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The Incidence and Temporal Patterning of Insomnia: a Pilot Study

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Abstract

To date very little research has been conducted on night-to-night variability in the incidence of insomnia. Unclear from prior research is whether subjects with Primary Insomnia (PI) exhibit good sleep (or better than average sleep) on some interval basis. In the present study, pilot data are provided on 1) the frequency with which “good sleep” occurs in subjects with PI and 2) whether these events occur in a non-random manner. 10 PI subjects participated in this “naturalistic” study. All subjects completed daily sleep diaries for a minimum of 20 days. None of the subjects received treatment for their insomnia during the monitoring period. The night-tonight data were evaluated by typing each night’s sleep as “Good” or “Bad” and then by determining the number of bad nights that occurred prior to a good night for each subject. Good and bad nights were typed in two ways: 1. using a 85% cutoff and 2. using a better than the individual’s mean sleep efficiency (idiographic cutoff). Subjects exhibited good sleep on between 29% (> 85% criteria) and 55% (idiographic criteria) of the nights evaluated. The temporal patterning analysis (based on a idiographic cutoff) revealed that better than average sleep most frequently occurred (> 89% of instances) following one to three night’s of poor sleep. These data suggests that insomnia severity may be mediated/moderated by sleep homeostasis and that the homeostat, or input to the homeostat, may be abnormal in patients with Primary Insomnia.

Keywords

Insomnia; illness severity; temporal; patterning

INTRODUCTION

None of the sleep disorders disease classification systems (American Academy of Sleep Medicine 2005; American Psychiatric Association 2000; World Health Organization 1992) or the recent RDC criteria (Edinger *et al.* 2004) define insomnia with respect to severity or symptom frequency (Perlis *et al.* 2005a). That is, there are no quantitative cutoffs for what constitutes abnormal sleep continuity^Ψ and there are no criteria for how often patients must experience abnormal sleep continuity for this to be considered clinically relevant. This said, most research protocols set quantitative cutoffs for severity and frequency as part of their study inclusion criteria. Generally speaking, sleep latency and wake after sleep onset must equal or exceed a 30 minute threshold and this must occur on three or more nights per week (Edinger *et al.* 2004; Lichstein *et al.* 2003)[✕]. The frequency criteria which is so often adopted is interesting as it clearly suggests that, even when chronic and severe, insomnia does not occur on a nightly basis. The conceptualization of insomnia as a waxing and waning disorder, where symptom severity waxes and wanes over relatively short time intervals, lends itself to a fundamental question: is the occurrence of good sleep, or better than average sleep, a random phenomena in patients with Chronic Insomnia?

To date, there has been one theoretical paper and one empirical on this topic. The theoretical paper suggested that insomnia occurs on a periodic basis and that the regular occurrence of good sleep may serve to reinforce placebo effects (Perlis *et al.* 2005b). Further, a simple method for detecting night-to-night periodicity was recommended in this paper (p.385 - Table 1) and it was hypothesized that most subjects would experience good sleep following 1–5 nights of poor sleep.

The empirical paper by Vallieres and colleagues provided the first assessment of how illness severity varies over time in untreated subjects with Primary Insomnia (PI) (Vallieres *et al.* 2005). In this study, it was found that night-to-night variability in illness severity does not represent a global feature of insomnia but instead represents patient subtypes. That is, there are essentially three types of subjects; one group exhibits a high probability of having poor sleep on any given night, the second group exhibits “a low and decreasing probability” of having poor sleep on any given night, and the third group exhibits an unpredictable pattern. It was also found that 1) insomnia severity was higher for the high probability and unpredictable pattern groups and 2) the “second cluster showed a predictable pattern of sleep given that after three poor nights of sleep they had 0% chance to experience a fourth consecutive poor night” (p.240).

^ΨSleep continuity refers to the collection of variables that correspond to sleep initiation and maintenance, including sleep latency, wake after sleep onset, number of awakenings, and total sleep time. While the term is not formally part of the sleep lexicon, it has the heuristic value of being a global term whose meaning may be contrasted with the class of variables that correspond to sleep architecture.

[£]While not part of the established nosologies, at least two attempts ((Lichstein *et al.* 2002; Lineberger *et al.* 2006) have been made to define insomnia in quantitative terms. Lichstein and colleagues, based on epidemiologic data, recommend that abnormal SL and WASO be defined as ≥ 31 minutes in duration. Lineberger *et al.*, based on ROC type analysis (sensitivity/specificity analysis) recommend (when the assessment is based on prospective assessment [daily sleep diaries for two weeks]) that SL and WASO be defined as > 20 minutes in duration.

[✕]These cutoffs are not recommended by Edinger *et al.* or Lichstein *et al.*, but are noted in text as being common.

The Vallieres study is invaluable in that it is the first to formally assess night-to-night variability in insomnia severity and the first to demonstrate that high night-to-night variability is not characteristic of all subjects with chronic insomnia. One limitation of this otherwise seminal study is that it does not directly assay how good and poor sleep temporally covary, i.e., “how many bad nights tend to occur before the occurrence of a good night’s sleep”.

In the present study, the above noted frequency analytic approach (Perlis *et al.* 2005b) was used to assess 1) what percentage of the time patients with PI experience “good sleep” and 2) whether these events occur in a non-random manner. The guiding hypothesis for this analysis was that, in unmedicated subjects, each occasion of a poor night’s sleep should increase the probability of the occurrence of a good night’s sleep or a better than average night’s sleep.

METHODS

Data Source

The data for this analysis were based on a pilot study where subjects with Primary Insomnia, who were not in treatment for their insomnia, were enrolled into a “monitor only” study where they were required to keep daily sleep diaries. The study was approved by the University of Rochester’s IRB (RSRB#10215).

Subjects

All subjects met DSM IV criteria for Primary Insomnia and were deemed to be in good health as assessed by self report. None of the subjects were on medication at the time of the study, during the study, or for a minimum of two weeks prior to the study.

Primary Insomnia was operationalized as follows.

1. Subjects reported difficulty falling or staying asleep for 6 or more months, where the initiation or maintenance complaints (as assessed during an intake interview and with one to two weeks of sleep diaries) required that subjects report, on three or more nights per week,
 - 30 or more minutes to fall asleep, and/or
 - 2 or more awakenings for 30 or more minutes
 - early morning awakenings > 30 minutes prior to desired rise time
2. Subjects reported impaired daytime function which was attributed to insomnia

Frequency Assessment

The data from the sleep diaries were evaluated by classifying each night’s sleep as “Good” or “Bad”. Each night’s sleep was typed in two ways: 1. using a 85% sleep efficiency (SE) cutoff and 2. using a better than the individual’s mean sleep efficiency (idiographic) cutoff. Sleep Efficiency was used to categorically type each night’s sleep because this single variable captures abnormal SL and/or WASO and does not require absolute thresholds be

adopted for these parameters or for total sleep time. The 85% cutoff was selected to represent good sleep based on the procedures used in Cognitive Behavioral Therapy for Insomnia which suggests that 85–90% sleep efficiency represents stable and reasonably good sleep efficiency (Spielman *et al.* 1987a; Spielman *et al.* 1987b; Perlis *et al.* 2005a).

The idiographic cutoff was based on each subject's mean sleep efficiency. In this case, a “good night” (or rather a better than average night) was one that exceeded the subject's mean sleep efficiency. A “bad night” was one below or equal to the subject's mean sleep efficiency. Mean sleep efficiency was used to accommodate the subjects that exhibited temporal patterning (day to day variability) but had low sleep efficiencies.

Temporal patterning was accomplished by tabulating the number of instances per subject of bad nights following a better than average night and prior to the next better than average night (for any interval from 1 to 20 days). In the instances where there were a series of good nights, “the count” did not begin until the first worse than average night. Figure 1 represents several possible sequences for a period of one week.

RESULTS

Subjects

10 subjects' participated in this pilot study. All subject's in this study completed daily sleep diaries for a minimum of 20 days ($X=43$ [range 20–73 days]). Each subject's diary data was nearly 100% complete with only 2 subjects missing between 1 and 3 days' entries. None of the missing data was for contiguous nights. The mean and range values for the sleep continuity data are presented in Table 1. The overall average SE was $74\% \pm 13\%$. The specific average SE's were (from high to low) 87%, 86%, 80%, 84%, 84%, 73%, 72%, 69%, 67%, and 40%. Eight of the 10 subjects were female. The mean age of the sample was 45 years old (range 32–56). The sample's mean scores for the ISI, PSQI and BDI were as follows: ISI = $15.4SD = 3.9$; range 11–23), PSQI = $11.3SD = 3.3$; range 7–17) and BDI = $8.7SD = 7.4$; range 0–21).

Frequency of “good nights”

Based on a criteria of 85% sleep efficiency good sleep occurred on an average of 29% of the nights evaluated. Based on the idiographic criteria (mean sleep efficiency) subjects exhibited better than average sleep on 55% of the nights evaluated.

Average difference between of “good” and bad nights based on the idiographic criteria

The worse than and better than averages across subjects were significantly different. The mean SE% difference was $\sim 20\%$ ($t=3.469$, $p < .0032$). This illustrates that the average difference between “better than average” and “worse than average” sleep is, for this data set, significant and of a reasonably large magnitude (i.e., $\sim 20\%$).

Temporal patterning

This analysis (based on the idiographic criteria) revealed that a good night's sleep most frequently occurred following one (49%), two (29%) or three (11%) night's of poor sleep.

This is graphically represented in Figure 2. All sequences observed, except for one, were for intervals equal to, or shorter than, 5 days. The one outlier out of 106 sequences observed was a sequence in which two good nights were separated by a 17 day interval.

DISCUSSION

The data from this pilot study suggest that, in untreated subjects, insomnia severity varies with time and in such a manner that subjects experience good sleep 29–55% of the time and that nearly 90% of the instances of better than average sleep tend to occur following 1–3 nights of poor sleep. These results are both consistent with, and different from, those of Vallieres and colleagues (Vallieres *et al.* 2005). The results are similar in that both studies found that subjects exhibit distinct patterns of insomnia severity over time. The results differ in that our study shows that better than average sleep reliably occurs (for the group as a whole) in 1–3 day intervals. Vallieres found that only one of her subgroups exhibited a reliable pattern. In this instance, the subgroup showed a “0% chance of experiencing a fourth consecutive poor night” following three poor nights of sleep (p.240).

The finding that better than average sleep tends to occur following 1–3 nights of poor sleep, if confirmed in other and larger studies, suggests that 1) the occurrence of better than average sleep may be mediated/moderated by sleep homeostasis, 2) sleep homeostasis may be abnormal in patients with Primary Insomnia, 3) the non-randomness of good sleep may serve to reinforce maladaptive beliefs and behaviors, and 4) the non-randomness of good sleep may serve to potentiate placebo effects.

The occurrence of “better than average sleep” may be mediated/moderated by sleep homeostasis

The occurrence of “better than average sleep” intervals following 1–2 nights of poor sleep is consistent with the notion that sleep debt accrues over successive days and that this provides a level of homeostatic prime that results in better than average sleep.

Sleep homeostasis may be abnormal in patients with Primary Insomnia

The present results, if confirmed in other and larger studies, may be taken to suggest that greater than normal levels of sleep debt are required to produce efficient sleep in patients with insomnia. This may be true for one or more of several reasons. First, in keeping with the “hyperarousal” perspective, additional sleep drive may be required to attenuate arousal to a level that is compatible with sleep. Second, in keeping with behavioral theory and practice, increased sleep pressure may be required to compensate for the tendency of patients to expand their sleep period in order to increase sleep opportunity. Third, there may be a primary defect in the sleep homeostat which simply requires more sustained wakefulness (or sleep debt) to produce normal sleep and that this alone, or interaction with arousal and/or behavioral factors, may modulate the incidence and severity of insomnia.

The non-randomness of good sleep may serve to reinforce maladaptive beliefs and behaviors

As noted above, expanded sleep opportunity is thought to be the behavior that is adopted by patients to cope with insomnia (Spielman *et al.* 1987a)(p. 546)). The behavior, however, is considered to be one of the primary perpetuating factors for insomnia. Thus, one must wonder how it is that patients end up adhering to this strategy. One possibility may be that the occurrence of non-random good sleep may serve to reinforce the maladaptive strategy. If a subject compensates for poor sleep by phase advancing the sleep period (i.e., scheduling bedtime at an earlier hour) and then holds this schedule constant, it would be expected (based on the data from this study) that the early bedtime will, 89% of the time, coincide with good sleep (or better than average sleep) at least once in each of three occasions. This non-random occurrence of improved sleep continuity would amount to an interval reinforcement of the strategy of “expanding sleep opportunity”. Further, If the subject elected to advance bedtime following 2–3 night’s of bad sleep, it would be expected that the early bedtime would coincide with good sleep on every occasion. This would amount to a contingent reinforcement of the strategy of “expanding sleep opportunity”. Both forms of reinforcement would be expected to be highly reinforcing of a behavioral strategy that is thought to be maladaptive.

The non-randomness of good sleep may serve to potentiate placebo effects

Recently, it was hypothesized that placebo effects that occur in insomnia trials (as assessed with sleep diaries) are unusually potent owing to partial or full reinforcement (Perlis *et al.* 2005b). This idea was predicated on the notion that, even in patients with chronic severe insomnia, “good sleep happens” and that this occurs regularly enough to be paired with pill taking behavior so as to reinforce the initial clinical gains that occur in association with expectancy. The present study serves to document, in a preliminary way, that good sleep does indeed happen and with increasing probability with the successive occurrence of poor sleep.

CONCLUDING REMARKS

The present study suffers from several limitations. First, and most obvious, is the study’s small sample size. Future studies would benefit from the use of large clinically heterogeneous samples where each subject’s clinical profile for insomnia is well characterized regarding insomnia type (e.g., Psychophysiological, Paradoxical, Idiopathic insomnia, etc.), subtype (i.e., Initial, Middle, Late, and Mixed insomnia), age of onset, duration of illness, and index episode severity. Each of these factors may moderate/mediate the observed periodicity.

Second, the eligibility criteria used for the present study required that subjects experience insomnia on three or more nights per week. While 3 night rule is consistent with how many define insomnia (Edinger *et al.* 2004; Lichstein *et al.* 2003), it has the disadvantage of making it appear that the range of resolvable frequencies was truncated. This is true, but only for the extreme left side of the spectrum (long intervals of good sleep prior to bad sleep [See Figure 1]). The remainder of the spectrum was free to vary based on the size of the

assessment window. In the case of a 7 day window the number of nights between one good sleep episode (or better than average sleep episode) and the next could be between 0 and 5 nights. Given the 20 day window used in the present analysis the number of nights between one good sleep episode (or better than average sleep episode) and the next was between 0 and 18 nights. This said, future research in this area may benefit from allowing this aspect of the definition of insomnia to be “free to vary”. In this manner, the true frequency distribution can be resolved and an empirical assessment can be made regarding insomnia frequency.

Third, the use of a threshold cutoff for both “amplitude” criteria (SE of 85% or mean SE%) means that very small deviations would be binned into the “Good” or “Bad” categories and would be evaluated as the same as large deviations[€]. For example both of the following sequences would be characterized as BBGBBGB: 84%-84%-86%-84%-84%-86%-84% vs. 80%-80%-96%-80%-80%-96%-80%. While there is no doubt that the latter is more clinically relevant, both sequences nonetheless have the same period. With this concern in mind, we attempted to reassure the reader that the average differences between “Good” and “Bad” nights were not trivial. As noted in the results, the mean difference in SE% was statistically significant and was clearly of a magnitude that was clinically relevant (“Good” vs. “Bad” SE% was about 20%). This said, future analysis should also take into account amplitude issues.

Fourth, the use of only subjective measures obviously begs the question: would such variability be observed with extended PSG monitoring? While interesting, such a study is unlikely to be undertaken given the expense of such an assessment (both in terms of subject burden and the costs of the assessment). A more fruitful approach might be to polysomnographic assess the implications of the observational findings. For example, if one implication of the present work is that patients with chronic primary insomnia require an exceptionally high “homeostatic prime” to produce good (or better than average sleep), then a PSG study could be conducted to assess this possibility. That is, a PSG assessment prior to and following sleep restriction (1–2 hours), partial sleep deprivation (2–4 hours), or true sleep deprivation (4–8 hours) would be expected to produce differences in SWS latency and SWS density in PI subjects as compared to normal healthy sleepers. For a review of the literature with respect to insomnia and sleep homeostasis, the reader is referred to a paper by the Rochester Group (Pigeon and Perlis 2006).

In sum, while the present findings are suggestive, they need to be replicated in a large scale long term trial. This would allow for an analysis using multiple sleep continuity parameters and multiple techniques to assess periodicity. If the present findings are confirmed in such a study, they may not only shed light on the above noted issues, they will have immediate clinical implications in that they will allow the clinician to tell their patients that a “good” (or better than average) night’s sleep is generally only 1–3 nights away.

[€]This problem is handled within 1) power spectral analysis via the quantification of frequency in terms of cumulative amplitude and 2) period analysis via the application of amplitude criteria. Future studies will benefit from the use of these more sophisticated techniques, perhaps in addition to the simple method used here.

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0.5 Interval (3 bad nights per week)

Hight	1	2	3	4	5	6	7
SE%	78%	90%	86%	79%	93%	89%	75%
Categorization	B	G	G	B	G	G	B

1.0 Interval (4 bad nights per week)

Hight	1	2	3	4	5	6	7
SE%	70%	90%	78%	85%	75%	89%	69%
Categorization	B	G	B	G	B	G	B

2.0 Interval (5 bad nights per week)

Hight	1	2	3	4	5	6	7
SE%	70%	65%	85%	68%	75%	89%	69%
Categorization	B	B	G	B	B	G	B

3.0 Interval (6 bad nights per week)

Hight	1	2	3	4	5	6	7
SE%	70%	65%	78%	89%	62%	68%	70%
Categorization	B	B	B	G	B	B	B

4.0 Interval (6 bad nights per week)

Hight	1	2	3	4	5	6	7
SE%	70%	65%	78%	69%	82%	68%	70%
Categorization	B	B	B	B	G	B	B

5.0 Interval (6 bad nights per week)

Hight	1	2	3	4	5	6	7
SE%	70%	65%	80%	68%	62%	81%	70%
Categorization	B	B	B	B	B	G	B

6.0 Interval (6 bad nights per week)

Hight	1	2	3	4	5	6	7
SE%	70%	65%	78%	69%	62%	68%	80%
Categorization	B	B	B	B	B	B	G

FIGURE 1. Frequency Assessment of “Good” and “Bad” Sleep

Note: 1) the first entry at Day 1 presumes that the preceding day (Day 0) was classified as “Good”.

2) This example uses an idiographic SE cutoff of 79% and only illustrates 7 possible sequences.

FIGURE 2.
Bad and good nights were defined idiographically

TABLE 1

	MEAN	STD DEV	RANGE
SLEEP LATENCY	35	17	10–66
WAKE AFTER SLEEP ONSET	87	30	24–134
EARLY AM AWAKENINGS	42	33	10–99
TOTAL SLEEP TIME	357	73	210–440
SLEEP EFFICIENCY	74%	13%	40–87% **

** One subject had a SE% of 40%. The remaining nine subjects had SE% > 67%.