	1.04	3.54	0.95	−0.07	0.46
Positive attitude toward life	4.71	1.07	4.73	0.97	0.02	0.80
	4.77	0.98	4.69	0.97	−0.09	0.30

Note. Upper values are for males (early school start time: $n = 1208$; late school start time: $n = 189$), lower values for females (early school start time: $n = 1165$; late school start time: $n = 154$). *P*-values adjusted for age and native language.

was the relation between behavioral persistence and positive attitude toward life (both $p < .05$). Apart from these differences, the models were remarkably similar across gender. Further multi-group comparisons showed that the models were robust across students of the 8th and the 9th grade ($\chi^2(7) = 2.8$, $p = .91$) as well as across assessment waves in spring 2010 and spring 2011 ($\chi^2(7) = 4.7$, $p = .69$) implying similarity of findings across grade levels and year of assessment. In sum, the models revealed an effect of short sleep on positive attitude toward life that was partly mediated by daytime tiredness and behavioral persistence and an effect of sleep duration on academic achievement that was fully mediated.

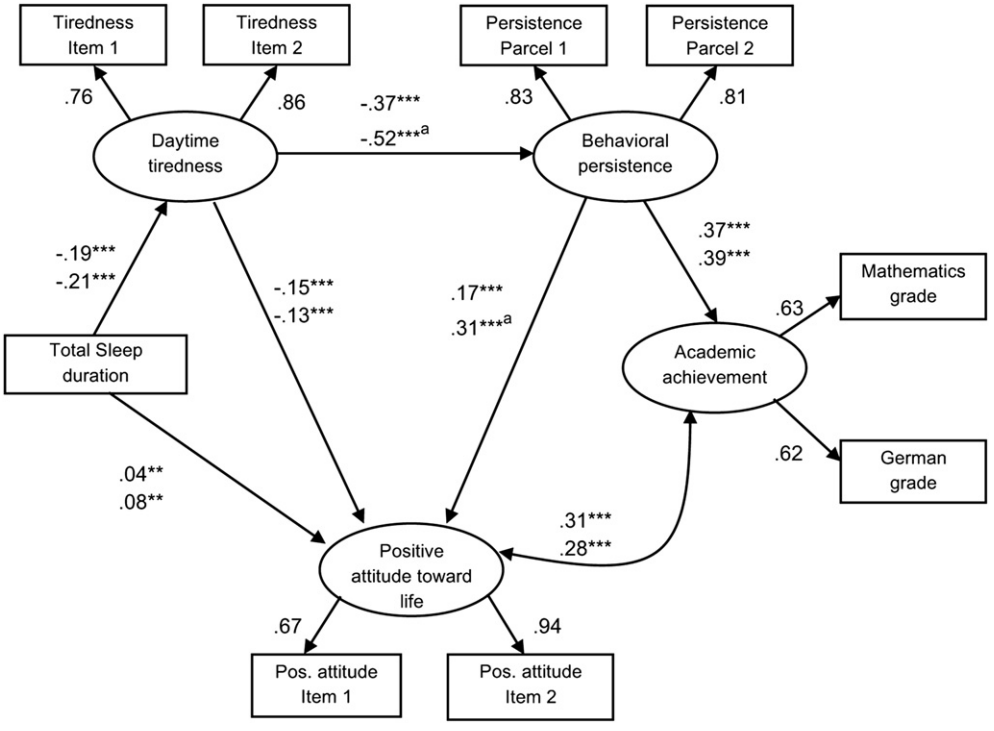

Fig. 1. Prediction of positive attitude toward life and academic achievement by sleep duration, daytime tiredness, and behavioral persistence: Structural equation model ($\chi^2(60) = 145.2$, $p < .001$, CFI = 0.986, RMSEA = 0.023). Upper path coefficients are for males ($n = 1397$), lower path coefficients are for females ($n = 1319$). Factor loadings were set equal across males and females. The models adjust for participants' age and native language (coefficients not presented). Non-significant path coefficients were omitted. ***$p < .001$. **$p < .01$. *$p < .05$. [a] coefficients are different between males and females.

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Discussion

We found that students with an insufficient sleep duration of less than 8 h showed more daytime tiredness, less behavioral persistence, less positive attitude toward life, and had lower school grades in mathematics and German language, in comparison to their counterparts who sleep longer. Thus, our findings are consistent with existing evidence that insufficient sleep during adolescence is associated with behavioral and emotional difficulties (Fallone et al., 2002; Fredriksen et al., 2004; O'Brien & Mindell, 2005) and poor performance at school (Chung & Cheung, 2008; Dewald et al., 2010; Wolfson & Carskadon, 2003). Further, our findings extend previous knowledge by showing that the relationship of sleep duration with positive attitude toward life and school grades was partly mediated by daytime tiredness and behavioral persistence. Finally, the results indicated that students in a school that started 20 min later than the other schools, reported getting 16 min more sleep on school nights, which was also associated with less tiredness during the day. This finding is in line with a recent study showing that a delay in school start time by half an hour resulted in longer sleep on school nights among adolescents due to later rise up times in the morning (Owens et al., 2010). However, behavioral persistence and positive attitude toward life were not affected by later school start times in the present study.

Our findings point to the importance of sufficient night time sleep for feeling well-rested, possessing high levels of behavioral persistence, experiencing positive well-being, and achieving good school grades. Effect sizes were in the small to moderate range, and match effect sizes of sleep duration reported in the literature (Dewald et al., 2010). While there was on average a reliable disadvantage for students sleeping less than 8 h, we, however, did not find strong support for differences between students who sleep in the borderline sufficient range (8–8:59 h) and students sleeping 9 h or more, regarding behavioral persistence, positive attitude toward life, and school grades.

Based on these findings, we suggest recommending that families strive to attain a sleep duration of at least 8 h for adolescents. Furthermore, a short delay of school start times by 20 min may already have ascertainable and relevant effects on adolescents' sleep duration and daytime tiredness, although 20 min appears too short to produce noticeable effects on behavioral persistence, positive attitude toward life, and school grades. While changing school start times by 1 h might probably have stronger positive effects, it may also imply substantial logistic considerations at the community level and an impact on family life. By contrast, a 20-min delay in school start time might keep these difficulties at a minimum while still resulting in positive effects for adolescent students.

The present study had several limitations that could be addressed in future work. First, the cross-sectional design did not allow for conclusions to be drawn regarding the development of, and causal relations among, the studied variables. While it was possible to compare schools with different start times in the present study, an experimental design studying the effect of a delay in school start times in pre-to-post comparison and in comparison with a control group would have allowed for a causal interpretation of the findings, and should be an area for future research. Further, although all six schools were located in close proximity to one another, and our analyses controlled for age, gender, and native language, it is still possible that the students from the schools with different start times differed on other variables that we did not assess. Second, we estimated sleep duration from reported usual bed- and rise times on school days and weekends. Thus, sleep onset latency (i.e., the time it takes to fall asleep after bedtime) was not taken into consideration in estimation of sleep duration. On the other hand, calculated sleep duration from usual bedtime and rise time is considered to be more accurate than self-reported sleep duration in hours and minutes, which tends to be underestimated by adolescents (Loessl et al., 2008). Although there is evidence that sleep data from sleep logs and questionnaires do fit well with objective data (cf. Brand, Gerber, Hatzinger, et al., 2010; Werner, Molinari, Guyer, & Jenni, 2008) assessment of sleep via actigraphy or sleep-EEG probably would have revealed results of higher validity. Third, we did not assess sleep difficulties. From other studies, it is known that sleep difficulties may have an impact on adolescents' well-being and functioning at school (Dewald et al., 2010; Meijer et al., 2000). Moreover, we did not assess use of substances, such as smoking, drinking alcohol, and caffeine consumption, which can also interfere with the ability to fall asleep and sleep quality. As a strength of the study, a majority of all lower track secondary school students of the region with a large proportion of students of immigration status and low SES (Swiss Federal Office of Statistics, 2011), considered at increased risk for mental health and school problems (Vazsonyi et al., 2006), participated in the study, thus adding to knowledge about sleep in less advantaged groups.

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References

Andersson, H., & Bergman, L. R. (2011). The role of task persistence in young adolescence for successful educational and occupational attainment in middle adulthood. *Developmental Psychology, 47*, 950–960.

Arbuckle, J. L., & Wothke, W. (1999). *Amos user's guide. Version 4.0.* Chicago: Small Waters Corporation.

Brand, S., Gerber, M., Beck, J., Hatzinger, M., Pühse, U., & Holsboer-Trachsler, E. (2010). Exercising, sleep-EEG patterns, and psychological functioning are related among adolescents. *World Journal of Biological Psychiatry, 11*, 129–140.

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Brand, S., Gerber, M., Hatzinger, M., Beck, J., Pühse, U., & Holsboer-Trachsler, E. (2010). High exercise levels are related to favorable sleep patterns and psychological functioning in adolescents: a comparison of athletes and controls. *Journal of Adolescent Health, 46*, 133–141.
Browne, M. W., & Cudeck, R. (1989). Single sample cross-validation indices for covariation structures. *Multivariate Behavioral Research, 24*, 445–455.
Buckhalt, J. A. (2011). Insufficient sleep and the socioeconomic status achievement gap. *Child Development Perspectives, 5*, 59–65.
Carskadon, M. A., Acebo, C., & Jenni, O. G. (2004). Regulation of adolescent sleep: implications for behavior. *Annals of the New York Academy of Sciences, 1021*, 276–291.
Chung, K. F., & Cheung, M. M. (2008). Sleep-wake patterns and sleep disturbance among Hong Kong Chinese adolescents. *Sleep, 31*, 185–194.
Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Hillsdale, NJ: Lawrence Erlbaum Associates.
Cooper, M. L., Wood, P. K., Orcutt, H. K., & Albino, A. (2003). Personality and the predisposition to engage in risky or problem behaviors during adolescence. *Journal of Personality and Social Psychology, 84*, 390–410.
Crowley, S. J., Acebo, C., & Carskadon, M. A. (2007). Sleep, circadian rhythms, and delayed phase in adolescence. *Sleep Medicine, 8*, 602–612.
Dewald, J. F., Meijer, A. M., Oort, F. J., Kerkhof, G. A., & Bogels, S. M. (2010). The influence of sleep quality, sleep duration and sleepiness on school performance in children and adolescents: a meta-analytic review. *Sleep Medicine Reviews, 14*, 179–189.
Digdon, N., & Howell, A. (2008). College students who have an eveningness preference report lower self-control and greater procrastination. *Chronobiology International, 25*, 1029–1046.
Duckworth, A. L., & Seligman, M. E. P. (2005). Self-discipline outdoes IQ in predicting academic performance of adolescents. *Psychological Science, 16*, 939–944.
Dupeyrat, C., & Mariné, C. (2005). Implicit theories of intelligence, goal orientation, cognitive engagement, and achievement: a test of Dweck's model with returning to school adults. *Contemporary Educational Psychology, 30*, 43–59.
Dweck, C. S. (1986). Motivational processes affecting learning. *American Psychologist, 41*, 1040–1048.
Eliasson, A., Eliasson, A., King, J., Gould, B., & Eliasson, A. (2002). Association of sleep and academic performance. *Sleep and Breathing, 6*, 45–48.
Fallone, G., Owens, J. A., & Deane, J. (2002). Sleepiness in children and adolescents: clinical implications. *Sleep Medicine Reviews, 6*, 287–306.
Fend, H., & Prester, H. G. (1986). *Documentation of the scales of the project "Development during Adolescence"* [*Dokumentation der Skalen des Projekts Entwicklung im Jugendalter*]. Konstanz: Sozialwissenschaftliche Fakultät.
Fortier, M. S., Vallerand, R. J., & Guay, F. (1995). Academic motivation and school performance: toward a structural model. *Contemporary Educational Psychology, 20*, 257–274.
Fredriksen, K., Rhodes, J., Reddy, R., & Way, N. (2004). Sleepless in Chicago: tracking the effects of adolescent sleep loss during the middle school years. *Child Development, 75*, 84–95.
Gangwisch, J. E., Babiss, L. A., Malaspina, D., Turner, J. B., Zammit, G. K., & Posener, K. (2010). Earlier parental set bedtimes as a protective factor against depression and suicidal ideation. *Sleep, 33*, 97–106.
Gillison, F., Standage, M., & Skevington, S. (2011). Motivation and body-related factors as discriminators of change in adolescents' exercise behavior patterns. *Journal of Adolescent Health, 48*, 44–51.
Grob, A., Little, T. D., Wanner, B., Wearing, A. J., & EURONET. (1996). Adolescents' well-being and perceived control across 14 sociocultural contexts. *Journal of Personality and Social Psychology, 71*, 785–795.
Loessl, B., Valerius, G., Kopasz, M., Hornyak, M., Riemann, D., & Voderholzer, U. (2008). Are adolescents chronically sleep-deprived? An investigation of sleep habits of adolescents in the Southwest of Germany. *Child Care Health and Development, 34*, 549–556.
McDonald, R. P., & Ho, M.-H. R. (2002). Principles and practice in reporting structural equation analyses. *Psychological Methods, 7*, 64–82.
Meijer, A. M., Habekothé, H. T., & Van den Wittenboer, G. L. H. (2000). Time in bed, quality of sleep and school functioning of children. *Journal of Sleep Research, 9*, 145–153.
National Sleep Foundation. (2006). *Sleep in America poll*. Washington DC: National Sleep Foundation.
O'Brien, E. M., & Mindell, J. A. (2005). Sleep and risk-taking behavior in adolescents. *Behavioral Sleep Medicine, 3*, 113–133.
Owens, J. A., Belon, K., & Moss, P. (2010). Impact of delaying school start time on adolescent sleep, mood, and behavior. *Archives of Pediatrics & Adolescent Medicine, 164*, 608–614.
Randazzo, A. C., Muehlbach, M. J., Schweitzer, P. K., & Walsh, J. K. (1998). Cognitive function following acute sleep restriction in children ages 10–14. *Sleep, 21*, 861–868.
Swiss Federal Office of Statistics. http://www.bfs.admin.ch/bfs/portal/en/index.html. Accessed 20.12.11.
Tangney, J. P., Baumeister, R. F., & Boone, A. L. (2004). High self-control predicts good adjustment, less pathology, better grades, and interpersonal success. *Journal of Personality, 72*, 271–324.
Vazsonyi, A. T., Trejos-Castillo, E., & Huang, L. (2006). Are developmental processes affected by immigration? Family processes, internalizing behaviors, and externalizing behaviors. *Journal of Youth and Adolescence, 35*, 799–813.
Wahlstrom, K. (2010). School start time and sleepy teens. *Archives of Pediatrics & Adolescent Medicine, 164*, 676–677.
Wahlstrom, K. L. (2002). Changing times: findings from the first longitudinal study of later high school start times. *NAASP Bulletin, 96*, 3–21.
Werner, H., Molinari, L., Guyer, C., & Jenni, O. G. (2008). Agreement rates between actigraphy, diary, and questionnaire for children's sleep patterns. *Archives of Pediatrics & Adolescent Medicine, 162*, 350–358.
Wills, T. A., Isasi, C. R., Mendoza, D., & Ainette, M. G. (2007). Self-control constructs related to measures of dietary intake and physical activity in adolescents. *Journal of Adolescent Health, 41*, 551–558.
Wolfson, A. R., & Carskadon, M. A. (2003). Understanding adolescents' sleep patterns and school performance: a critical appraisal. *Sleep Medicine Reviews, 7*, 491–506.
Wolfson, A. R., Spaulding, N. L., Dandrow, C., & Baroni, E. M. (2007). Middle school start times: the importance of a good night's sleep for young adolescents. *Behavioral Sleep Medicine, 5*, 194–209.
World Medical Association. http://www.wma.net. Accessed 20.12.11.

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