efpsa Journal of European Psychology Students

Ness, T. E. B., and Saksvik-Lehouillier, I. (2018). The Relationships between Life Satisfaction and Sleep Quality, Sleep Duration and Variability of Sleep in University Students. *Journal of European Psychology Students*, 9(1), 28–39, DOI: https://doi.org/10.5334/jeps.434

RESEARCH ARTICLE

The Relationships between Life Satisfaction and Sleep Quality, Sleep Duration and Variability of Sleep in University Students

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Life satisfaction and its relationship to aspects of sleep were investigated in 701 Norwegian university students using recreated sleep logs, questions about sleep-related experiences, a sleep quality item and the Satisfaction with Life Scale. The results indicated that better sleep quality, longer mean sleep duration, less variability in sleep duration and less variability in rise time were all associated with greater life satisfaction, but only sleep quality and variability of sleep duration were significant predictors of life satisfaction in a regression model. Consistent with previous research, the results emphasize the importance of sleep quality, and adds to existing research by suggesting that in some populations, variability of sleep duration might be more relevant to well-being than sleep duration itself.

Keywords: life satisfaction; sleep quality; sleep duration; sleep variability; university students

Life satisfaction is commonly used as an indicator of general well-being (Diener, Emmons, Larsen, & Griffin, 1985), and has been found to be related to perceived stress, reported level of social support, and self-efficacy in university students (Coffman & Gilligan, 2002). However, few studies have looked at how life satisfaction relates to different aspects of sleep in student populations (Lund, Reider, Whiting, & Prichard, 2010), even though the importance of sleep for well-being has been documented in other populations. Paunio and colleagues (2009) found in a nationwide cohort study including 18 631 Finnish twins, that poor sleep can predict life dissatisfaction. Similarly, a longitudinal study by Kalak, Lemola, Brand, Holsboer-Trachsler, and Grob (2014) found that sleep duration in Swiss and Norwegian adolescents prospectively predicted psychological well-being (as measured by the Bern well-being questionnaire for adolescents-subscale). Considering that sleep problems have been found to also be present at alarming levels in college and university students (Buboltz, Brown, & Soper, 2001; Lund et al., 2010), more research regarding the relationship between sleep variables and well-being in college and university students is needed.

Life Satisfaction

Definitions of well-being and happiness can be grouped into three categories: normative, affective and cognitive (Diener, 1984). Only the two latter categories, the affective and cognitive, consider the individual's own assessments, and is therefore relevant to subjective well-being. The affective category of happiness focuses on positive and negative affect, and has more resemblance to how we use the word happiness in everyday discourse. The cognitive category on the other hand, includes definitions that have focused on what make individuals evaluate their life in positive terms. One type of well-being, *life satisfaction*, falls into this cognitive category of happiness according to Shin & Johnson (1978) and is defined as a judgmental process where individuals assess the quality of their life by using their own criteria. Importantly, the judgement of the degree to which people are satisfied with their life is based on a comparison with a standard set by the individual him or herself, and is not externally imposed (Diener et al., 1985).

Another construct that has been used when studying well-being is quality of life. Although this construct has been given countless definitions, it seems to often be defined in a broader way than life satisfaction and concerns the general well-being of people and societies (Felce & Perry, 1995). However, it is also sometimes used interchangeably with life satisfaction (e.g., Frisch, Cornell, Villanueva, & Retzlaff, 1992). In the current study, only life satisfaction, as defined above, is used.

Sleep

As sleep is a complex phenomenon, it can be helpful to consider which aspects of sleep one is interested in when studying its relationships to other concepts. Using more than one aspect of sleep also allows for a comprehensive assessment of sleep, and provides the opportunity to investigate

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how individual components of sleep relate to a construct of interest. One method of classification (Pilcher, Ginter, & Sadowsky, 1997; Pilcher & Ott, 1998) is to divide sleep into two components: sleep quality and sleep quantity. Other studies (e.g., Rowe et al., 2008) have also included a measure of variability. The present study therefore includes two components of sleep variability (variability in sleep schedule and variability in sleep duration) in addition to sleep quality and sleep quantity. Of note, the current study considers sleep variability to be a separate construct than sleep quality and sleep quantity, meaning that distinct effects for each of these constructs could be expected.

Sleep quantity and sleep quality. Sleep quantity, or sleep duration, can be easily quantified and is often measured in hours or minutes, either by self-report, or objective measures such as polysomnography or actigraphy (Augner, 2011; Groeger, Zijlstra, & Dijk, 2004; Lemola, Ledermann, & Friedman, 2013; Lemola, Raikkonen, Gomez, & Allemand, 2013; Pilcher et al., 1997; Pilcher & Ott, 1998). Sleep quality, on the other hand, seems to lack an established definition. Researchers have looked at which objective sleep variables correlate with self-reported good sleep. Åkerstedt, Hume, Minors, and Waterhouse (1994) found subjective sleep quality was defined as sleep continuity, whereas Keklund and Åkerstedt (1997) reported that sleep quality also seemed to be a matter of depth. Harvey, Stinson, Whitaker, Moskovitz, and Virk (2008) investigated the subjective meaning of sleep quality and found that tiredness upon waking and throughout the day, feeling rested and restored when waking, and the number of awakenings experienced during the night, were the factors most often considered when judging sleep quality. Sleep quality is also sometimes used to refer to a collection of measures, such as total sleep time, sleep latency, sleepiness, sleep disturbances and nightly awakenings. The most widely used measure is the Pittsburg Sleep Quality Index (PSQI; Buysse, Reynolds, Monk, Berman, & Kupfer, 1989), a 19-item long questionnaire combining seven components of sleep. The current study used a self-created index of sleep quality that highly corresponded to the items? or components? included in the PSQI.

Sleep variability. Maintaining a consistent sleep schedule is commonly known to be good practice for sleep (Lim & Dinges, 2010). Data from normal sleepers support this notion by showing that following good sleep practices (often referred to as *sleep hygiene*) can positively affect sleep quality and quantity (Stepanski & Wyatt, 2003). Therefore, it seems reasonable to include measures of sleep variability, in addition to sleep quality and quantity, when investigating how different aspects of sleep relate to life satisfaction.

Sleep variability can refer to different aspects of sleep: variability in sleep schedule (e.g., Rowe et al., 2008) or variability of sleep duration (e.g., by Lemola et al., 2013). Variability in sleep schedule refers to the degree to which bedtimes and rise times varying from night to night. Some people go to bed and rise at very different times during the week, and such variability has been shown to negatively affect sleep quality (Brown, Buboltz, & Soper, 2002). Variability in sleep duration refers to not sleeping the same number of hours each night. It is worth noting that even though someone might have high variability in their sleep schedule (i.e., have a high variation of bedtimes and rise times), they might still manage to sleep approximately the same number of hours each night, for example, if the person has a flexible work or study schedule. Thus, the night-to-night variations of sleep duration can be low, even though variability in sleep schedule is high.

The Relationship between Sleep Variables and Well-Being in University Students

Sleep quality. The research concerning the relationship between sleep quality and well-being in graduate and undergraduate students has shown that low sleep quality is associated with worse health and well-being (Augner, 2011; Howell, Digdon, Buro, & Sheptycki, 2008; Lemma, Gelaye, Berhane, Worku, & Williams, 2012; Lund et al., 2010; Pilcher et al., 1997; Preisegolaviciute, Leskauskas, & Adomaitiene, 2010). Of the seven studies referred to above, only two (Howell et al., 2008; Pilcher et al., 1997) included some measure of life satisfaction. Pilcher and colleagues (1997) measured sleep quality by using the PSQI and used the same scale for life satisfaction as the current study: the Satisfaction with Life Scale (SWLS; Diener et al., 1985). Howell and colleagues (2008) however, looked at how sleep quality (measured by the Sleep Quality Scale; Yi, Shin, & Shin, 2006) was related to emotional well-being, which combined items on positive affect and life satisfaction. Pilcher and colleagues (1997) performed two studies to assess whether measures of health, well-being and sleepiness were more strongly related to sleep quality or to sleep quantity. The same study was repeated a year later by Pilcher and Ott (1998) as a repeated-measures approach to investigate the stability of the measures and relationships over a three month period. Measures of health and well-being were more strongly associated with quality rather than quantity of sleep in all these studies.

Sleep duration. In contrast to the literature investigating sleep quality and well-being in graduates and undergraduates, studies looking at sleep duration show more inconsistent results. Studies typically find sleep duration to be a weak predictor of mood and cognitive functioning in undergraduate students (Gray & Watson, 2002; Pilcher et al., 1997; Verlander, Benedict, & Hanson, 1999), although several studies have documented its importance in younger adolescents (Fuligni & Hardway, 2006; Kalak et al., 2014; Saxvig, Pallesen, Wilhelmsen-Langeland, Molde, & Bjorvatn, 2012; Sivertsen et al., 2013). In contrast, Kelly (2004) found that life satisfaction accounted for 5.5% of the variance in sleep duration in a group of graduate and undergraduate students, suggesting that perhaps this aspect of sleep could be important in this age group. The literature on this specific relationship is scarce, and the study by Kelly (2004) is the only study to our knowledge that specifically focuses on life satisfaction and sleep duration in undergraduates and graduates. Even in non-student adult populations, there are inconsistent findings in the literature. Kelly's (2004) findings are in accordance with a large national survey conducted in the United States (National Sleep Foundation, 2002), reporting that those who slept more than six hours on weekdays

were more likely to be optimistic and/or satisfied with their life. Other studies using representative samples have also found that sleep durations which are too short or too long have been linked to undesirable outcomes, such as poorer self-rated health and quality of life (Groeger et al., 2004; Magee, Caputi, & Iverson, 2011), lower optimism and self-esteem (Lemola, et al., 2013), and even higher mortality (Hublin, Partinen, Koskenvuo, & Kaprio, 2007). In contrast, Jean-Louis, Kripke, and Ancoli-Israel (2000) found that sleep duration was not, neither by self-report, nor as measured by actigraphy, associated with quality of well-being. Similarly, Lemola et al. (2013) reported that sleep duration, measured by actigraphy, was unrelated to life satisfaction when controlling covariates and other sleep variables.

Sleep variability. There seems to exist very little evidence on the relationship between regularity of sleep schedule and life satisfaction, although there have been some studies linking regularity of sleep schedule to better sleep quality (Monk, Reynolds, Buysse, DeGrazia, & Kupfer, 2003; Soehner, Kennedy, & Monk, 2011), with only one including university students (Carney, Edinger, Meyer, Lindman, & Istre, 2006).

A few studies have compared some measure of sleep variability or sleep schedule to other sleep variables to determine those that seem to be the most essential for students' well-being. Gray and Watson (2002) found that sleep quality was related to measures of positive and negative emotionality (measured using the Positive and Negative Affect Schedule), whereas sleep duration and sleep schedule were not. Sleep schedule in this study was operationalized as average rising time and average bedtime, however. No measure of sleep variability was included.

Lemola et al. (2013) found that high night-to-night variability in sleep duration, more than sleep duration itself, was related to poor subjective sleep quality and lower life satisfaction in a study of 441 adults. Fuligni and Hardway (2006) on the other hand, reported that low variability of sleep duration and sleep duration itself were approximately equally important for the psychological well-being of 14–15 year olds. There seem to be no studies investigating how variability of sleep duration relates to life satisfaction in graduate and undergraduate students.

Research Question and Hypotheses

As indicated by the literature review above, sleep quality seems to be an important predictor of well-being for students, whereas sleep duration and variability in sleep schedule show more inconsistent relationships and lack of specific research on these populations. There seems to be more studies reporting a positive relationship between sleep duration and well-being, than studies reporting a non-significant relationship, when considering all types of populations. The relationships tend to be weak however, and in many cases disappear when controlling for other sleep variables. The very few studies looking at night-to-night variability in sleep duration and its relation to well-being suggest a negative relationship, but none, to our knowledge, have used student populations. The same is true for the few studies that have reported a relationship between variability of sleep schedule and sleep quality, and to our knowledge, no study has investigated how variability of sleep schedule relates to life satisfaction, directly. The aim of the present study is therefore to get a clearer picture of the following problem: "How is life satisfaction associated with different aspects of sleep in a group of Norwegian graduate and undergraduate students?" The relevant sleep aspects we will investigate are: (a) sleep quality, (b) sleep duration, (c) variability in sleep duration and (d) variability in sleep schedule. The current study addressed the problem using self-reported recreated sleep logs (meaning the log was not filled in every morning, but recreated at one point in time), questions about sleep related behavior and experiences, and the SWLS.

Based on the existing literature, we present four hypotheses: Our first hypothesis is that better sleep quality is associated with greater life satisfaction. Our second hypothesis is that longer mean sleep duration is associated with greater life satisfaction. Our third hypothesis is that less variability in sleep duration is associated with greater life satisfaction. Finally, our fourth hypothesis is that less variability in sleep schedule is associated with greater life satisfaction.

Method

Participants and Sampling

An invitation to participate in the study was sent to 1665 college and university students. Seven hundred and one participants started the survey, but only 474 completed it, resulting in a response rate of 42.1% and a completion rate of 67.6%. The participants were selected through convenience sampling with the aim of collecting enough data to get a broad perspective on life satisfaction and sleep among students. When there were approximately 500 respondents on the questionnaire, we were confident, based on a power analysis, that this would be sufficient in a regression with five or more independent predictors, when searching for a small to medium effect size (Cohen, 1992; Field, 2013). Six participants reported still attending "videregående" (the Norwegian equivalent to High School) and were for this reason excluded from the sample. Two hundred and twenty-five (32.1%) of the respondents were graduate students and 462 were undergraduate students (65.9%). We assumed that the population would be rather homogenous regarding age, therefore age was collected as a nominal variable (see **Table 2** for details) with all respondents older than 32 years in one category. To see how age was categorized, see **Table 2**. The majority (88.5%) of the students were between 20–25 years, whereas 2.3% were 19 years or younger and 1.8% were older than 29 years. Four hundred and seventy-nine were female (69.9%), and 490 (72.2%) were studying in Mid-Norway.

Procedure

Respondents were recruited by distributing a questionnaire by e-mail or by an invitation to a closed Facebook event. The invitation consisted of general information regarding the purpose of the study, estimated time to complete the questionnaire (approximately 15 minutes) and

a URL-link to the questionnaire. A week later a reminder was sent, and the invited participants were informed that the survey would be open an additional week. The data was collected during February, and at that time the sun rises at around 8 a.m. and sets at around 5 p.m. in mid-Norway (times for sunrise and sunset in different parts of Norway can be found at http://www.timeanddate.no).

According to Norwegian law on research ethics and medical research, all projects concerning medical or health research are obliged to notify the Regional Committees for Medical and Health Research Ethics (REC), and all projects processing personal data are obliged to notify the Norwegian Social Science Data Service (NSD). Prior to the distribution of the questionnaire, an evaluation form to assess whether the project was obligated to apply for further approval from REC was evaluated by REC. The project was evaluated as not concerning medical or health research, and we were given permission to execute the study without further approval by the REC. The project was also approved by NSD.

Instruments

Questionnaire. The questionnaire included the SWLS (Diener et al., 1985), questions about sleep related habits and experiences, personality measures, questions about lifestyle, demographics, and some study related items such as field of study, study region, level of education and grade average. All items and instruments were presented in Norwegian. The demographics, the SWLS and the sleep related questions were the only relevant parts of the questionnaire to the present study.

Life satisfaction. The Norwegian version of the Satisfaction with Life Scale (Vittersø, 2009) was used to assess life satisfaction. This scale comprises translated versions of the statements originally presented by Diener and colleagues (1985), and assess the individual's opinions on life (e.g., "In most ways my life is close to my ideal"). The Norwegian version of the SWLS is scored in the same way as the original SWLS: The respondents rate how much they agree with the statements on a seven-point Likert scale. The total score can range from 5 to 35, in which a higher score indicates a higher level of life satisfaction. SWLS is widely used to assess global life satisfaction, and has been shown to have high internal consistency, high temporal stability and to correlate highly to moderately with other measures of subjective well-being (Diener et al., 1985; Vittersø, 2009). The Cronbach's Alpha for SWLS in the current sample was .90.

Sleep quality. The self-created sleep quality measure comprised scores from six sleep variables: sleep depth, sleepiness, perceived sufficiency of amount of sleep, mean sleep latency, mean sleep duration (sleep latency extracted) and sleep efficiency. All six components could have a minimum value of zero (most optimal) and a maximum of four (least optimal), which contributed to the total sleep quality score. Thus, the highest possible score was 24, which would indicate worst possible quality of sleep.

Sleep depth was assessed by asking the participants how their sleep usually was, on a scale from one (*very light*) to five (*very deep*). This question is collected from a sleep diary that was originally published by Morin (1993), but modified by Bjorvatn and colleagues (2006). Sleepiness was assessed by asking if the respondents usually felt sleepy during work or studies, and the answers ranged from one (*not at all*) to five (*very much*). Perceived sufficiency of amount of sleep was assessed by asking to what degree the participants felt that they got the sleep they needed, ranging from one (*to a very little degree*) to five (*to a large degree*). Sleep depth and perceived sufficiency of amount of sleep were reverse-coded before added to the total score. Mean sleep latency was derived from the answers given to the following questions (in Norwegian): "How long does it usually take you to fall asleep on weekdays (answer in minutes)?" and "How long does it usually take you to fall asleep on weekends (answer in minutes)?". The most optimal score (zero) for mean sleep latency was given to respondents reporting an average of less than 15 minutes to fall asleep, whereas the least optimal score (4) was given to those reporting an average of one hour or more before falling asleep. The rest of the scoring for sleep latency can be seen in **Table 1**. Mean sleep duration was extracted from the sleep logs, which is explained in detail in the following section about mean sleep duration. The most optimal score for this component was given to those reporting an average of seven hours or more, whereas an average of five hours or less gave the least optimal score. It could be noted that questions about Wake After Sleep Onset (WASO) was not included in the questionnaire, and could therefore not be subtracted from mean sleep duration.

Sleep efficiency was calculated by dividing the reported time in bed by the estimated time asleep (sleep duration with sleep latency extracted). Sleep efficiencies over 95% were categorized as being the most optimal score, whereas scores less than 65% were categorized as the least optimal score. The rest of the scoring for sleep efficiency can be seen in **Table 1**.

Mean sleep duration, mean sleep latency, sleep efficiency and sleep depth correspond to components one to four in the PSQI (Buysse et al., 1989). The component labeled sleepiness is similar to the components called daytime dysfunction, existing in both the PSQI and in the Sleep Quality Scale (Yi et al., 2006). The last component, perceived sufficiency of sleep amount, corresponds closely to a component in Sleep Quality Scale that is not included in PSQI, called restoration after sleep. The Cronbach's Alpha for the sleep quality measure was. 66.

Table 1: Assigned Scores to Sleep Latency and Sleep Efficiency.

Sleep Latency (min)	Sleep Efficiency (%)	Sleep Quality Score
<15 min	>95	0
15–30 min	85–95	1
30–45 min	75–85	2
45–60 min	65–75	3
>60	<65	4

Mean sleep duration. The participants were asked to imagine a typical week, and to fill out a schedule for when they would normally go to bed and rise every day. Rising and retiring had 24 hours available, to the nearest whole hour. A typical week was used because we judged it as likely to lead to less bias than the use of a possibly non-typical recent week. From this schedule, sleep durations were calculated by subtracting the reported time it took to fall asleep on weekdays and weekends (sleep latency), separately. Minutes were converted to hours before subtracting them from the hours spent in bed on weekdays and weekends. To calculate sleep durations as simple extractions (rise times from bedtimes), bedtimes past midnight were adjusted by adding 24 hours (e.g., 01 hours became 25 hours), which placed rise times and bedtimes on a continuous scale.

Next, the mean sleep duration was calculated by using the sleep durations for the whole week. This method for assessing mean sleep duration and sleep schedule is similar to the one used by Gray and Watson (2002), with the exception that they used a recreation of a sleep log from the previous week instead of a typical one. Moreover, they compared this index of sleep duration to a general question on how many hours they usually slept, often referred to as the method by Kumar and Vaidya (1984), and these two indices for mean sleep duration produced nearly identical estimates (7.2 and 7.1, respectively), suggesting that it is a reliable method of assessing mean sleep duration.

Variability of sleep duration. As a measure of night-to-night variation in sleep duration, the Coefficient of Variation (CV), or the mean variation across the nights, was used. This variable, labeled variability in sleep duration, shows the extent of variation across the nights in relation to the mean, and is calculated by dividing the standard deviation of the sleep durations across the week by the mean sleep duration, and multiplying by 100. Lower values indicate stability whereas higher values indicate greater night-to-night variability (Rowe et al., 2008). Several other researchers have, in recent years, also recognized the utility of this variability measure of sleep (Lemola et al., 2013; Merklinger-Gruchala, Ellison, Lipson, Thune, & Jasienska, 2008; Suzuki et al., 2005; Tryon, 2005).

Variability of sleep schedule. Sleep schedule variability was extracted from the sleep logs to create two variables: one for rise times and one for bedtimes. Gray and Watson (2002) operationalized sleep schedule in the same way, but used the average rise times and bedtimes. In the current study however, we were interested in the variability of sleep, and therefore used the average deviation from the mean rise time and bedtime to calculate night-to-night variation, resulting in the variables rise time deviation and bedtime deviation, respectively. These two variables represent the average discrepancy (in hours) from the mean rise times and bedtimes in a typical week.

Statistical Analysis

We used IBM SPSS Statistics version 21.0 (IBM Corp., 2012) for the statistical analysis in this study, and alpha-level was always set at .05. First, a correlation analysis including all study variables was performed to assess correlations and to investigate which of the variables were significantly correlated with life satisfaction. Second, a hierarchical multiple regression analysis was performed to predict life satisfaction and included all variables that were significantly correlated with life satisfaction. Since we assume that age and gender could affect both life satisfaction and sleep variables, we controlled for these aspects to determine to what extent the sleep variables contribute to life satisfaction beyond demographic variables.

Although 701 students started the questionnaire, only 475 completed it. No substitutions for missing data were performed. The sub-sample that completed the questionnaire did not appear to be different from the sample that started the questionnaire, when considering the demographic variables: Seventy percent were still female, and the majority of participants were still between 20 and 25 years. The mean age category was 2.68 in the sample that completed the questionnaire, compared to 2.66 in the sample that started the questionnaire. To see how age was categorized, see **Table 2**.

Results

Descriptives

Table 2 shows descriptive statistics and correlations for life satisfaction, gender, age, and all sleep variables.

Correlations Between Study Variables

Life satisfaction correlated significantly with all sleep variables, except bedtime deviation. Thus, the three first hypotheses were supported, and the fourth, which concerned variability in sleep schedule, was partly supported with only rise time deviation being significantly related to life satisfaction. Life satisfaction had a moderate negative correlation with sleep quality (higher sleep quality score means worse quality; $r = -.337$, $p < .001$), and a weak positive correlation with mean sleep duration ($r = .128$, $p = .003$). Furthermore, life satisfaction had a weak negative correlation with variability of sleep duration ($r = -.212$, $p < .001$) and rise time deviation ($r = -.148$, $p = .001$).

There existed some very weak correlations among control variables and sleep variables. **Table 2** indicates that being male was associated with having better sleep quality ($r = -.087$, $p = .041$), and to sleep less ($r = -.153$, $p < .001$). Additionally, being female was associated with higher bedtime deviations ($r = -.102$, $p = .012$). Furthermore, older age was associated with shorter mean sleep duration ($r = -.142$, $p = .001$) and more regular bedtimes ($r = -.115$, $p = .005$). All correlations can be seen in **Table 2**.

Relationships Between Sleep and Life Satisfaction

Prior to conducting the hierarchical regression analyses, the assumptions of the analysis were tested. A sample size of 474 is about five times the usual recommended minimum for a model of six predictors (Field, 2013). The model was checked for linearity, independent residuals and for multicollinearity with no results suggesting any violations of these assumptions.

A diagnostic analysis of the standardized residuals indicated that the residuals were roughly within the limits of what could be expected in an ordinary sample. Still,

a few potential outliers were spotted as indicated by Mahalanobis distances that were found to be substantially larger than the recommended cut-off point by Barnett and Lewis (1994), and were therefore inspected. Considering that no single case had a large effect on the model or on the individual parameters (indicated by appropriate Cook's distances and standardized DFBeta values; Cook and Weisberg, 1982; Field, 2013), we concluded that none of the cases were of great concern for the model and therefore were not removed from the sample.

A hierarchical multiple regression model including age and gender in the first step, and sleep quality, mean sleep duration, variability of sleep duration and rise time deviation in the second step, explained 14.3% of the variance ($F(6, 467) = 12.96$, $p < .001$) in life satisfaction. The sleep variables could account for close to all this variance (13.8%). The weights, standard errors, beta weights and probability, as well as R^2 change values can be seen in **Table 3**.

Life satisfaction was moderately and positively associated with better sleep quality ($\beta = -.340$, $p < .001$) and weakly negatively related to variability of sleep duration ($\beta = -.159$, $p = .011$). The relationships between life satisfaction and gender, age, mean sleep duration and rise time deviation were non-significant.

Discussion

The aim of this study was to investigate how different aspects of sleep were related to life satisfaction in graduate and undergraduate students. The results show that all sleep variables except bedtime deviation were related to life satisfaction. Better sleep quality, longer mean sleep

Table 2: Means/Frequencies, Standard Deviations (SD) and Pearson's Correlations for all Variables.

Variable	Mean (SD)/ Frequency	Correlations							
		Age	Gender	LS	SQ	MSD	VoSD	RTD	BD
[a]Age (category)	2.66 (0.75)	–							
Gender (1 = female, 2 = male)	479 (69.9%) female	.147***	–						
Life satisfaction	23.08 (6.41)	.027	–.026	–					
Sleep quality	5.79 (3.00)	–.004	–.087*	–.337***	–				
Mean sleep duration (hours)	8.22 (0.93)	–.142**	–.153**	.128**	–.387***	–			
Variability of sleep duration	12.09 (6.84)	–.020	.004	–.212***	.178***	–.186***	–		
Rise time deviation (hours)	1.42 (0.61)	–.053	–.024	–.148**	.104*	–.098*	.704***	–	
Bedtime deviation (hours)	0.98 (0.54)	–.115**	–.102*	–.077	.008	–.031	.159***	.433***	–

[a] Age categories were as follows: 19 years or younger = 1, 20–22 years = 2, 23–25 years = 3, 26–28 years = 4, 29–31 years = 5 and 32 years or older = 6.

* $p < .05$. ** $p < .01$. *** $p < .001$ (2-tailed).

Table 3: Hierarchical Multiple Regression Analysis Predicting Life Satisfaction from Sleep Quality, Mean Sleep Duration, Variability of Sleep Duration and Rise Time Deviation (N = 474).

	Δ R^2	β	*b*	SE
Step 1	.005			
Gender		–.043	–.604	.649
Age		.061	.513	.390
Step 2	.138***			
Gender		–.077	–1.079	.617
Age		.055	.465	.366
Sleep quality		–.340***	–.711***	.101
Sleep duration		–.056	–.402	.347
Variability of sleep duration		–.159**	–.146**	.057
Rise time deviation		.022	.234	.643
Total R^2	.143***			

* $p < .05$. ** $p < .01$. *** $p < .001$.

duration and less variability in sleep duration were all associated with greater life satisfaction. Thus, the first three hypotheses were supported. The fourth hypothesis concerning variability of sleep schedule was partly supported, with only rise time deviation being significantly associated with life satisfaction. This direct relationship between variability of sleep schedule and life satisfaction has, to our knowledge, not previously been investigated in graduate and undergraduate students. However, rise time regularity, but not bedtime regularity, have previously been related to sleep quality among college students (Carney et al., 2006) and working adults (Soehner et al., 2011). This relationship was found in the current study as well.

As the design of this study is cross-sectional, the directions of the temporal relations cannot be established. The relationships are also likely to be bidirectional, with disturbed sleep affecting how satisfactory the students judge their life, and the amount of satisfaction with their life affecting how well they sleep. On the other hand, some longitudinal studies have shown that sleep quality (Paunio et al., 2009; Totterdell, Reynolds, Parkinson, & Briner, 1994) and sleep quantity (Kalak et al., 2014) affects life satisfaction, whereas no evidence was found for the reverse relationship. These results suggest that, in the current study, sleep affected life satisfaction more than life satisfaction affected sleep.

There might be many explanations for the relationship between rise time deviation and life satisfaction. It seems likely that the relationship is the result of a third variable, for example a personality characteristic that reflects how well the students are able to structure their life in general. It may also be that great variations in rise times, more than reducing the quality of sleep, leads to less synchronization with the external environment. This might affect well-being by, for example, leading to reduced efficiency of work or studies, or less social contact. These possibilities are only speculations, and further research is required to examine them.

Variability of sleep duration correlated strongly with rise time deviation. The overlap between these two variables can explain why variability of sleep duration was a significant predictor of life satisfaction, whereas rise time deviation was not, although both were associated with life satisfaction.

Consistent with previous research on graduates and undergraduates (Howell et al., 2008; Pilcher et al., 1997), the results of this study suggest that better sleep quality was moderately associated with greater life satisfaction. The correlation coefficient between life satisfaction and sleep quality was considerably higher than that between life satisfaction and mean sleep duration (–.34 versus .13, respectively), which is also consistent with the findings from Pilcher and colleagues (1997). Furthermore, the correlation coefficient between life satisfaction and regularity of sleep duration was higher than that between life satisfaction and sleep duration, which is consistent with Lemola et al. (2013). This is however, less consistent with Fuligni and Hardway (2006), who reported that regularity of sleep duration and mean sleep duration were about equally related to well-being in adolescents. A possible explanation might be that the current sample is more comparable to the mid-aged participants in Lemola et al. (2013) study, than the 14–15 year olds in the study by Fuligni and Hardway (2006). The participants in the current study were young, but adults nonetheless.

Although mean sleep duration was significantly positively related to life satisfaction, this relationship was weak, and mean sleep duration was a non-significant predictor of life satisfaction in the regression model. This is consistent with previous studies that have found sleep duration to be a weak predictor of mood and functioning (Gray & Watson, 2002; Pilcher et al., 1997; Verlander et al., 1999). This is less consistent however, with the fact that in Kelly's (2004) study, scores on the SWLS could explain 5.5% of the variance in sleep duration in a group of college students. However, it should be noted that in the current model sleep duration was one component of the sleep quality item (which is the case for all other studies who have used the PSQI), and thus sleep quality accounted for some of the variance in life satisfaction that otherwise could have been explained by mean sleep duration. Notwithstanding, the current data showed that a simple linear regression with mean sleep duration as the sole predictor could explain only 1.5% of the variance in life satisfaction, suggesting that there is another explanation for why Kelly (2004) found a stronger relationship between sleep duration and life satisfaction than the current study. One explanation could be that the mean sleep duration found by Kelly (2004) was more than one hour lower than what was found in the current study. It could be hypothesized that in a sample where the average respondent is sleep deprived, sleep duration will have a stronger relationship to life satisfaction, than in a sample where the average respondent gets sufficient amounts of sleep. However, the fact that Lemola et al. (2013) reported an even lower mean sleep duration, and still found sleep duration to be unrelated to life satisfaction when other sleep variables were controlled for, makes this an unlikely explanation.

When comparing the sample of Kelly (2004) to the sample in the current study, it can be seen that although the mean age was very similar and the distribution of the sexes was roughly the same, the participants in Kelly's (2004) study consisted of solely of psychology students, whereas the current study included students in various fields. Furthermore, Kelly (2004) had less than half the sample size compared the current study and Lemola et al. (2013). These sample differences might explain why Kelly (2004) found a stronger relationship between sleep duration and life satisfaction.

A possible explanation for why the students in our sample seemed to sleep more than found in several other student samples (Gray & Watson, 2002; Jean-Louis et al., 2000; Lemma et al., 2012; Lund et al., 2010; Pilcher et al., 1997; Steptoe, Peacey, & Wardle, 2006), is that a large portion of the students most likely had very flexible sleep schedules, due to few mandatory school activities. The

irregular rise times showed by many of the students might illustrate this: The average student in the sample deviated 1.42 hours on average from their mean rise time across a typical week (rise time deviation). Although the mean for bedtime deviation was notably smaller (M = 0.98), it still represents an average of one hour discrepancy from the mean bedtime. Nearly half of the students in the sample (48.5%) were studying social sciences at Norwegian University of Science and Technology (NTNU), and therefore have less arranged and/or mandatory activities, than, for example, engineering programs. Many of the students at social science programs at NTNU have only six hours of lectures each week, and many courses have no mandatory activities during the whole semester (information about schedules and mandatory activities for study programs can be found at www.ntnu.no).

Day lengths in Norway differ markedly with seasons due to the country's northern altitude, and these factors might affect sleep patterns and well-being (Laberge et al., 2000). However, the longitudinal study by Kalak and colleagues (2014) did not find stronger seasonality of sleep duration in the adolescents in Norway compared to the adolescents in Switzerland, when measurements took place in May and November (when hours of daylight between these months differ with approximately 10 hours in mid-Norway. To see how many hours of sun the different months have at different locations in Norway, see http://www.timeanddate.no). Considering this result, it does not seem likely that seasonality can explain why the current sample slept longer than what has been found in other student samples (Gray & Watson, 2002; Jean-Louis et al., 2000; Lemma et al., 2012; Lund et al., 2010; Pilcher et al., 1997; Steptoe, Peacey, & Wardle, 2006).

Strengths and Limitations

The sleep aspects that were included in this study were chosen on the grounds of previous research and theory. All variables were to a great extent based on methods that have previously been used and/or validated, and that have good face validity. The sleep quality measure was self-created, but composed of components that highly correspond to the ones included in the PSQI, a widely used and validated sleep quality measure (Buysse et al., 1989). The sleep quality measure in the current study had an internal reliability of α = 0.66, and even though it is often stated that 0.70 or 0.80 is an acceptable Cronbach's alpha value for a scale, Kline (2000) notes that values below this can be expected for more diverse constructs. Sleep quality is a broad construct consisting of relatively distinct aspects of sleep, and can therefore be expected to have lower inter-correlation among items, than for example the highly similarly phrased items constituting the SWLS. In fact, a Cronbach's Alpha just above .5 has been reported as sufficient for a three-item sleep quality measure (Augner, 2011). Although it would have been beneficial to have additional validation (e.g., criterion-related validity) to support the sleep quality index, this should not be a grave concern for the overall relevance of the findings of this study. Sleep quality is the only sleep variable in which there is existing research, allowing for more conclusive findings regarding its relationship to well-being in many different populations. This finding was replicated in the current study (which can be considered a form of validation for the index). The value of the current study lies in its addition to the literature: results regarding the relationships of the other, less studied, sleep variables and how they relate to life satisfaction in a sample of university students.

Some limitations regarding the way mean sleep duration was calculated are worth noting. First, some studies have shown that people do not accurately assess the number of hours they sleep, even on the morning following overnight (Baker, Maloney, & Driver, 1999; Lauderdale, Knutson, Yan, Liu, & Rathouz, 2008; Silva et al., 2007). Although some studies have found that participants underestimated the amount of sleep they get (Carskadon et al., 1976; Happe et al., 2005; McCall, Turpin, Reboussin, Edinger, & Haponik, 1995), these studies have often used small sample sizes and special populations, such as clinical populations. In contrast, two studies using larger, non-clinical samples compared subjective and objective assessments of sleep (Lauderdale et al., 2008; Silva et al., 2007) and found that people tended to overestimate the amount they slept. These results might be more comparable to the current sample (which was non-clinical), suggesting that the participants in the current study might have overestimated their amount of sleep as well.

Second, participants were asked to imagine a typical week when creating the sleep logs, and even though we judged that the use of a typical week would likely lead to less bias than the use of a possibly non-typical last week, this method might still have been affected by more memory errors than would a sleep log filled in every morning.

Third, awakenings during the night, or in the early morning before rising (WASO), were not reported, and thus could not be subtracted from the mean sleep duration. It is not known whether WASO was a problem for students in the sample, but it is a possibility that should have been accounted for because it could have affected average mean sleep duration, and perhaps allowed sleep duration to account for more variance in the regression model.

For these reasons, it seems likely that the mean sleep duration in this sample was somewhat exaggerated compared to the true mean sleep duration. However, the method used to collect mean sleep duration in this study has been shown by Gray and Watson (2002) to generate nearly identical numbers as the method by Kumar and Vaidya (1984)—a general question about how many hours of sleep they get in a 24 hour period—for the same participants. Thus, this limitation seems more related to the self-report aspect in general, rather than the type of self-report used. The fact that all the data generated from the students were based on self-report, is an important limitation. This means that the information may not have accurately reflected the sleep habits that were of interest. Nonetheless, it is reasonable to assume that people have at least a fairly good idea of the number of hours they usually sleep, and the benefits gained from being able to collect self-report from hundreds (or thousands) of people at almost no cost, might be worth a somewhat lower accuracy.

First-year students might face adaptation problems when adjusting to university life, and such problems are likely to affect both sleep patterns and psychological well-being. In the current study, age was significantly and negatively correlated with mean sleep duration and bedtime deviation, indicating that the younger participants were associated with sleeping less and more variable bedtimes. Although this finding might indicate the existence of such adaptation problems, the data in the present study do not allow for any conclusions regarding this fact, and further research would be needed to investigate the effect that adaptation problems might have on sleep and well-being.

Lastly, the information drawn from this study was based on university students from all regions of Norway, and included many types of study programs. Some regions and study programs were largely overrepresented, and, hence, the results may not be generalizable to all university students in Norway. The generalizability of the results is also likely to have been affected by the fact that less than half of the participants who were invited to the study responded (42.1%), as well as a relatively high drop-out rate (32.4%) for those who started the survey. However, the return rate of the survey in the present study was not lower than what can be expected for electronic surveys in general, according to a meta-analysis of electronic surveys which found that the mean response rate for 68 electronic surveys was at 39.6% (Colleen, Fred, & Russell, 2000). Furthermore, internet surveys within psychological research often suffer from relatively high drop-out rates that can be predicted from a function of length of the survey (Hoerger, 2010). This is a problem that should be taken seriously, especially since it was quite high in the current study, but unfortunately it cannot be avoided completely.

Notwithstanding these limitations, the results in this study are based on a relatively large group of university students, thus adding valuable information to the literature on how different aspects of sleep relate to life satisfaction in this group. Moreover, the current study processes sleep in a particularly comprehensive manner and, to our knowledge, is the only study to include all these aspects of sleep in one study, to see how they relate to life satisfaction in graduate and undergraduate students.

Implications for Practice and Future Research

The results of the current research underline the importance of good sleep quality for university students, and suggest that efforts to improve sleep quality might have a positive effect on students' well-being. Furthermore, the results suggest that variability of sleep duration might be of greater importance to some students' well-being than sleep duration itself. Accordingly, students should be advised to sleep approximately the same number of hours each night. When it comes to variability of sleep schedule, the results suggest that standardizing rise times should be emphasized, and that this might be of greater importance than standardizing of bedtimes in cases where regular sleep durations are not maintained (obviously it is not possible to have regular rise times, irregular bedtimes and still sleep the same number of hours each night).

Future studies are recommended to include a construct of sleep variability in addition to sleep quality and quantity, to ensure that sleep is assessed in a comprehensive manner. It is particularly recommended that future studies investigate the temporal relation between variability of sleep and life satisfaction using longitudinal methods, and to include objective measures of sleep. Such investigations may lead to a more comprehensive assessment of sleep, better advisement of students sleep habits and improvements of every day well-being.

Conclusion

This study extends and adds to existing research on how different aspects of sleep are related to life satisfaction in graduate and undergraduate students. In order of strength: better sleep quality, less variability in sleep duration, longer sleep duration and more consistent rise times were all positively related to life satisfaction in this group of students. Sleep quality and variability of sleep duration were the only significant predictors of life satisfaction. The results are consistent with previous research which emphasize the importance of sleep quality, and suggest that variability of sleep duration might be more relevant to some students' life satisfaction than sleep duration itself. More research, particularly on sleep variability, is needed to establish these relationships. Preferably, longitudinal studies should be conducted to investigate the temporal directions of the relationships between different aspects of sleep and life satisfaction.

Competing Interests

The authors have no competing interests to declare.

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How to cite this article: Ness, T. E. B., and Saksvik-Lehouillier, I. (2018). The Relationships between Life Satisfaction and Sleep Quality, Sleep Duration and Variability of Sleep in University Students. *Journal of European Psychology Students*, 9(1), 28–39, DOI: https://doi.org/10.5334/jeps.434

Published: 09 October 2018

]u[*Journal of European Psychology Students* is a peer-reviewed open access journal published by Ubiquity Press.

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