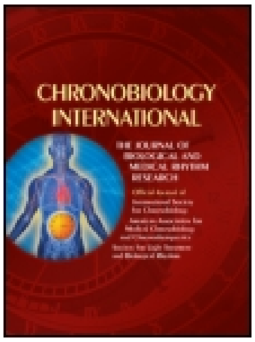

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The Relationship Between Lifestyle Regularity and Subjective Sleep Quality

Timothy H. Monk,* Charles F. Reynolds III, Daniel J. Buysse, Jean M. DeGrazia, and David J. Kupfer

Clinical Neuroscience Research Center, Western Psychiatric Institute and Clinic, University of Pittsburgh Medical Center, Pittsburgh, Pennsylvania, USA

ABSTRACT

In previous work we have developed a diary instrument—the Social Rhythm Metric (SRM), which allows the assessment of lifestyle regularity—and a questionnaire instrument—the Pittsburgh Sleep Quality Index (PSQI), which allows the assessment of subjective sleep quality. The aim of the present study was to explore the relationship between lifestyle regularity and subjective sleep quality. Lifestyle regularity was assessed by both standard (SRM-17) and shortened (SRM-5) metrics; subjective sleep quality was assessed by the PSQI. We hypothesized that high lifestyle regularity would be conducive to better sleep. Both instruments were given to a sample of 100 healthy subjects who were studied as part of a variety of different experiments spanning a 9-yr time frame. Ages ranged from 19 to 49 yr (mean age: 31.2 yr, s.d.: 7.8 yr); there were 48 women and 52 men. SRM scores were derived from a two-week diary. The hypothesis was confirmed. There was a significant (rho $= -0.4$, $p < 0.001$) correlation between SRM (both metrics) and PSQI, indicating that subjects with higher levels of lifestyle regularity reported fewer sleep problems. This relationship was also supported by a categorical analysis, where the proportion of "poor sleepers" was doubled in the "irregular types" group as compared with the "non-irregular types" group. Thus, there appears to be an association between lifestyle regularity and good sleep, though the direction of causality remains to be tested.

*Correspondence: Timothy H. Monk, D.Sc., WPIC Room E1123, 3811 O'Hara St., Pittsburgh, PA 15213, USA; Fax: 412-624-2841; E-mail: monkth@msx.upmc.edu.

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Key Words: Human; Circadian rhythm; Sleep; Social rhythm metric.

INTRODUCTION

One major function of the human endogenous circadian pacemaker is to prepare the individual for a restful night of sleep. In an inquisitive, social and visually oriented species such as *Homo Sapiens*, suppression of various behaviors and drives needs to be undertaken, and the physiological milieu needs to be appropriate, if the individual is to obtain sufficient rest (Aschoff, 1965). Whereas the function of the circadian pacemaker during the day is to maintain alertness and activity, at night appetite, thirst, the need to void, and the desire to move about and socially interact all have to be suppressed so that sleep can occur. It thus naturally follows that if the circadian pacemaker is *not* functioning properly, then it is *unlikely* that a restful seven or eight hours of sleep will be obtained. The truth of that is confirmed in field studies of shift workers and transmeridian air travelers in which sleep disruption is found to be a major symptom of circadian dysfunction (Arendt et al., 1997; Klein et al., 1972; Moore-Ede and Richardson, 1985), and in laboratory studies involving phase shifts or abnormal "day" lengths in which the amount of sleep obtained is found to be dependent on the circadian phase at which sleep is attempted (Carskadon and Dement, 1975; Dijk et al., 1997; Lavie, 1991). Conventional wisdom in the field of human circadian rhythms thus holds that good (i.e., robust and appropriately phased) circadian rhythms lead to better sleep, and many behavioral techniques to counter insomnia prescribe behaviors (such as regularity in bedtimes) that are likely to lead to high-amplitude, phase-stable, circadian rhythms (Manber and Bootzin, 1991; Morin et al., 1994).

As we have noted elsewhere (Monk et al., 2002), in much the same way that there are *physiological* circadian rhythms in variables such as core body temperature and plasma hormone concentrations, so too are there *behavioral* circadian rhythms related to the timing with which various social, work, feeding, and rest-related activities occur. Early human circadian rhythm researchers using time isolation laboratories had the subject record when activities such as meals took place, so that the subjective day could be plotted out in relation to successive sleep/wake cycles (Wever, 1979). It was found that the gap in timing between, for example, breakfast and lunch, could predict subjective day length as a whole in free-running conditions (Aschoff et al., 1984). Historically, though, more attention has typically focused on the physiological variables than on the behavioral ones. This is despite the latter's salience to the person involved, for whom the *only* observable impact on *his or her* circadian system is when it affects how hungry or sleepy one feels at a particular time of day or night (Monk, 1991).

Interindividual phase differences in the habitual timing, or phase, of behavioral events can be gleaned from studies in which "morning larks" are compared to "night owls" (Horne and Ostberg, 1976). It is interesting to note that behavioral rhythm phase differences are often greater than those observed in physiological variables (Patkai, 1971). Separate from the issue of habitual *timing* (phase) of behavioral circadian rhythms are interindividual differences in lifestyle regularity. Because irregularity in phase leads to a reduction in overall educed amplitude (i.e., a flattening in the "time of day" effect when plotted on an average basis), measures of lifestyle regularity can be considered as the analog of circadian *amplitude* within the behavioral domain. Simple observation reveals that some people have very regimented lives with events taking place at the same time each day, while others have much more irregular schedules. Similarly, within the same individual, lifestyle regularity may decrease, for example when the individual is on vacation, sick, or retired (Ehlers et al., 1993). Psychiatric illness, in particular, can lead to a disintegration of the temporal patterning of daily events, as well as the behavioral and physiological circadian rhythms underlying them (Kupfer et al., 1988; Shear et al., 1994; Szuba et al., 1992). Such illness has also been shown to disrupt sleep (Kupfer et al., 1978).

The Social Rhythm Metric [SRM] (Monk et al., 1990; 1994) was developed to quantify the extent to which a person's life is regular vs. irregular on a daily basis with respect to event timing. The SRM yields a numerical index of lifestyle regularity, with higher numbers representing greater regularity, lower numbers less regularity. Details of the instrument and its scoring appear in the Methods section. The SRM score can be considered as a measure of behavioral circadian rhythm amplitude and is indeed found to be related to differences in amplitude of the physiological circadian rhythm of core body temperature (Monk et al., 1994).

A number of SRM studies have been conducted exploring lifestyle regularity in healthy young adults (Monk et al., 1994), depressed and nondepressed elderly bereaved persons (Brown et al., 1996; Prigerson et al., 1996), depressed inpatients (Szuba et al., 1992), depressed outpatients in remission (Monk et al., 1991), anxiety disorders patients (Shear et al., 1994), and new parents (Monk et al., 1996). The SRM score appears to increase over the life span when different age groups are studied, with healthy seniors in their eighth and ninth decades of life being about one standard deviation higher (i.e., more regular) in SRM score than young adults in their third decade (Monk et al., 1992; 1997). In earlier papers we have posited that high SRM scores (i.e., greater lifestyle regularity) might be protective of successful aging and better sleep (Monk et al., 1994; 1997). Recently, we have reported a shorter five-item SRM instrument (SRM-5) which appears to correlate well with results obtained from the full 17-item instrument (Monk et al., 2002). The present report uses both SRM-5 and SRM-17 metrics to estimate lifestyle regularity, using the same 17-item diary.

In the area of sleep assessment, we developed the Pittsburgh Sleep Quality Index (PSQI) as a self-rated questionnaire for evaluating subjective sleep quality (Buysse et al., 1989). Subsequent studies in our institution have used the PSQI in studies of maintenance treatment response in late-life depression (Reynolds et al., 1997a,b), sleep disorders consequent upon bereavement (Pasternak et al., 1992), and the effects of aging (Buysse et al., 1991). The PSQI, which has proved to be popular with other researchers, is now used in several different laboratories and has been translated into German, Dutch, Chinese, Spanish, Japanese, and Italian. Published papers from investigators in other laboratories have used the PSQI to examine sleep quality in patients suffering from brain injury (Fichtenberg et al., 2002), retinitis pigmentosa (Gordo et al., 2001; Ionescu et al., 2001), victims of sexual assault (Krakow et al., 2001), cancer caregivers (Carter and Chang, 2000), and patients with chronic pain (Menefee et al., 2000).

The aim of the present study was to explore the relationship between lifestyle regularity (as assessed by SRM-17 and SRM-5 metrics) and subjective sleep quality (as assessed by the PSQI) in a sample of 100 people. We sought to test three main inter-related hypotheses: 1) that there would be a significant negative correlation between SRM and

PSQI scores (*greater regularity associated with fewer sleep problems*); 2) that subjects with PSQI scores at or above 5 (the cutoff score at which pathology is suspected) would have significantly lower SRM scores than those with PSQI scores below 5 (i.e., *the subjects with sleep problems would have more irregular lifestyles*); and 3) when categorized by the SRM as an "irregular type" (i.e., with an SRM more than one s.d. below the mean), the subject would be more likely to be a "poor sleeper," having a PSQI score at or above 5 (i.e., *the irregular lifestyle types would be more likely to be the poor sleepers*).

METHODS

Details of the SRM and PSQI Instruments

In its full original form, the SRM is a diary-like instrument with one page used per day. It is completed each evening before going to bed and requires the subject to record when and with whom 17 event categories occurred. The 17 events are: 1) Get out of bed, 2) First contact with another person, 3) Morning beverage, 4) Breakfast, 5) Go outside, 6) Start work, housework, or volunteer activities, 7) Lunch, 8) Afternoon nap, 9) Have dinner, 10) Exercise, 11) Evening snack or drink, 12) TV news, 13) Other TV program, 14) Activity A, 15) Activity B, 16) Return home last time, and 17) Go to bed. Activity A and Activity B are activities idiosyncratic to the individual (e.g., phone mother) which are "written-in" for the duration of the study. The seven sheets from a given week are then scored as a unit. First, the habitual time for each event is calculated (for events occurring three or more times per week) using an outlier elimination algorithm. Then, a count is made of how many events in the week occurred within 45 min of the habitual time (i.e., could be scored as a "hit") with a maximum of seven, for example, when the event was done at the same time each day of the week. Averaging these hit counts over the contributing event categories (items) then yields an overall score on a continuum between 0 and 7. This SRM score then represents the subject's level of daily lifestyle regularity for that week (higher number = more regular). Recently, a shorter five-item version of the SRM has been described (Monk et al., 2002). For SRM-5, the events recorded are 1) Get out of bed, 2) First contact with another person, 3) Start work, housework, or volunteer activities, 4) Have dinner, and 5) Go to bed. The scoring procedures are otherwise identical. The present report uses both SRM-5 and SRM-17 metrics to estimate lifestyle regularity, using the same 17-item diary.

The PSQI is a single questionnaire that includes 19 questions regarding the subject's habitual sleep over the past one month. The questions require open-ended answers regarding sleep timing and multiple-choice responses regarding the severity or frequency of other sleep habits and problems. The 19 questions are combined into seven clinically derived component scores (broadly defined as: sleep quality, habitual sleep efficiency, daytime dysfunction, sleep latency, sleep disturbances, sleep duration, use of sleep medications). The seven component scores are given values of 0, 1, 2, or 3 and then added to obtain a global score ranging from 0 to 21. Higher scores indicate worse sleep quality, and a score at or above 5 is considered indicative of sleep pathology (Buysse et al., 1989).

Subjects and Procedure

From a variety of studies conducted at the University of Pittsburgh over the past 9 yr we collected a total of 100 two-week 17-item SRM studies completed by healthy control subjects who had also completed the PSQI questionnaire. Mostly, these subjects had taken part as members of a healthy control group for studies of aging and/or mental illness, or as subjects in a normative study of lifestyle regularity. Selection was done blindly with reference to the SRM or PSQI score, but open to age and gender, so that the two genders were approximately equally represented and were matched for mean age (women: 32 yr, men: 31 yr). Ages ranged from 19 yr to 49 yr (mean age: 31.2 yr, s.d.: 7.8 yr) and there were 48 women and 52 men. All analyses were based on averages of the two weeks. Subjects were required to be free from a history of past or present mental or sleep disorders. Shift workers, and those recently returned from different time zones, were not studied. Two SRM analyses were performed on each subject's data—one using the SRM-17 score, the other the SRM-5 score (though both came from the same 17-item diary instrument). The PSQI was completed during the initial screening process that usually took place before the two-week SRM study. The present analysis focuses on the overall PSQI score calculated by the addition of the seven component scores. Secondary analyses evaluated correlations between the seven individual component PSQI scores and the SRM. All correlations used the nonparametric Spearman's rho statistic.

RESULTS

The 100 subjects had a mean overall PSQI score of 3.05 (s.d. = 2.00), a mean SRM-17 score of 3.57 (s.d. = 0.79), and a mean SRM-5 score of 4.48 (s.d. = 0.98). There was a significant negative correlation between the SRM-17 and overall PSQI scores (rho = −0.44, $p < 0.001$), indicating that a more regular lifestyle was associated with fewer sleep problems. A scattergram between SRM-17 and PSQI (overall) scores is illustrated in Fig. 1. A significant negative correlation was also found when lifestyle regularity was assessed using SRM-5 (rho = −0.45, $p < 0.001$).

The difference of about 0.9 units between the SRM-17 and SRM-5 was significant (t = 21.3, $p < 0.001$) and is in accord with previous findings, discussed elsewhere (Monk et al., 2002). No significant gender difference emerged in PSQI score (t = 1.14, $p > 0.25$), but both SRM indices showed a significant gender effect, with males about 0.4 units higher (more regular) than females (SRM-17: 3.76 vs. 3.36, t = 2.59, $p < 0.02$; SRM-5: 4.68 vs. 4.26, t = 2.18, $p < 0.05$). Such a difference has been found before in some, but not all, of our previous studies (Monk et al., 2002). The correlations between lifestyle regularity and sleep quality also appeared when the two genders were considered separately, both for SRM-17 vs. PSQI (males: rho = −0.526, $p < 0.001$; females: rho = −0.469, $p < 0.001$), and for SRM-5 vs. PSQI (males: rho = −0.565, $p < 0.001$; females: rho = −0.414, $p < 0.003$).

When the sample was divided into those scoring on the overall PSQI at or above 5 (n = 21) and those scoring below 5 (n = 79), the former had significantly lower SRM scores than the latter (3.2 vs. 3.7, t = 2.39, $p < 0.02$). Thus, those subjects with PSQI scores suggesting sleep pathologies were also those with the lower SRM-17 scores

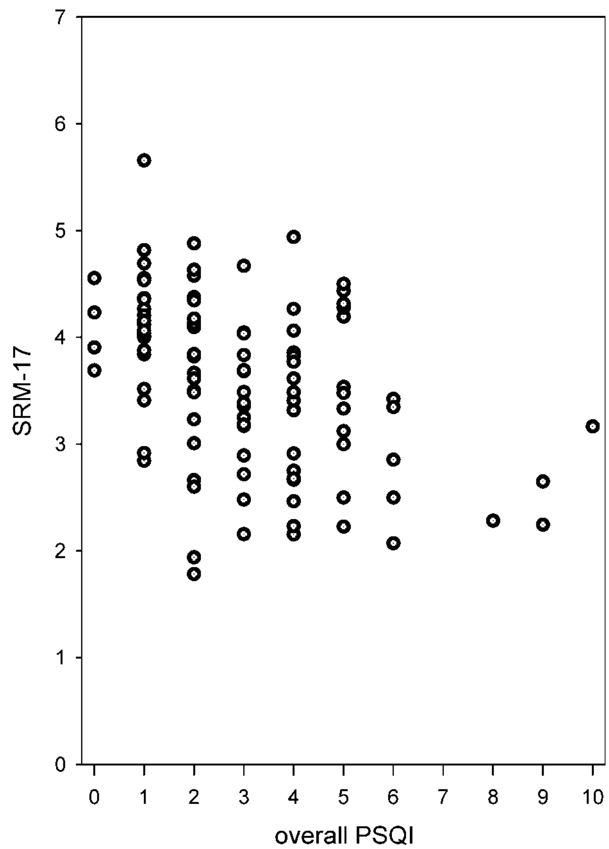

Figure 1. Scattergram of SRM-17 vs. PSQI (n = 100).

indicating lifestyle irregularity. A category-based analysis of lifestyle regularity, when "SRM irregular" types were defined by subjects who scored more than one standard deviation below the SRM-17 mean (i.e., below 2.78), resulted in 20 such subjects (6 men, 14 women). A total of 35% of these "irregular types" (7/20) had PSQI scores at or above 5 (i.e., were categorized as "poor sleepers"); but only 17.5% (14/80) of the other 80 (i.e., "non-irregular type") subjects were "poor sleepers" ($p = 0.08$, Fisher's exact probability test). Thus, there were more poor sleepers (on a proportional basis) in the "irregular type" group than in the "non-irregular type" group.

Correlations between scores on the seven individual PSQI components and SRM-17 were noisy because of the large number of zero scores on these components (component scores could only be 0, 1, 2, or 3). However, the strongest correlations ($p < 0.05$) appeared in sleep quality, sleep efficiency, daytime dysfunction, and sleep latency, rather than in the other three components. This suggested that the sleep pathologies manifest in the overall PSQI versus SRM correlations were probably at best only weakly driven by sleep medication use, sleep disturbances, or sleep duration.

DISCUSSION

The underlying hypothesis linking lifestyle regularity with sleep quality is supported by the present findings. It should be noted, though, that the direction of causality of this link remains to be determined. While the present report has focused on the concept of a well-functioning circadian system leading to improved sleep, the opposite direction of causality is equally plausible. Thus, a person having poor sleep (for whatever reason) may be more likely to make inappropriate (and irregular) bedtime and waketime choices in the desire to obtain sufficient sleep. Moreover, there are stresses (e.g., caring for a sick child) and disorders (e.g., depression) that are known to have a detrimental effect on *both* lifestyle regularity *and* sleep.

As we have shown in developing the SRM-5 (Monk et al., 2002), rhythmicity (or the lack of it) in bedtime and waketime choices may well drive the rhythmicity observed in the waking day as a whole. Irregularity in bedtime and waketime from poor sleep may then lead to a reduction in lifestyle regularity metrics, such as the SRM. However, recognizing that this study involved only subjectively reported sleep data (which tend to be noisy), the correlation of 0.44 would appear to be both clinically and statistically significant, especially given the large sample size of 100. Of course, this still accounts for less than 20% of the variance, and a number of other factors are undoubtedly influencing sleep.

Importantly, given the gender difference in lifestyle regularity, the correlation between lifestyle regularity and sleep quality appeared even when males and females were considered separately. The present results thus buttress the common sense notion (espoused by many sleep hygiene behavioral prescriptions) that a regular lifestyle, presumably by inducing robust circadian rhythms, is likely to lead to improved sleep. It is noteworthy that both transverse (Monk et al., 1992), and longitudinal (Minors et al., 1998) studies of aging have indicated that the presumed weaknesses of the circadian pacemaker (and/or its efferents) in advanced age can be (partially) compensated for by the individual adopting an increased lifestyle regularity. Generally, further work is needed, though, in which physiological circadian rhythm measures are taken, so that the mediating role of the circadian pacemaker can be tested.

When one moves to the *mechanism* by which lifestyle regularity might be associated with improved sleep, the issue becomes somewhat more complicated than it might initially appear. This is particularly true when lifestyle regularity is being considered as a source of coherent 24h zeitgebers (circadian time cues). Recent human circadian rhythm research refutes the previous conventional wisdom (Wever, 1979) that the "natural" or free running period of the human circadian pacemaker is about 1h slower than the 24h rotation period of planet Earth. Results from "forced desynchrony" studies suggest instead a period length of about 24.1 or 24.2 h (Czeisler et al., 1999). Thus the old theory—that without a strong zeitgeber signal "reining in" the pacemaker, individuals would very soon be sleeping at the "wrong" circadian phase—becomes somewhat less plausible when the mismatch in period is only 0.1 or 0.2 h. Thus, even fairly weak zeitgebers might be sufficient to accomplish the 6 to 12 min per day adjustment. However, it remains true that from both a photic and behavioral and physiological point of view, much is changing at bedtime and at waketime, and it is quite plausible that these changes represent strong circadian zeitgebers. Thus, it is noteworthy that the five-item SRM (which has two of the five items as "get out of bed" and "go to bed") was as strong a correlate of sleep quality as was the full SRM-17 version (rho $= -0.4$ both cases). Thus, it may well be that irregularity in bedtimes and waketimes might induce excessive zeitgeber noise into the circadian system. Such irregularity may, of course, itself result from poor sleep forcing the individual into unwise bedtime and waketime choices.

Alternatively, one could make an argument based on behavioral circadian rhythms, rather than on zeitgebers. Thus, in individuals with a monophasic sleep–wake cycle, one might regard the alternation of sleep and wakefulness as arguably the most profound behavioral circadian rhythm, and one that relies upon an entire cascade of underlying physiological and psychological circadian rhythms to correctly "set the stage" (Campbell and Broughton, 1994). Irregularity in the sleep episode may well lead to an inability of these underlying rhythms to do their work, since the sleep episode would no longer coincide with the anticipated circadian time. There is a fairly comprehensive literature on the relationship between sleep and circadian phase at sleep onset, indicating the importance of the latter in determining the characteristics and the duration of the subsequent sleep (Dijk and Duffy, 1999; Lack and Lushington, 1996; Murphy and Campbell, 1997). Thus, variability in bedtime may be an important player in the role of lifestyle irregularity as a disrupter of sleep. Although much work needs to be done concerning verification of the direction of causality, and the presumed mediation of the circadian pacemaker, the empirical verification of the link between lifestyle regularity and sleep given by the present study may be an important first step in determining therapies by which sleep can be improved by simple changes in lifestyle.

CONCLUSIONS

There is a correlation between lifestyle regularity and sleep quality, such that subjects with higher levels of lifestyle regularity report fewer sleep problems. This conclusion is also supported by a categorical analysis based upon identifying "poor sleepers" and/or "irregular types" and is general to both genders.

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