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SLEEP QUALITY VERSUS SLEEP QUANTITY: RELATIONSHIPS BETWEEN SLEEP AND MEASURES OF HEALTH, WELL-BEING AND SLEEPINESS IN COLLEGE STUDENTS

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Abstract—Two studies assessed whether measures of health, well-being, and sleepiness are better related to sleep quality or sleep quantity. In both studies, subjects completed a 7-day sleep log followed by a battery of surveys pertaining to health, well-being, and sleepiness. In subjects sleeping an average of 7 hours a night, average sleep quality was better related to health, affect balance, satisfaction with life, and feelings of tension, depression, anger, fatigue, and confusion than average sleep quantity. In addition, average sleep quality was better related to sleepiness than sleep quantity. These results indicate that health care professionals should focus on sleep quality in addition to sleep quantity in their efforts to understand the role of sleep in daily life. © 1997 Elsevier Science Inc.

Keywords: Sleep habits; Health; Well-being; Sleepiness; College students.

INTRODUCTION

For many young people, college provides a degree of personal freedom not previously experienced. One of the life-style habits that young people frequently alter upon entering college is sleep. Perhaps due to social and academic demands, many college students choose an irregular sleeping pattern. This voluntarily irregular sleeping pattern results in a degree of variability in sleep habits that is not often available in nonclinical and non-shiftwork populations. Therefore, college students provide a population in which variable sleep habits can be studied without the direct influence of more clinical concerns, such as sleep apnea or shiftwork schedules. One sleep-related area that has received little attention in college students and other nonclinical populations is the relationship between sleep habits and subjective measures of health, well-being, and sleepiness.

One method of examining the relationships between sleep and measures of health, well-being, and sleepiness is to classify sleep into two components, sleep quantity and sleep quality. Although these components of sleep overlap to some extent, there is a qualitative difference between them. In addition to the more easy quantifiable components of sleep such as number of awakenings at night, sleep latency, and sleep duration, sleep quality includes largely subjective indices of sleep,

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such as depth of sleep, how well rested one feels upon awakening, and general satisfaction with sleep [1, 2]. In an effort to better quantify the quality of sleep, researchers have developed subjective sleep quality indexes (e.g., [3, 4]). These questionnaires usually define sleep quality as a composite score of sleep quantity, length of time to fall asleep, number of awakenings at night, length of time to fall back asleep after awakening, a feeling of fatigue/restfulness upon awakening in the morning, and general satisfaction with sleep.

The relationships between health and the two components of sleep, quantity and quality, have been studied in some detail in clinical populations. For example, sleep duration has been linked to cardiovascular disease [5–7] and gastrointestinal disorders [8]. In addition, sleep itself has been shown to be a health risk in clinical populations, perhaps due to the physiological changes that occur during sleep [9]. Similarly, poor sleep quality has been linked to increased health complaints in sleep disorder (e.g., [10, 11]), clinical disorder (e.g., [12]), and shiftwork (e.g., [13, 14]) populations.

A few population survey studies have examined sleep habits in nonclinical populations using self-report data on sleep habits and health. Studies concentrating on sleep quantity report that 7–8 hours of sleep at night is positively associated with self-report health status and longevity [15, 16]. In contrast, a number of studies [17–19] could not find significant differences in health between short and long sleepers. Studies examining sleep quality have found a positive relationship between good sleep quality and self-report health [20, 21]. However, no study to date has specifically examined the relationships between both sleep quality and sleep quantity and self-report health in a nonclinical population.

Documenting physical health, however, may not present a total picture of general health. For example, the World Health Organization has identified three major components of health: mental, social, and physical. To better understand this more general concept of health, one must examine facets of life in addition to physical health, such as general well-being and mental health. Well-being is commonly identified by three major components: life satisfaction, negative affect, and positive affect [22, 23]. The relationships between these components of general well-being and sleep have not been thoroughly investigated in nonclinical populations. There is some support for a relationship between measures of well-being and good sleep quality [11, 24]. In contrast, studies focusing on sleep quantity and measures of well-being have reported mixed results [25–27].

Another area associated with general well-being and health is a feeling of sleepiness. For example, sleepiness increases the likelihood of a person getting into accidents at work or during leisuretime [28]. Although few studies have examined sleepiness in nonclinical populations, there is some support for a relationship between less sleep and increased sleepiness [29, 30] as well as poorer sleep quality and increased sleepiness [20, 21].

Surprisingly few studies have attempted to investigate health, well-being, and sleepiness simultaneously, and no study to date has looked at both sleep quality and sleep quantity in relation to all three measures. The intent of the current investigation was to directly address this issue using self-report sleep logs and surveys on health, well-being, and sleepiness. To better understand the relationships between measures of sleep quantity and quality and measures of health, well-being, and

sleepiness, we first examined the extent to which sleep quantity and sleep quality overlap. Because length of sleep is one component of sleep quality, some correlation would be expected between the two dimensions of sleep; however, the amount of independence of sleep quality indices from pure sleep quantity measures is important to ascertain. Psychometrically, a high degree of overlap would make it difficult to isolate the individual effects of sleep quantity and quality. More practically, it is important to know the extent to which quantity of sleep affects quality of sleep. Second, we investigated whether the measures of health, well-being, and sleepiness were differentially related to either aspect of sleep.

METHOD

Study 1

Subjects. Volunteers were solicited from an upper division psychology class at a midwestern university. The students were offered extra credit points as an incentive to participate. Of the 45 students enrolled in the class, 39 (28 females, 11 males) volunteered to take part in the study. Thirty of these volunteers (22 females, 8 males) completed the experiment. The mean age of the subjects was 20.9 years (SD=0.98).

Procedures. To assess sleep, health, and well-being during a stressful period, we administered the surveys (described below) on the day preceding each subject's last final exam. The surveys were administered between 6:00 and 9:00 P.M. in a classroom setting for all subjects and took between 30 and 60 minutes to complete. The order of survey presentation was counterbalanced to control for fatigue effects.

For the 7-day period prior to his or her survey date, each subject maintained a daily sleep log. To document sleep habits under normal sleeping conditions in college students, we utilized self-report sleep logs. Self-report estimates of sleep have been shown to be highly correlated with polygraphic measures of sleep quantity and quality [31, 32]. In addition, self-report data have been shown to provide additional information about the effects of psychological distress on sleep patterns not provided by quantitative measures [33]. The subjects made entries in the sleep log each morning after awakening. The sleep log, modeled after that used by Hawkins and Shaw [34], contained six questions: (1) total amount of time in bed for longest sleep period of the day (in hours and minutes); (2) total amount of time asleep for major sleep period (in hours and minutes); (3) rating of daily sleep quality (1=awful to 7=great); (4) time to bed the previous night; (5) time out of bed in the morning; and (6) length in minutes of napping or dozing during the day. The sleep log provided two estimates of sleep quantity (questions 1 and 2) and one estimate of daily sleep quality (question 3).

Surveys. Subjects completed all surveys on the day preceding their last final exam. As a general measure of sleep quality during the last month, each subject completed the Pittsburgh Sleep Quality Index (PSQI) [3] as part of the survey battery. The PSQI has been shown to have strong internal validity (a coefficient alpha of 0.83) and temporal stability (0.85 for an average of 28.2 days). The PSQI contains ten different questions that relate to normal sleep habits (e.g., hours of actual sleep at night, trouble going to sleep, overall sleep quality rating). Subjects were directed to make each response accurately reflect the majority of days and nights during the last month.

Current level of sleepiness at the time of survey administration was measured using two self-report scales. Self-report measures are frequently used to assess level of sleepiness both inside and outside of laboratory settings and have been shown to relate to severity of sleep disturbance, previous time awake, and performance [35–37]. The Stanford Sleepiness Scale (SSS) [35] required the subjects to rate their current sleepiness on a seven-point scale (1=alert to 7=almost asleep). The Epworth Sleepiness Scale (ESS) [36] instructed the subjects to rank their current chance of falling asleep when imagining themselves in eight different situations (e.g., watching TV, sitting and reading) on a four-point scale (0=never to 3=high chance).

The three major components of subjective well-being (positive affect balance, negative affect balance, and general satisfaction with life) were assessed using three independent scales. The Satisfaction with Life Scale (SWLS) [38] is commonly used as an indication of general well-being. The SWLS contains five statements regarding subjective opinions of life (e.g., the conditions of my life are excellent). Using a seven-point scale, the subjects had to agree (7) or disagree (1) with each statement. The SWLS has consistently shown strong internal reliability (a coefficient alpha of 0.87) and moderate temporal stability (0.54 for 4 years) [39]. To measure affect balance, we used the Bradburn Affect Balance Scale (ABS) [40]. The ABS consists of ten yes/no questions, five which indicate a positive affect and five a negative affect (e.g., Did you feel pleased about having accomplished something?). Subjects were told to consider the past few weeks of their lives when responding to the questions. The ABS has been shown to have

Table I.—Summary of scales used in survey battery

Scales	Minimum score	Maximum score and meaning	
Pittsburgh Sleep Quality Index	0	21	Severe sleep disturbance
Stanford Sleepiness Scale	1	7	Extremely sleepy
Epworth Sleepiness Scale	0	24	Extremely sleepy
Cornell Medical Index (both subscales)	0	100%	More health complaints
Bradburn Affect Balance Scale	0	9	Greater positive affect
Satisfaction with Life Scale	5	35	Greater satisfaction
Profile of Mood States			
Tension/anxiety	0	36	Greater tension
Depression/dejection	0	60	Greater depression
Anger/hostility	0	48	Greater anger
Vigor	0	32	Greater vigor
Fatigue	0	28	Greater fatigue
Confusion/bewilderment	0	28	Greater confusion

strong internal validity (a coefficient alpha of 0.76) and moderate temporal stability (0.50 for four tests at least 2 months apart) [40]. For the purposes of this study, we used the five positive affect questions and four of the negative affect questions.[1] In addition to using the ABS as a measure of positive and negative affect, we used the Profile of Mood States (POMS; Educational and Industrial Testing Service, San Diego, CA) to measure general mood as a component of well-being. The POMS supplies a list of words related to six mood states: tension/anxiety, depression/dejection, anger/hostility, vigor, fatigue, and confusion/bewilderment. The subjects ranked each word on a five-point scale from "not at all" (0) to "extremely" (4) according to how they had felt during the past week.

To assess subjective feelings of health, we included The Cornell Medical Index (CMI) [41] in our battery of surveys. The CMI has been widely used as an aid in medical-history taking and significant correlations (0.52 for women and 0.57 for men) have been obtained between physicians' rating and self-rating of psychological and physical health [42]. The CMI poses yes/no questions regarding physical and psychological health. We simplified the CMI for administration to college students by eliminating questions that pertain to only one gender and by deleting questions that apply specifically to aging.[2] The questions in the CMI are grouped into clusters A through R with each cluster representing a different type of health complaint. Clusters A through K represent physical health complaints, such as complaints about eyes and ears and digestive processes. Clusters L through R represent health concerns related to psychological well-being, such as excessive nervousness and loneliness. All scales administered as part of the survey battery are summarized in Table I.

Data analyses. To consolidate the data from the sleep logs, we averaged each subject's response across the 7 days for each of the six questions. The remaining surveys were scored according to the directions given for each scale. We calculated one PSQI score, one SSS score, one ESS score, one SWLS score, one ABS score (total affect), and six POMS scores (tension/anxiety, depression/dejection, anger/hostility, vigor, fatigue, and confusion/bewilderment). In addition, we created two health variables as recommended in the scoring instructions for the CMI. We calculated the percentage of yes responses to questions in clusters L through R to determine a single score for psychological health complaints. To determine a total physical health complaints score, we computed the percentage of yes responses to questions in clusters A through K. Higher numbers on all scales represent a greater frequency of the related occurrence (see Table I).

All statistical analyses were completed on SAS (SAS Institute Inc., Cary, NC). First, we determined the degree of overlap between sleep quantity and sleep quality by conducting a correlational analysis between these variables, resulting in four correlation coefficients. Second, we completed a correlational analysis of the measures of sleep quantity and sleep quality with the measures of health, well-being, and sleepiness. The correlational analyses between the measures of sleep and measures of health, well-being, and sleepiness resulted in a total of 48 correlation coefficients. Third, to control for the effects of the covariation between sleep quality and sleep quantity on the relationships between sleep quality and measures of health, well-being, and sleepiness, we completed a partial correlational analysis of sleep quality after removing the variance due to both estimates of sleep quantity (time in bed and time asleep).

[1] We chose to eliminate question 8, "depressed or very unhappy," from the ABS, due to a typographical error which resulted in responses that could represent either positive or negative affect.

[2] The exact questions used in our modified version of the CMI are available upon request.

Table II.—Average sleep habits

Sleep log question	Study 1 M	Study 1 SD	Study 2 M	Study 2 SD
1. Time in bed	7 hr 17 min	1.01	7 hr 42 min	1.02
2. Time asleep	6 hr 41 min	1.07	7 hr 4 min	1.11
3. Daily quality rating[a]	4.87	0.88	4.99	0.97
4. Time into bed	2:05 A.M.	1.57	1:45 A.M.	1.18
5. Time out of bed	9:23 A.M.	1.50	9:30 A.M.	1.02
6. Time napping (min)	27.27	23.55	17.71	21.61

[a] Daily sleep quality rating scale: 1 = awful to 7 = great.

Study 2

To better document the relationships between sleep quality and measures of health, well-being, and sleepiness, we replicated study 1 with a larger group of subjects at a less stressful time of the semester.

Subjects. Volunteers were solicited from two general introductory psychology courses. The students were offered extra credit points as an incentive to participate. None of the subjects from study 1 were permitted to participate in study 2. Of the 279 students enrolled in both courses, 99 (69 females, 30 males) volunteered to take part in the study. Of these volunteers, 87 (62 females, 25 males) completed the study. The mean age of these subjects was 18.9 (SD=1.1).

Procedures. The procedures used for the second study were similar to the first study, with the exception that the sleep logs were kept during the third week of the semester and the surveys were administered on the fourth Wednesday of the semester. As in study 1, the subjects maintained the sleep log for a 7-day period prior to the survey date. All subjects completed the surveys between 7:00 and 9:00 P.M. in a similar classroom setting to that used in study 1. The order of the survey presentation was counterbalanced to control for fatigue effects.

Measures. The sleep log and battery of surveys used in study 2 were identical to those used in study 1.

Data analysis. For comparison purposes, the data from study 2 were initially analyzed exactly as the data were analyzed in study 1. The same measures of sleep quantity, sleep quality, health, well-being, and sleepiness were calculated and similar correlational analyses were conducted. In addition to the correlation and partial correlation analyses completed in study 1, we tested whether the relationships between sleep quantity and measures of health, well-being, and sleepiness were significantly different from the relationships between sleep quality and measures of health, well-being, and sleepiness. Using Fisher's *r*-to-*z* conversion [43], we first normalized all correlations and then conducted a chi-square analysis to test for significant differences between the correlations for sleep quantity (time in bed, time asleep) and sleep quality (average sleep quality, daily sleep quality) for each of the health, well-being, and sleepiness variables.

In sum, study 2 was a replication of study 1 with three differences: (1) study 2 had more subjects; (2) study 2 took place early in the semester, specifically avoiding the more stressful time around final exams; and (3) the subjects in study 2 maintained their sleep logs for the same 7-day period.

RESULTS

Study 1

The sleep habits of the 30 subjects in study 1 are summarized in Table II. On average, the subjects were in bed for slightly more than 7 hours a night and reported taking less than 30 minutes to go to sleep. Subjects usually had relatively late bedtimes and late rising times. In addition to their major sleep period of the day, subjects reported an average of 30 minutes of napping each day.

In general, the correlation between the measures of sleep quantity and sleep quality were relatively small. Amount of time in bed correlated −0.02 with daily sleep quality rating and −0.17 with the PSQI. Estimated time asleep correlated 0.08 with daily sleep quality rating and −0.31 with the PSQI.

The results from the analyses of the relationships between measures of sleep

quantity and quality and measures of health, well-being, and sleepiness are summarized in the first two columns of Table III. In general, health and well-being measures were better related to sleep quality than sleep quantity. Poor sleep quality, as measured by the PSQI, was significantly correlated with increased physical health complaints, and with increased feelings of tension, depression, anger, fatigue, and confusion. Similarly, poor sleep quality, as measured by the daily ratings was significantly correlated with increased physical health complaints and elevated tension, depression, fatigue, and confusion. On the other hand, sleep quantity as measured by average time in bed or average time asleep was not significantly correlated with any measure of health or well-being. Increased sleepiness as measured by the SSS was equally related to a decrease in sleep quality and quantity, whereas increased sleepiness as measured by the ESS was not related to either sleep quality or quantity. The third column of Table III shows the partial correlation of sleep quality accounting for the covariance due to sleep quantity. The partial correlations for sleep quality are virtually identical to the normal Pearson correlations for sleep quality (middle column Table III) indicating that the relationships between sleep quality and measures of health, well-being, and sleepiness are independent of any effect by sleep quantity.

Study 2

As shown in Table II, the sleeping habits of the subjects in study 2 were very similar to those of study 1. Subjects in study 2 were in bed for approximately 7 hours 45 minutes each night and estimated sleeping for about 7 hours each night. Their bedtimes were relatively late, as were their rising times, and they reported napping an average of 18 minutes each day.

As in study 1, we calculated correlation coefficients between each sleep quantity and quality measure as an estimate of overlap. Similar to study 1, the correlations between sleep quantity as measured by time in bed and sleep quality were relatively small. Amount of time in bed correlated 0.15 with daily sleep quality rating and -0.08 with the PSQI. Estimated time asleep was moderately correlated with the sleep quality measures (daily sleep quality rating: 0.34; PSQI: -0.27).

The results of the correlational analyses between measures of sleep quantity and quality and measures of health, well-being, and sleepiness are summarized in the first two columns of Table IV. As in study 1, health and well-being were clearly better related to sleep quality than sleep quantity. Poor sleep quality as measured by the PSQI was significantly correlated with increased psychological and physical health complaints, and with many measures of well-being, including a more negative affect; less satisfaction with life; and increased feelings of tension, depression, anger, fatigue, and confusion. Similarly, poor sleep quality as measured by the daily ratings was significantly correlated with increased psychological and physical health complaints and with many measures of well-being, including a more negative affect, less satisfaction with life, and more tension, depression, anger, vigor, fatigue, and confusion. On the other hand, sleep quantity as measured by either the average time in bed or the average time asleep was not significantly correlated with either measure of health and with only two measures of well-being. As estimated time in bed and time asleep decreased, feelings of fatigue and confusion increased. Increased sleepiness as measured by the SSS was significantly correlated with a de-

Table III.—Study 1: Correlations between measures of average sleep quantity and quality and measures of health, well-being and sleepiness

Measure	Sleep quantity		Sleep quality		Partial sleep quality	
	Time in bed	Time asleep	PSQI[a]	Daily rating[b]	PSQI	Daily rating
Cornell Medical Index						
Psychological health complaints	−0.04	−0.08	0.35	−0.34	0.33	−0.32
Physical health complaints	0.16	0.06	0.60***	−0.47**	0.61***	−0.43*
Bradburn Affect Balance Scale	−0.05	−0.08	−0.17	0.24	−0.24	0.28
Satisfaction with Life Scale	−0.05	−0.06	−0.31	0.33	−0.38*	0.36
Profile of Mood States						
Tension/anxiety	−0.10	−0.05	0.44*	−0.52**	0.53**	−0.57***
Depression/dejection	0.08	0.12	0.39*	−0.52**	0.51**	−0.57***
Anger/hostility	−0.01	−0.17	−0.60***	−0.32	0.52**	−0.24
Vigor	−0.11	−0.15	−0.31	0.24	−0.43*	0.29
Fatigue	−0.19	−0.23	0.55**	−0.57***	0.52**	−0.57***
Confusion/bewilderment	−0.09	−0.07	0.42*	−0.41*	0.48**	−0.44*
Stanford Sleepiness Scale	−0.31	−0.41*	0.37*	−0.35	0.22	−0.32
Epworth Sleepiness Scale	0.00	−0.02	0.11	0.06	0.10	0.08

[a] Higher numbers indicate poorer sleep quality.
[b] Higher numbers indicate better sleep quality.
* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

Table IV.—Study 2: Correlations between measures of average sleep quantity and quality and measures of health, well-being and sleepiness

Measure	Sleep quantity		Sleep quality		Partial sleep quality	
	Time in bed	Time asleep	PSQI[a]	Daily rating[b]	PSQI	Daily rating
Cornell Medical Index						
Psychological health complaints	−0.02	−0.17	0.34***	−0.36***	0.44****	−0.36**
Physical health complaints	0.01	−0.16	0.39***	−0.40***	0.52****	−0.43****
Bradburn Affect Balance Scale	−0.01	0.04	−0.26**	−0.40***	−0.25*	0.43****
Satisfaction with Life Scale	0.04	0.19	−0.22*	0.24*	−0.19	0.28*
Profile of Mood States						
Tension/anxiety	−0.06	−0.17	0.30**	−0.29**	0.28*	−0.28*
Depression/dejection	0.04	−0.10	0.40***	−0.32**	0.38***	−0.32**
Anger/hostility	−0.03	−0.19	0.37***	−0.35***	0.38***	−0.37**
Vigor	0.06	0.07	−0.19	0.21*	−0.18	0.25*
Fatigue	−0.24*	−0.28**	0.26*	−0.30**	0.32**	−0.32**
Confusion/bewilderment	−0.26*	−0.39***	0.44***	−0.39***	0.45****	−0.37***
Stanford Sleepiness Scale	−0.09	−0.15	0.24*	−0.23*	0.25*	−0.30**
Epworth Sleepiness Scale	−0.18	−0.15	0.26**	−0.15	0.38***	−0.20

[a] Higher numbers indicate poorer sleep quality.
[b] Higher numbers indicate better sleep quality.
* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$; **** $p < 0.0001$.

Table V.—Study 2: Chi-square analysis between sleep quantity and sleep quality measures

Sleep quality measure	Time in bed		Time asleep	
	PSQI	Daily rating	PSQI	Daily rating
Cornell Medical Index				
Psychological health complaints	9.96**	2.96	15.16***	0.97
Physical health complaints	10.11**	6.59*	15.73***	3.18
Bradburn Affect Balance Sheet	1.35	8.57**	1.22	8.93**
Satisfaction with Life Scale	1.47	2.40	3.53	0.78
Profile of Mood States				
Tension/anxiety	2.72	2.20	3.57	1.54
Depression/dejection	4.77**	5.35*	7.75**	3.07
Anger/hostility	8.86**	4.16*	16.16***	0.99
Vigor	1.60	1.37	1.18	1.82
Fatigue	11.05***	0.07	11.05***	0.07
Confusion/bewilderment	20.03***	0.37	25.89***	0.00
Stanford Sleepiness Scale	4.01*	1.76	5.45*	1.04
Epworth Sleepiness Scale	9.88**	0.01	9.88**	0.01

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$.

crease in both reports of sleep quality but neither measure of sleep quantity. Increased sleepiness as measured by the ESS was significantly correlated with poor sleep as measured by the PSQI but not the daily sleep quality ratings or either measure of sleep quantity. The partial correlations for sleep quality accounting for the covariance due to sleep quantity are given in the third column of Table IV. As in the first study, the partial correlations for sleep quality are virtually identical with the normal Pearson correlations for sleep quality (middle column Table IV). This indicates that the relationships observed between sleep quality and measures of health, well-being, and sleepiness are independent of any effect due to sleep quantity.

The chi-square analysis indicated that a number of the correlations between sleep quality and measures of health, well-being, and sleepiness were significantly different from the correlations between sleep quantity and measures of health, well-being, and sleepiness (Table V). More specifically, the correlations between the PSQI and the measures, CMIX, CMIY, POMD, POMA, POMF, POMC, SSS, and ESS, were significantly greater than the correlations for either of the sleep quantity measures. Interestingly, the correlations between daily sleep quality ratings and measures of health, well-being, and sleepiness were not as different from the correlations pertaining to sleep quantity as those correlations with PSQI were. The correlations between the daily sleep quality ratings and ABS were significantly greater than the correlations for either of the sleep quantity measures. In addition, the correlations between the daily sleep quality ratings and the measures, CMIY, POMD, and POMA, were significantly greater than the correlations for sleep quantity as estimated by the time in bed.

In sum, the results from study 1 and study 2 were very similar. Both studies suggested that the measures of sleep quality were only marginally related to measures of sleep quantity. Furthermore, both studies clearly indicate that measures of health, well-being, and sleepiness are better related to sleep quality than sleep quantity. In addition, the partial correlations for sleep quality demonstrate that the

relationships between sleep quality and measures of health, well-being, and sleepiness were independent of any covariation with sleep quantity. Finally, the chi-square analysis in study 2 showed that the correlations associated with sleep quality, especially the PSQI, were significantly greater than the correlations associated with the sleep quantity measures.

DISCUSSION

The current results suggest that sleep quality is better related to measures of health, well-being, and sleepiness than sleep quantity in a nonclinical population reporting an average of 7–8 hours of sleep at night. Specifically, in two separate groups of college students, one during final exam week (study 1) and one during the first third of the semester (study 2), poor sleep quality was correlated with increased physical health complaints, as measured by the Cornell Medical Index, and to increased feelings of anxiety, depression, anger, fatigue, and confusion, as measured by the Profile of Mood States (POMS). Furthermore, poor sleepers in study 2 reported a decrease in positive affect and a decrease in satisfaction with life. In addition, poor sleepers in both studies reported increased levels of sleepiness, especially as measured by the Stanford Sleepiness Scale (SSS). Last, the results from the chi-square analysis indicated that, of the two sleep quality measures, the Pittsburgh Sleep Quality Index (PSQI) and daily sleep quality, the relationships between the PSQI and measures of health, well-being, and sleepiness were more significantly different from the sleep quantity relationships.

To better understand and interpret the relationships between sleep and measures of health, well-being, and sleepiness, we investigated the degree to which the two aspects of sleep, sleep quantity and sleep quality, overlap. Because sleep quantity is one component of sleep quality, it was expected that the two would correlate to some extent. The current data indicate that estimated time asleep, but not estimated time in bed, was moderately correlated with the sleep quality measures, especially the PSQI. However, this relatively small overlap did not directly affect the current conclusions because the partial correlations (removing the variation due to both measures of sleep quantity) between sleep quality and measures of health, well-being, and sleepiness were virtually identical to the standard Pearson correlations on sleep quality. Thus, the components of sleep quality other than simply sleep quantity (e.g., number of awakenings at night, general satisfaction with sleep) appear to be largely responsible for the relationships between sleep quality and measures of health, well-being, and sleepiness. It must be noted, however, that these relationships exist in nonclinical populations where the subjects report 7–8 hours of sleep at night and that sleep duration outside of the 7–8-hour range may have a substantial effect on health, well-being, and sleepiness not seen in the current study [44, 45].

The use of correlational data allow us to estimate the amount of variance in health, well-being, and sleepiness accounted for by sleep quantity and sleep quality. When examining the standard Pearson correlations in the two studies, it can be seen that the proportion of variance explained ranges from 0.0 to 0.372. Whereas the amount of variance explained is not large, it is consistent with other studies looking at sleep, health, and well-being across a variety of populations (e.g., [5, 24, 27, 35, 36]). When the r^2 values are examined more closely, it can be seen that sleep quality

accounts for more of the variance in health measures (study 1: M=0.20±0.11; study 2: M=0.14±0.02) and well-being measures (study 1: M=0.17±0.10; study 2: M=0.10±0.05) than sleep quantity (health measures: study 1: M=0.01±0.01; study 2: M=0.01±0.02 and well-being measures: study 1: M=0.01±0.01; study 2: M=0.03±0.04). However, sleep quality (study 1: M=0.07±0.07; study 2: M=0.05±0.02) and sleep quantity (study 1: M=0.07±0.08; study 2: M=0.02±0.01) account for approximately equal amounts of variance in sleepiness. While these data indicate that sleep is only one of several life-style factors contributing to the overall health, well-being, and sleepiness of the individual, sleep quality clearly accounts for more of the variance in both health and well-being as measured by the surveys used in the current study than sleep quantity.

One relevant point to consider is the external conditions present during study 1 and study 2. Study 1 was conducted in December, during final exam week, a presumably stressful time for college students, whereas study 2 was completed in February, during the fifth week of the semester, a presumably less stressful time for college students. In spite of the difference in time of the semester for the sleep log and survey administration, little difference in the pattern of relationships between measures of sleep and measures of health, well-being, and sleepiness was found. It is feasible that the stability of the relationships found in the current set of studies may be more dependent upon seasonal effects than on other external stimuli, such as perceived stress due to final exams. However, the data could also indicate that the relationships are relatively robust and are not easily altered by external conditions.

One notable finding was the lack of consistency in results between the Epworth Sleepiness Scale (ESS) and the SSS. Our data indicated that the SSS was better related to sleep measures, particularly sleep quality, than the ESS. This difference may be due to the manner in which the scales assess sleepiness. By asking the subjects to project their sleepiness to a different setting, the ESS may be altering the manner in which the subjects report sleepiness in comparison to the SSS. If both scales were measuring sleepiness in the same manner, one would expect the two measures to be highly correlated. However, the correlations between the ESS and the SSS were relatively low. In study 1, the ESS correlated 0.15 with the SSS, and in study 2 the ESS correlated 0.29 with the SSS. Therefore, it is likely that the two sleepiness scales are measuring sleepiness in different manners and that the method used by the SSS is more meaningful in relation to subjective sleep quality measures.

There are several experimental limitations to be considered when drawing conclusions from the current studies. Certainly, any self-report data must be cautiously interpreted. However, there is substantial evidence that self-report estimates of sleep are highly correlated with polygraphic measures of sleep quantity and quality [31, 32] and as such provide a meaningful data set from which to draw conclusions. In addition, self-report measures on health, well-being, and sleepiness are frequently used and provide meaningful data based on subjects' self-perceptions of these variables (e.g., [46–48]). Another concern with the current design is the number of actual correlations computed. It is possible that some of the correlations would be significant between measures of sleep and measures of health, well-being, and sleepiness simply by chance. However, with the current data, this concern is less valid. If the correlations reported were due mostly to chance, one would expect the correlations to be more evenly distributed between the sleep quantity and sleep

quality categories. Because the vast majority of significant correlations occurred with the sleep quality variables, this particular concern does not meaningfully affect the conclusions from the current set of studies. In addition, the partial correlations on sleep quality indicate that the relationships between sleep quality and measures of health, well-being, and sleepiness are independent of any covariance with sleep quantity, thus providing additional support for the conclusion that health, well-being, and sleepiness are better related to sleep quality than sleep quantity.

In sum, our results lend further support to the importance of sleep and its relationships to health, well-being, and sleepiness in nonclinical populations sleeping an average of 7–8 hours a night. Few studies prior to ours have used a comparably extensive set of measures of health, well-being, and sleepiness with nonclinical populations as those used here, and those studies that did [20, 21] yielded similar results. Unlike these two earlier studies, our research specifically compared sleep quantity to sleep quality. The current data indicate a predictable pattern of correlations between sleep quality and measures of health, well-being, and sleepiness. However, a similar pattern was not found between these measures and sleep quantity. In addition, the relationships between measures of health, well-being, and sleepiness and sleep quality were significantly greater than many of the relationships between measures of health, well-being, and sleepiness and sleep quantity. In addition, we found that the relationships between sleep quality and measures of health, well-being, and sleepiness are independent of the effect of sleep quantity on sleep quality. The current results demonstrate that future research on sleep and preventative medicine in nonclinical populations should focus on sleep quality in addition to sleep quantity to better understand the role of sleep in daily health, well-being, and sleepiness.

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