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Determinants of unhealthy sleeping habits among Belgian university students: an application of the Theory of Planned Behavior

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ABSTRACT

Objectives: This study investigated if unhealthy sleeping habits of university students can be explained by the Theory of Planned Behavior. **Method:** An online questionnaire was administered to 1006 undergraduate students at a Belgian university to measure their frequency of irregular sleeping times, daytime napping, and pre-bedtime alcohol or internet use, as well as the attitudes, perceived norms, perceived control and intentions for these behaviors. **Results:** Principal Component Analysis and internal consistency analysis confirmed the validity and reliability of the scales measuring the TPB dimensions. Expected outcomes, perceived norms and perceived control significantly explained intentions to avoid irregular sleeping times, daytime naps, pre-bedtime activity and pre-bedtime alcohol use. Intentions and perceived behavioral control explained self-reported irregular sleeping times, daytime napping, pre-bedtime activity, and pre-bedtime alcohol use. Significant differences in predictions were found for gender, study program, type of residence and age. **Conclusions:** The TPB provides a useful theoretical framework to explain students' sleeping behaviors.

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Introduction

Sleep is a fundamental aspect of life and affects cognitive, behavioral, social and physiological functioning. Decades of research into cognitive functioning during sleep have shown that the different phases of sleep have a strong impact on learning and memory functions. The cholinergic activity during REM sleep plays an important role for the enhancement of attention, learning, and memory consolidation in the procedural memory,[1] whereas the slow wave stages of sleep facilitate the consolidation of content in the episodic memory.[2] Other studies have highlighted the beneficial effect of REM sleep on the consolidation of emotional content,[3] which can be explained by the activation of the amygdala during this stage of sleep.[2] Due to its role in memory processes and affect regulation,[4] insufficient or disturbed sleep can lead to poor academic performance.[5–7] In addition, it can also have harmful physical consequences such as glucose metabolism dysregulation, which is linked to diabetes and obesity[8] and to cardiovascular problems.[9] Several studies have reported an increased cardiovascular mortality risk resulting from insufficient sleep, among both women and men.[10–16] Finally, sleep also has an impact on hormone regulation,[8] and thus plays an important role in affect regulation. Specifically, poor sleep quality is associated with more negative and less positive affect,[17] while a lack of sleep reduces peoples' capacity to feel positive emotions and enhances negatives ones.[18]

Sleep disturbances can be concerned with either the quantity or the quality of sleep. Whereas sleep *quantity* only refers to the duration of sleep, sleep *quality* involves a combination of features, including sleep duration, sleep disturbance or dysfunction, sleep latency period, sleep efficiency, and the subjective feeling of having slept well.[19] Sleep quality is predicted by *sleep hygiene,*[20,21] which according to Riedel[22] refers to behavioral patterns that may interfere with or facilitate sleep. Since sleep quality is an important predictor of health, well-being and sleepiness,[23] sleep hygiene by association is a relevant concept to focus on to prevent these problems.

As the cognitive implications of sleep disturbances can influence academic performance, it is not surprising that sleep hygiene is considered a health concern for the student population. Several studies have documented the impact of poor sleep habits in student populations, highlighting their important social, psychological and academic consequences.[24,25] For example, students who spend much time looking at a screen (and less time on physical activity) not only show poor sleep quality more often, but also more anxiety and psychopathological symptoms.[26] On the other hand, students who get enough sleep (i.e., 7.5 h or more per night) but at irregular times, show higher levels of daytime sleepiness than those who have regular sleep patterns.[27] Furthermore, students who take daytime naps at least once per week also more often report irregular sleep-wake cycles.[28]

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In addition to these direct effects of sleep hygiene on the subjective well-being of college students, it also has an indirect effect,[29] due to the relationship between poor sleep hygiene and poor sleep quality. According to Digdon and Landry[30] the latter is associated with less effective problem coping, characterized by a lower problem focus, more perception of negative emotions, more problem avoidance, and more use of alcohol as a coping strategy. Other authors found that emotional stress accumulation coupled with academic stress can lead to sleep disturbances and insufficient sleep quantity,[31–33] which in turn can have an impact on the students' academic performance[34] and on their mental health.[31]

Given these important consequences, it would seem indicated to promote good sleep hygiene habits among students, to help them achieve a better sleep quality. Yet in order to change these habits, it is necessary to understand the factors that cause them. To that effect, use can be made of behavioral theories or models that identify the factors that induce or influence health-related behavior. Various models have been proposed to identify these behavioral determinants,[35–40] most of which focus on the socio-cognitive factors that determine intentional behavior such as going to sleep. For the present study we drew on the *Theory of Planned Behavior* (TPB).[41,42] This model identifies behavioral intention as a proxy of behavior, and posits that the intention to perform a given behavior is influenced by three belief-based factors: attitudes (i.e., the expected behavioral outcomes and their subjective value), subjective norms (i.e., the belief of what other people do or think about the behavior and the motivation to comply with these norms), and perceived control (i.e., the belief whether or not one is capable of performing the behavior).[42] Percieved control can also directly influence behavior, without a mediating role for intention. The TPB has been applied to a wide range of health-related behaviors, and its validity has been confirmed by several meta-analyses, including the ones by Godin and Kok[43] and by Armitage and Conner.[44] The latter showed that the three components of the TPB explain up to 40% of the variance of behavioral intention, while intention accounts for 25% of the variance in behavior.

Some authors have used the TPB or variables contained in this model to study the determinants of sleep habits among college students and teenagers.[45–47] None of these studies, however, looked at sleep hygiene as an outcome variable. Moreover, none of them investigated whether the different determinants of sleep hygiene are the same for different groups of students, based on their age, gender, age, type of residence, or study major. On the other hand, the few studies that investigated the role of certain TPB components as determinants of sleep problems, without testing the model as a whole, have yielded interesting results. For instance, a positive attitude toward sleep was found to be directly associated with longer sleep duration and indirectly with better sleep quality.[48] An association was also found between sleep problems and social support,[49] and between cognitive flexibility (or more precisely, perseverance as a facet of self-regulation) and good sleep practices.[50] The latter leads to the recommendation to pay attention to this component when developing sleep hygiene interventions.

To complement and refine these findings, the present study explored whether the factors that are included in the TPB explain unhealthy sleep hygiene among university students in Belgium. Specifically, it considered the role of attitudes, perceived norms, perceived behavioral control, and behavioral intention as determinants of four behaviors representing inadequate sleep hygiene, i.e. irregular sleep-wake cycle, daytime napping, activities before bedtime, and alcohol use before bedtime.

Method

Procedure

To investigate the degree to which the dimensions of the Theory of Planned Behavior[41,42](TPB) influence unhealthy sleep hygiene among university students, a questionnaire study was performed among students at a Belgian French-speaking university, using a newly developed questionnaire based on similar applications of the TPB in other health behaviors. Students registered at the university in the academic year 2015–2016 were contacted by e-mail and invited to participate anonymously in an online survey. They were contacted for this only once, there was no follow-up. Ethical approval for the study was obtained from the Ethics Commission of the Research Institute in Psychological Sciences of the Université Catholique de Louvain (UCLouvain). Data collection took place in April to May 2016.

Measures

A 86-item questionnaire was developed measuring the frequency of four sleep hygiene behaviors and their determinants, based on the TPB, as well as demographic characteristics. Demographic variables included gender, age, type of study (humanities, health sciences or sciences and technology), year of study (bachelor level, master level or other) and place of residency (living with parents, shared housing, studio apartment, or other).

With regard to sleep hygiene, four behaviors were considered which according to the revised International Classification of Sleep Disorders[51,52] feature amongst the main elements of poor sleep hygiene, notably: (i) variable wake-up times or bedtime, (ii) daytime napping at least twice per week, (iii) exercise or screen activity close to bedtime, and (iv) routine use of alcohol in the period preceding bedtime. For each of these behaviors, a separate section of the questionnaire was created each one having a similar structure, with one item measuring the frequency of the behavior using a 5-point Likert scale (ranging from "never" to "always"), a variable number of items measuring attitudes, subjective norms and perceived control regarding the behavior on a 7-point Likert scale (ranging from "not agree at all" to "fully agree"), and one item measuring behavioral

intention on a 5-point Likert scale (ranging from "absolutely not" to "certainly"). Specifically:

- For *variable wake-up and bedtimes*, 1 item measured the behavioral frequency ("I go to bed or wake up at variable times"), 10 items measured the *attitude* toward the behavior through behavioral beliefs (e.g., "Varying my bedtime allows me to participate in evening activities"), 6 items measured *subjective norms* (e.g., "My parents think that it is better to avoid varying my wake-up and bedtimes") and the motivation to comply with these norms (e.g., "I find what my parents think about regular sleep important"), 2 items measured *perceived control* (e.g., "It is easy for me to avoid going to bed and waking up at variable times"), and 1 item measured *intention* ("In the future, I will avoid going to bed or waking up at variable times").
- For *daytime napping*, 1 item measured the frequency of the behavior ("I take a nap at least twice a week")[1], 9 items measured the *attitude* toward the behavior (e.g., "Napping is a waste of time" or "Taking a nap during the day makes me feel better"), 6 items measured *subjective norms* (e.g., "my friends think it is not good to take daytime naps"), 2 items measured *perceived control* (e.g., "I can control whether or not I take a daytime nap"), and 1 item measured *intention* ("In the future, I will avoid taking daytime naps").
- For *activity before bedtime*, which include internet use, cleaning, playing videogames, watching a movie or TV, etc., 1 item measured the behavioral frequency ("I do activities that keep me awake before going to bed"), 11 items measured the *attitude* toward the behavior (e.g., "Doing activities before bedtime is pleasant"), 6 items measured *subjective norms* (e.g., "My parents think it is better to avoid doing activities close to bedtime"), 2 items measured *perceived control* (e.g., "I can avoid doing activities that keep me awake before bedtime if I want to"), and 1 item measured *intention* (e.g., "In the future, I will avoid to do activities that keep me awake close to bedtime").
- For *routine alcohol use before bedtime*, 1 item measured the behavioral frequency ("I drink alcohol before going to bed"), 14 items measured the *attitude* toward the behavior (e.g. "Drinking alcohol before going to bed helps me to relax" or "Drinking alcohol before going to sleep is bad for my health"), 6 items measured *subjective norms* (e.g., "My parents think that I should not drink alcohol before going to bed"), 2 items measured *perceived control* on a more internal level (e.g., "It is easy for me to avoid drinking alcohol before going to bed") while 2 other items assessed *perceived control* on a more external level (e.g. "Due to the proximity, accessibility, or even my entourage, I am tempted to consume alcohol"), and 1 item measured *intention* ("In the future, I will avoid to drink alcohol before going to bed").

Before using the questionnaire for data collection in the study, it was pilot tested on a small convenience sample of 10 students to assess the duration of completion and to detect any misunderstandings, ambiguities, or other difficulties participants may encounter with the questions. As no problems were encountered through this pilot test, the pilot questionnaire was used for the study without further modification.

Sample

All 29,716 students who had registered at the university in the academic year 2015–2016 received an invitation by e-mail to participate anonymously in the online survey *via* LimeSurvey. A total of 1006 students fully completed the questionnaire. Most of them (70.4%) were female. Their ages ranged between 17 and 30 years ($M = 21.41$; $SD = 2.44$), with the highest number of respondents belonging to the age group between 21 and 25 years (55.9%), followed by 17–20 years (39.2%), and 25–30 years (5%). Approximately half of the respondents (53.8%) were enrolled in a humanities study program (theology, law, economics, management, philosophy, arts and literature, or psychology), 22.9% in health sciences (medicine, dentistry, pharmacy, biomedical sciences, public health, physical therapy and sports sciences), and 23.4% in science and technology (polytechnics, architecture, engineering, urban planning, biology, agronomic sciences, veterinary sciences and environmental engineering). Slightly more than half (55.1%) were enrolled at bachelor level, 38.6% in a master program, and 6.4% in a specialized complementary study program, a certificate, or a PhD. Most of the respondents lived at home with their parents (36.9%), in shared housing such as a room in an apartment shared with others on or near the campus (35.5%), or in a studio apartment (19.8%). A small minority (7.9%) lived in a "cercle," "régionale," or "kot-à-projet," which are typical housing formats organized by student associations and linked to student folklore, often implying an involvement in extracurricular activities on campus.

Statistical analyses

The validation of the questionnaire scales involved a three-step process. First, an item analysis was performed upon which items with a standard deviation of < 0.75 or for which 95% or more of the respondents had given an identical response were removed. Secondly, Principal Component Analyses (PCA) with Varimax rotation were performed on the remaining items of the scales measuring attitudes, subjective norms and perceived control for each behavior, using the eigenvalue > 1 and scree plot criteria to determine the number of factors. Items with a factor loading lower than

1 For this item the average time of the nap (in minutes) was also asked.

0.3 were eliminated. In a first instance, four PCAs were performed for all items evaluating each of the four behaviors (variable wake-up and bedtimes, daytime napping, activity and alcohol use before bedtime). When the results of this PCA did not allow a meaningful interpretation of the resulting factors, separate PCAs were performed on the items measuring each determinant. Thirdly, internal consistency analyses (Cronbach α) were performed to test the reliability of each scale obtained through the PCA.

The contribution of the TPB dimensions to explain sleep hygiene behavior was tested by means of multiple regression analyses. For each behavior, a first regression analysis tested whether attitudes, subjective norms and perceived behavioral control explained intention, and a second analysis whether intention and perceived behavioral explained (self-reported) behavior.

Finally, multivariate analyses of variance (MANOVA) were performed to compare subgroups of students based on gender, age, study program, study level and type of accommodation with regard to the reported frequency of the four sleep hygiene behaviors. Subsequent univariate ANOVAs were performed to test which behaviors contributed to the multivariate effects. Post hoc Tukey tests, *t*-tests and one Dunnett's T3 test were conducted to examine subgroup differences on those behaviors. The t-tests were performed for the post hoc comparisons for gender, and Tukey's HSD for the other a posteriori tests. Dunnett's T3 test was performed to test the differences in daytime napping according to the participants' type of accommodation, as the assumption of homogeneity of variances was not met for this variable.

Results

Scale validation

A PCA on the items measuring the determinants of *variable wake-up and bedtimes* resulted in five factors explaining 59.55% of the total variance. The first factor consisted of five items measuring *perceived disadvantage* of having variable wake-up and bedtimes, the second of three items measuring *motivation to comply with subjective norms*, the third of three items related to the *perceived advantage*, the fourth of three items measuring the *subjective norms* as perceived among significant others, and the fifth of two items measuring *perceived behavioral control.*

For the items measuring determinants of *daytime napping*, the PCA also resulted in five factors explaining 68.43% of the total variance. The first factor contained four items measuring *perceived advantage*; the second contained five items measuring *perceived disadvantage*; the third three items related to *subjective norms*; the fourth was composed of three items measuring the *motivation to comply* with norms; and the fifth of two items measuring *perceived behavioral control.*

Concerning *activity before bedtime*, the PCA resulted in five factors explaining 66.4% of the total variance. However, as there was a significant cross-load of items across the factors, a separate PCA was performed on the items measuring the *attitude* component. Following the removal of two items with low loadings, a solution was obtained consisting of five items measuring *perceived advantage*, four items measuring *perceived disadvantage,* three items measuring *subjective norm,* three items measuring the *motivation to comply* to subjective norms, and two items measuring *perceived behavioral control.*

Finally, for the items measuring *alcohol use before bedtime*, the overall PCA resulted in six factors explaining 66.34% of the total variance, but as the solution was difficult to interpret, a separate PCA was performed on the items measuring attitude, social norms and perceived behavioral control. As a result, a seven-factor structure was obtained. Three components measured attitudinal aspects: eight items measured *perceived advantage*, three measured *perceived disadvantage*, and three measured *health consequences*; two dimensions measured perceived behavioral control: *perceived internal control* (two items) and *perceived external control* (also two items); and two dimensions measured subjective norms: three items measuring perceived norms, and three the *motivation to comply* with norms.

Internal consistencies

Table 1 shows the number of items and internal consistencies (Cronbach α) for each of the scales obtained through the PCA. As this table shows, sufficient (.60) to adequate (.70 or higher) internal consistency coefficients were achieved for all scales except perceived subjective norms with regard to variable wake-up and bedtimes. The table also gives the Pearson correlations between the scales, revealing that the correlations between the dimensions were low to average. Unsurprisingly, perceived advantages and disadvantages for all the four behaviors were negatively correlated, as were perceived internal control and external control for alcohol use. In contrast, motivation to comply with norms appeared to be generally unrelated to other dimensions.

Determinants of sleep hygiene behavior

Table 2 gives the results of the multiple regression analyses for the contribution of the TPB components (perceived advantages and disadvantages, subjective norms, motivation to comply with norms, and perceived behavioral control) to the intentions to avoid variable wake-up and bedtimes, daytime napping, activity before bedtime, and alcohol use before bedtime. As this table shows, all TPB components significantly contributed to the intention to *avoid variable wake-up and bedtimes* and to *avoid activity before bedtime*. All TPB components except the motivation to comply with social norms also contributed significantly to the intention to *avoid daytime napping*. In contrast, perceived disadvantages and motivation to comply with social norms did not contribute significantly to the intention to *avoid alcohol use before bedtime*.

Multiple regression analysis for the determinants of self-reported behavior revealed that avoiding variable wake-up and bedtimes is explained by intention and perceived behavioral control (R^2=.15 with respectively $\beta = -0.33$, $p < .001$ and $\beta = -0.16$, $p < .001$). The same applies to avoiding

Table 1. Number of items, internal consistency and intercorrelations for the scales of the questionnaire measuring four sleep hygiene behavior based on the TPB model.

Scales	*N*	Cronbach *α*	Correlations 2	3	4	5	6	7
Variable wake-up and bedtimes								
1. Perceived advantages	5	0.63	−0.09**	.02	−0.03	.00		
2. Perceived disadvantages	5	0.85		.15**	.16**	−0.12**		
3. Subjective norms	3	0.59			.32**	−0.08*		
4. Motivation to comply with norms	3	0.79				−0.04		
5. Perceived behavioral control	2	0.65						
Daytime napping								
1. Perceived advantages	4	0.83	−0.48**	−0.12**	.02	−0.38**		
2. Perceived disadvantages	5	0.75		.22**	.05	.32**		
3. Subjective norms	3	0.75			.13**	.15**		
4. Motivation to comply with norms	3	0.89				.01		
5. Perceived behavioral control	2	0.77						
Activity before bedtime								
1. Perceived advantages	5	0.85	−0.31**	−0.09**	−0.02	−0.18**		
2. Perceived disadvantages	4	0.70		.34**	.18**	−0.19**		
3. Subjective norms	3	0.68			.32**	−0.06*		
4. Motivation to comply with norms	3	0.86				.01		
5. Perceived behavioral control	2	0.71						
Alcohol use before bedtime								
1. Perceived advantages	8	0.87	−0.13**	−0.28**	−0.19**	−0.08*	−0.35**	.48**
2. Perceived disadvantages	3	0.80		.45**	.22**	.11**	.08*	.03
3. Health consequences	3	0.77			.21**	.16**	.12**	−0.16**
4. Subjective norms	3	0.68				.43**	.21**	−0.12**
5. Motivation to comply with norms	3	0.85					.08**	−0.02
6. Perceived internal control	2	0.87						−0.45**
7. Perceived external control	2	0.65						

Note. *: $p < .05$; **: $p < .01$.

Table 2. Beta values, *t*-values and *p*-values of attitude, subjective norm and perceived behavioral control for the determinants of intention to avoid performing inadequate sleep hygiene behaviors.

	R^2	β	*t*	*p*
Variable wake-up and bedtimes	.21			
Perceived advantages		−0.23	−8.21	.000
Perceived disadvantages		.32	10.91	.000
Subjective norms		.09	2.86	.004
Motivation to comply with norms		.08	2.81	.005
Perceived behavioral control		.14	4.93	.000
Daytime napping	.74			
Perceived advantages		−0.08	−4.28	.000
Perceived disadvantage		.18	9.34	.000
Subjective norms		.07	4.17	.000
Motivation to comply with norms		.02	1.09	.274
Perceived behavioral control		.73	41.74	.000
Activity before bedtime	.27			
Perceived advantages		−0.17	−5.87	.000
Perceived disadvantages		.33	10.62	.000
Subjective norms		.08	2.56	.011
Motivation to comply with norms		.13	4.43	.000
Perceived behavioral control		.22	7.84	.000
Alcohol use before bedtime	.45			
Perceived advantages		−0.24	−8.57	.000
Perceived disadvantages		.02	.62	.535
Health consequences		.20	7.29	.000
Subjective norms		.18	6.61	.000
Motivation to comply with norms		.03	1.34	.181
Perceived internal control		.10	3.69	.000
Perceived external control		−0.28	−9.69	.000

daytime napping (R^2=.36 with respectively $\beta = -0.16$, $p < .001$ for intention and $\beta = -0.46$, $p < .001$ for perceived behavioral control), and avoiding activity before bedtime (R^2=.23 with respectively $\beta = -0.29$, $p < .001$ for intention and $\beta = -0.33$, $p < .001$ for perceived behavioral control). Avoiding alcohol use before bedtime is significantly explained by intention, perceived internal control and perceived external control (R^2=.51 with $\beta = -0.52$, $p < .001$, $\beta = -0.06$, $p < .05$ and $\beta = .26$, $p < .001$, respectively).

Comparative analyses

Multivariate analysis of variance (MANOVA) comparing the scores on the four sleep hygiene behaviors for student subgroups revealed significant differences between students' behaviors for gender (Wilks' lambda = 0.96; $F[4,1001] = 10.19$, $p < .001$), study program (Wilks' lambda = 0.95; $F[8,2000] = 6.09$, $p < .001$), and accommodation type (Wilks' lambda = 0.88; $F[12,2643.4] = 11.06$, $p < .001$). No significant multivariate difference was found for age group (Wilks' lambda = 0.99; $F[8,2000] = 1.71$, $p = 0.09$) or study year (Wilks' lambda = 0.99; $F[8,2000] = 1.79$, $p = 0.08$).

Univariate ANOVAs (Table 3) indicated that the multivariate difference for *gender* can be attributed to differences in daytime napping ($F[1,1004] = 22.03$, $p < .001$) and activity before bedtime ($F[1,1004] = 12.60$, $p < .001$). Subsequent *t*-test confirmed that female students were more likely to take daytime naps than male students ($t[1004] = 4.69$, $p < .001$), while male students reported more activity before bedtime than females ($t[576.80]$=-3.60, $p < .001$).

With regard to the participants' *study program*, significant univariate group differences were found for variable wake-up and bedtimes ($F[2,1003] = 12.81$, $p < .001$) and alcohol use ($F[2,1003] = 13.47$, $p < .001$). Post hoc Tukey's HSD tests revealed significant differences in variable wake-up and bedtimes between students from health sciences and humanities, with the latter reporting more irregular sleep-wake cycle ($p < .001$). For alcohol use before bedtime, health sciences students scored lower than students of humanities ($p < .001$), and students of sciences and technology ($p = .008$).

Table 3. Means and standard deviations from the multivariate differences regarding students sleep hygiene behaviors.

	Gender				Study program						Accommodation					
	Female (*M*±*SD*)	Male (*M*±*SD*)	*F*	*p*	Human Sciences (*M*±*SD*)	Health Sciences (*M*±*SD*)	Sciences and Technology (*M*±*SD*)	*F*	*p*	Living with parents (*M*±*SD*)	Shared housing (*M*±*SD*)	Studio apartment (*M*±*SD*)	Student association housing (*M*±*SD*)	*F*	*p*
Variable wake-up and bedtimes	3.28 (±0.94)	3.37 (±0.98)	2.13	.145	3.42 (±0.92)	3.05 (±0.95)	3.29 (±0.96)	12.81	.000	3.25 (±0.91)	3.38 (±0.91)	3.14 (±1.03)	3.66 (±0.97)	7.18	.000
Daytime napping	2.51 (±1.06)	2.16 (±1.06)	22.03	.000	2.40 (±1.05)	2.47 (±1.05)	2.34 (±1.12)	0.85	.426	2.26 (±1.03)	2.54 (±1.07)	2.37 (±1.14)	2.57 (±0.98)	4.92	.002
Activity before bedtime	3.73 (±0.96)	3.96 (±0.92)	12.60	.000	3.82 (±0.92)	3.73 (±0.99)	3.80 (±1.01)	0.73	.480	3.75 (±1.01)	3.82 (±0.88)	3.80 (±1.04)	3.87 (±0.79)	0.49	.692
Alcohol use before bedtime	2.37 (±1.01)	2.5 (±1.11)	3.37	.067	2.54 (±1.05)	2.12 (±1.03)	2.40 (±0.98)	13.47	.000	2.08 (±0.97)	2.70 (±0.99)	2.22 (±0.96)	3.10 (±1.08)	39.36	.000

With regard to differences based on *accommodation type*, the ANOVAs were significant for variable wake-up and bedtimes ($F[3,1002] = 7.18$, $p < .001$), daytime napping ($F[3,1002] = 4.92$, $p < .01$) and alcohol use ($F[3,1002] = 39.36$, $p < .001$). Post hoc Tukey's HSD tests revealed significant differences between students living with their parents or tutor or in a studio apartment, and those in the "other accommodation" group, with the latter reporting more irregular sleep-wake cycles than both other groups ($p = .002$ and $p < .001$, respectively). Dunnett's T3 test showed significant differences in daytime napping between students living with their parents or tutor and those living in a shared apartment ($p = .002$), with the latter more often reporting to take naps. Finally, post hoc Tukey's tests revealed significant differences in pre-bedtime alcohol consumption between students living with their parents or tutor and those living in a shared apartment ($p < .001$), with the latter more often reporting alcohol consumption, and between students living in a shared apartment and those living in a studio apartment ($p < .001$). Students in the "other accommodation" group more often reported pre-bedtime alcohol use than the three other groups, i.e., students living with their parents or tutor ($p < .001$), students living in a shared apartment ($p = .007$), students living in a studio apartment ($p < .001$).

Although no significant multivariate difference was found between the three age groups within the sample, univariate tests were also performed for this variable, revealing a significant age effect for variable wake-up and bedtimes ($F[2,1002] = 3.50$, $p = .030$) and for pre-bedtime alcohol use ($F[2,1002] = 3.88$, $p = .021$). Post hoc Tukey's HSD tests showed that both these behaviors were significantly less frequent among the older students (in the age group of 26–30 years) than among the younger ones (17–20 and 21–25 years).

Discussion

This study aimed to investigate the extent to which the components of the Theory of Planned Behavior (attitudes, subjective norms, and perceived behavioral control) explain four behaviors that represent poor sleep hygiene habits among university students, notably variable wake-up and bedtimes, daytime napping, activity and pre-bedtime alcohol use. It also examined if there were any differences regarding these four behaviors and their determinants between subgroups of students defined by age, gender, study program, study level and type of student accommodation.

The results show that, overall, the TPB components explain the intention to avoid inadequate sleep hygiene, and that this intention, in combination with perceived behavioral control, is linked to the self-reported sleep hygiene behaviors. This is consistent with other findings regarding the ability of the TPB to explain sleep behavior in a student population.[45,46] As a whole, the model explains between 21% and 74% of the variance in intention to perform the behaviors, with only three scales not contributing

significantly to all behaviors: motivation to comply with subjective norms does not impact daytime napping, and perceived disadvantages and motivation to comply with subjective norms are not significantly related to pre-bedtime alcohol use. The fact that motivation to comply with social norms has less impact raises the question as to the role of social influences in sleep hygiene behavior.[49] The lack of influence of perceived disadvantages of pre-sleep drinking is a cause of concern, given the problematic alcohol consumption of university students.[30] However, on the whole our results are consistent with those of meta-analyses attesting to the predictive validity of the TPB for other health-related behavior,[43] where an average R^2 of 39% was reported for the impact of attitudes, subjective norms, and perceived behavioral control on behavioral intentions, and an average of 27% explanation of the variance in health behavior by intentions and perceived behavioral control. In our study, intention and perceived control explain 15% to 51% of the self-reported sleep hygiene behaviors, which is within the same range.

When looking at different subgroups of students, our study revealed that female students report more daytime napping than male students. This confirms the findings of Tsai and Li[53] who also found longer naptimes among female college students to cope with daytime sleepiness and make up for insufficient sleep. A gender difference was also found for pre-bedtime activities, which are more prevalent among male than among female students. This concurs with the findings from studies showing that boys have more extended screen time than girls, and are more often engaged in video games, which are related to screen time, before going to sleep.[45,54] Gellis and Lichstein[55] noted that poor sleepers are often more engaged in emotional or exciting activities or activities that required concentration near bedtime. In that way, our study suggests that gender differences regarding screen time, which seem to be consistent across age groups, contribute to poor sleep quality among male college and university students in particular.

Whereas no significant gender difference was found for variable wake-up and bedtime, this behavior appears to be more prevalent among younger students and among those who study human sciences or science and technology, as compared to those who study health sciences. It is also more prevalent among students who reside in accommodation organized by student associations than among those in any other type of accommodation. The latter may be related to the many obligations of these students in terms of extracurricular activities such as meetings, projects, festivities and representing their association in university bodies.

Health sciences students also reported less pre-bedtime alcohol use than students from other programs. This may be related to their greater awareness of the health effects of alcohol use as a result of their studies. This may also hold true for older students, who also report less pre-bedtime alcohol use. Not surprisingly, alcohol use before bedtime was also less frequent among students who are living with their parents. This may be interpreted as an indication that parental control is an effective barrier to drinking alcohol before bedtime, but could also be linked to the lower involvement of these students in student activities, or reflect an internalization of their motives to refrain from alcohol use. Again, not unexpectedly, pre-bedtime alcohol use is the highest among students living in student association housing. This could be partially explained by the obligations and festivities resulting from their involvement with their association, but can also be related to the relationship between drinking motives and evening circadian preferences that have been reported in the literature.[27] Other studies have also pointed at the association between alcohol consumption and a preference to stay awake longer,[56,57] which concurs with the finding in our study that students living in a shared apartment also take more daytime naps than those living at home.

While this study provides insight into the determinants of sleep hygiene behaviors of university students that could be informative to encourage healthier sleeping habits, it is not without its limitations. Firstly, it only focuses on some sleep hygiene behaviors, and not on all. While the four behaviors that were investigated in the study are generally considered as very important, other sleep hygiene behaviors that are highlighted by the International Classification of Sleep Disorders[51] (ICSD) were not included. These include tobacco use or drinking coffee before bedtime, allowing mental activities such as thinking, planning or reminiscing to occur in bed, or using one's bed for non-sleep related activities. As the number of variables in this study was already substantial, it was not considered feasible to include all sleep hygiene behaviors in one study, and the choice was made to focus on the most important ones. A second limitation is that the study focuses primarily on sleep hygiene-related behaviors, and not on environmental elements that also affect sleep, such as room temperature, light in the room or noise. While the limitation to behavioral factors makes sense when considering the role of social cognitive theories such as the TPB, future research could also look at the combined or interactive effects of behavioral and environmental factors affecting sleep. Another limitation is concerned with the operationalization of the sleep hygiene behaviors and their determinants. In the questionnaire, the frequency of behaviors was measured via generic Likert scales asking whether the behavior occurred never, rarely, sometimes, frequently or always. As it is possible that respondents attach different meanings to these levels, it would have been better to specify their values (e.g. rarely means once or twice during the past month, sometimes means three to five times during the past month, frequently means six to eight times per month, etc.). Also, for the operationalization of attitudes a limited set of perceived advantages and disadvantages was represented, which means that important potential beliefs or perceived consequences may not have been accounted for. These limitations could have been reduced through more elaborate pilot testing of the questionnaire. A final limitation of the study is that stress was not considered as a factor related to sleep hygiene and sleep quality, whereas many studies have highlighted the relationship between stress and quality of sleep.[30–32,58,59] As university life not only involves academic tasks and pressure to succeed but also the challenges of adapting to a

new environment and the transition to young adulthood, it can be considered as a stressful period in life.[60,61]

To address these limitations, it would be interesting to verify if the results of this study can be confirmed in a replication study that includes additional sleep hygiene behaviors referred to by the ICSD and that takes stress into account as a potential confounding factor of sleep quality and sleep hygiene amongst university students. Ideally, such a study could follow a socio-ecological approach to increase its scope and also include environmental and cultural influences on students' sleep hygiene behaviors.

Despite these limitations, however, we think that our study adds to the knowledge about university students' sleep hygiene behavior, and especially about the motives that underly these behaviors. It also demonstrates that the TPB provides a useful theoretical framework to explain undergraduate students' healthy sleeping intentions and behaviors. Importantly, it also highlights the fact that sleep hygiene behaviors and their determinants may differ for male and female students, for students enrolled in different study programs, or for students residing in different types of accommodation. As such, the findings of this study add to the theoretical and empirical basis that can inform more targeted interventions to promote healthy sleep habits among university students. Health promoters can rely on the findings of this study to focus interventions on the determinants of sleep hygiene behaviors of university students that are identified in the TPB. Specifically, they should not only inform students about the importance of adopting healthy sleeping habits, but motivate them to change their attitudes, install social norms that are conducive to healthy sleep habits, and enhance perceived control. This would concur with studies that highlighted the importance of motivational aspects in sleep hygiene behaviors and recommend the use of motivational interviews.[62,63] In addition, interventions to enhance sleep hygiene among university students should take gender differences regarding the determinants of sleep hygiene into account, as well as the differences by study program or type of accommodation. In this way, more diversified and tailored interventions are likely to be more successful than standard actions aimed at the entire student population.

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