Sleep, 14(1):13–17

Sleep Variability Across Consecutive Nights of Home Monitoring in Older Mixed DIMS Patients

*†Jack D. Edinger, †Gail R. Marsh, †W. Vaughn McCall, †C. William Erwin, and †Anne W. Lininger

**Veterans Administration and †Duke University Medical Center, Duke University, Durham, North Carolina, U.S.A.*

Summary: Twenty patients with difficulties initiating and maintaining sleep (DIMS) were monitored in their homes for three consecutive nights using ambulatory polysomnography (PSG). Following each night of monitoring, patients provided subjective ratings of sleep disturbance and tolerance of the PSG equipment. Friedman analyses of variance performed on the objective and subjective parameters showed that the sample, as a whole, evidenced no systematic first night effects (FNE) in response to monitoring. Inspection of the data from each individual subject, nevertheless, showed that half of the sample did experience multiple FNE. Further, several scales from the Minnesota Multiphasic Personality Inventory discriminated those patients who showed multiple FNE from those who did not. However, far more striking was the finding that clinically and statistically significant intrasubject variability across nights was observed for each sleep parameter measured. Given this finding, a single ambulatory PSG study may not fully convey the nature of the sleep disturbance experienced by the DIMS patient even when FNE are absent. We, thus, recommend multiple ambulatory sleep studies for those clinical and research situations in which it is necessary to document patients' night-to-night sleep variability. In contrast, when the goal of the PSG study is that of determining a sleep diagnosis, a single ambulatory study, in combination with other clinical data, may be sufficient.
Key Words: DIMS—FNE—Sleep disturbance—PSG study—Older insomnia patients.

Polysomnography (PSG) is a valuable tool for basic sleep research and the clinical diagnosis of sleep disorders. Nevertheless, abundant research has shown that a single night of laboratory PSG may fail to provide representative sleep data. First night effects (FNE) including a delay in sleep onset, an increase in time awake during the night, a reduction in total sleep time, an increase in stage 1 sleep, and a delay in the onset of the first rapid eye movement (REM) episode often confound the initial night of sleep monitoring (1–4). In addition, various forms of sleep pathology may contribute to such night-to-night sleep variability that a single PSG study may not fully convey the nature of a patient's sleep disturbance (5–7). As a result, the practice of conducting multiple PSG studies on each subject/patient may be desirable in many research and clinical settings.

However, the majority of available information about FNE and sleep variability comes from the study of subjects in the sleep laboratory. Whether multiple PSG studies are needed when individuals are monitored in their homes is questionable. Although Sharpley et al. (8) recently found no FNE and negligible internight variability among young normal sleepers studied in their homes with ambulatory PSG, similar studies of patient groups have yet to be conducted. The current investigation was conducted to evaluate FNE and sleep variability shown by a mixed group of older insomnia patients monitored in their homes with ambulatory PSG.

METHOD

Subjects

Twenty (8 males, 12 females) patients who complained of difficulty initiating and maintaining sleep (DIMS) served as subjects for this study. The sample was composed of 1 45-year-old patient, 5 patients between 55 and 59 years of age, 13 patients between 60 and 69 years of age, and 1 72-year-old. The mean age of these patients was 62.3 years, whereas the mean duration of their insomnia complaints was 11.4 years (range = 3–44 years).

Accepted for publication September 1990.
Address correspondence and reprint requests to Jack D. Edinger, Ph.D., Psychology Service (116-B), VA Medical Center, 508 Fulton St., Durham, NC 27705, U.S.A.

Apparatus

PSG was conducted using an Oxford Medilog 9000 (Oxford Medical, Inc., Clearwater, FL) monitor. This is an ambulatory cassette recording device which includes an event marker, a digital timer, and the capacity for monitoring eight channels of electrophysiological data. A previous study conducted in our laboratory showed that the Medilog produces technically acceptable recordings with most patients and is generally well tolerated (9). Other research has shown that the Medilog and standard laboratory PSG produce comparable estimates of sleep onset latency, wake time after sleep onset, total sleep time, total sleep period, sleep efficiency, sleep architecture, REM latency, and REM density measures (10,11). Research has also demonstrated the usefulness of the Medilog system in the diagnostic evaluation of DIMS patients (11,12).

Procedure

Each patient participating in this study had volunteered to take part in one of two DIMS treatment studies being conducted at our sleep laboratory. The PSG and other diagnostic information obtained in the current investigation were, in fact, used in identifying patients with periodic leg movements in sleep or psychophysiological DIMS for these treatment investigations. Prior to undergoing sleep monitoring all patients completed a sleep history questionnaire and a clinical interview. These screening procedures provided diagnostic information and were used to identify patients who routinely used alcohol or sedative hypnotics to aid their sleep. Patients using such agents were required to abstain from their use for a minimum of 2 weeks prior to undergoing PSG. In addition to the other screening procedures, 18 of the 20 subjects completed the Minnesota Multiphasic Personality Inventory (MMPI) prior to their sleep studies. MMPI results were used primarily to screen subjects for possible mood disturbance or thought disorder.

To evaluate FNE, each patient underwent three consecutive nights of ambulatory PSG monitoring. The sleep monitoring montage consisted of two electroencephalogram (EEG) channels (C_3-A_2, Oz—Cz), bilateral electrooculogram (EOG) (left eye—A_2, right eye—A_1), submental chin electromyogram (EMG), two channels of anterior tibialis EMG (right and left leg), and nasal–oral respiration (thermistor). Patients reported to the sleep laboratory where electrodes (except respiration thermistor) were attached each day between 12:30 and 4:30 p.m., but they slept in their own homes each night during the study. Because the nasal–oral thermistor is worn on a headstrap, patients were allowed to put this device on themselves just prior to retiring each evening. Patients were instructed to refrain from daytime napping prior to each night of monitoring. Also, patients were encouraged to engage in their usual presleep behaviors and to adhere to their usual bedtimes and arising times on each study night. Each morning following a night of monitoring patients completed a standard sleep diary (described below) and then returned the PSG equipment to the sleep laboratory.

The sleep diaries required each subject to respond to four Likert-style items designed to provide subjective estimates of sleep disturbance and reactions to the monitoring equipment. Item 1 asked subjects to indicate the difficulty they had *falling asleep* whereas Item 2 required them to rate the difficulty they had *staying asleep.* In responding to these items subjects used a five-point scale with 1 = extremely difficult and 5 = very easy. Item 3 required subjects to rate the *overall quality* or *level of satisfaction* with their sleep using the scale 1 = very poor and 5 = excellent. The final item asked subjects to rate the extent to which the PSG equipment disturbed their sleep on a scale with 1 = a very great deal and 5 = not at all.

An experienced polysomnographer (G.R.M.) scored all taped PSG data directly on the screen of the Medilog scanner using standard scoring procedures (13) and a combination of visual and auditory data for stage assignment (14). Screen scoring was chosen for convenience because a previous study conducted in our laboratory demonstrated that this method produces results comparable to those obtained from epoch-by-epoch scoring of sleep records printed on paper (15). Because our main scorer (G.R.M.) did not blindly score the sleep data, a second accredited clinical polysomnographer (ACP) scorer (W.V.M.) blindly screen scored a randomly selected subset (10%) of the 60 records produced by the subjects. Epoch-by-epoch comparisons resulted in a highly acceptable interscorer agreement rate of 82.2% (SD = 5.3%). Thus, scoring results were regarded as reliable.

Following the check for scoring reliability, estimates of total sleep time, sleep efficiency percent, percent time awake after sleep onset, percentage of stage 1 sleep, percentage of stage 2 sleep, percentage of slow wave sleep, REM percent, REM latency, latency to stage 1 sleep, and latency to stage 2 sleep were derived from each record. These PSG data were combined with sleep history, interview, and MMPI findings to determine a primary sleep disorder diagnosis for each patient. Although not employed in subsequent across-night comparisons, movement-arousal indices were calculated when appropriate to assist in the diagnosis of periodic leg movements in sleep. An experienced sleep disorders clinician (J.D.E.) determined each patient's sleep diagnosis using ASDC (Association of Sleep

Disorders Centers) criteria (16). Consistent with Coleman's (17) procedure, a diagnosis of periodic leg movements in sleep was assigned to patients with a mean movement-arousal index ≥ 5 across nights. A diagnosis of DIMS resulting from a psychiatric disorder was assigned when a patient met diagnostic criteria (18) for a major psychiatric disorder and this disorder was viewed as responsible for the DIMS. After patients were assigned sleep diagnoses, a series of analyses were conducted to evaluate FNE and the night-to-night variability observed for each sleep parameter.

RESULTS

Technical quality of recordings

All recordings were technically acceptable; no recordings were lost due to technical failure. Minor technical problems were encountered on 8 of the 60 recording nights. On four of the nights patients either forgot to wear the respiration thermistor or respiration data were lost due to the thermistor being out of place. Data were lost on two nights from an EEG channel, on one night from the chin EMG, and on another night from one EOG channel. In each of these cases the malfunction was caused by an electrode coming loose. Only 1 of the 20 subjects had any data loss on more than one recording night. This subject lost an EEG channel each of the first two recording nights. Despite these minor problems all nights were scoreable and sufficient PSG data were available for the diagnosis of each patient.

Diagnostic findings

All 20 patients met ASDC criteria for a DIMS. The majority of patients were diagnosed as suffering from periodic leg movements in sleep (PLMS) (n = 11) or psychophysiological DIMS (P-DIMS) (n = 7). One of the remaining patients displayed an alpha–delta sleep pattern on PSG and was, thus, assigned a diagnosis of DIMS with atypical polysomnographic features. The final patient met criteria (18) for a major depressive disorder and was assigned a sleep diagnosis of DIMS resulting from a psychiatric disorder.

Evaluation of FNE

Prior to evaluating FNE, the statistical independence of objective sleep parameters and sleep diary ratings was tested by computing correlations between selected objective and subjective measures. On average, subjects' ratings of their sleep onset difficulties correlated -0.457 ($p < 0.05$) with stage 1 sleep latency and -0.542 ($p < 0.01$) with stage 2 sleep latency across the three PSG nights. The average correlation between subjects' ratings of their difficulties staying asleep and the percentage of wake time after sleep onset was only -0.338 ($p > 0.05$). These correlations were all modest and indicated that only a small portion (<30%) of the variance seen in these objective parameters could be predicted from the subjective ratings. Thus, evaluation of FNE shown by both objective and subjective sleep parameters appeared warranted.

Table 1 shows the means and standard deviations for the 10 objective and 4 sleep diary parameters. Inspection of these data shows that the internight variations in mean values for most parameters were rather small relative to their respective variances. FNE were tested by comparing values of the various parameters obtained on the first PSG night with values of these parameters obtained on subsequent nights. Because these data were not normally distributed and substantial intersubject variability was noted, Freidman's nonparametric analysis of variance by ranks was used in these comparisons. Results of these comparisons indicated no significant differences between nights for any of the sleep parameters. Hence, when considered as a group, our subjects showed no systematic FNE.

Despite these results, it was recognized that some subjects may have evidenced FNE, whereas the group as a whole did not. To explore this possibility a number of common markers of FNE were selected to identify subjects with a relative disruption of their sleep on the first PSG night. Each of the following findings was regarded as a FNE:

1) Total sleep time was the lowest on the first of these PSG nights.
2) The lowest sleep efficiency percentage was observed on the first night.
3) Percent wake time after sleep onset was highest on night 1.
4) Stage 1 percentage was highest on night 1.
5) Stage 1 latency was longest on night 1.
6) Stage 2 latency was longest on night 1.
7) REM latency was longest on night 1.
8) The subjective sleep disturbance resulting from PSG monitoring was greatest on night 1 (sleep diary item 4).

A frequency count showed that 50% (n = 10) of the sample evidenced four or more of these markers, whereas the remaining subjects showed two or fewer such FNE. The subgroup showing four or more FNE was composed of three subjects with P-DIMS, six subjects with PLMS, and one depressed patient. The other subgroup was composed of four subjects with P-DIMS, five with PLMS, and one with alpha–delta sleep. A statistical comparison of the proportions of P-DIMS and PLMS subjects in each subgroup was nonsignificant (Fisher exact, > 0.30). However, *t*-test compar-

TABLE 1. *Means and standard deviations for the objective and subjective sleep parameters from the three consecutive recording nights*

Parameter	Night 1		Night 2		Night 3	
	Mean	SD	Mean	SD	Mean	SD
Total sleep time (min)	346.0	82.0	373.8	54.3	352.1	35.0
Sleep efficiency (%)	73.7	15.5	81.1	7.0	78.2	10.4
Wake time after sleep onset (%)	18.8	9.1	16.0	7.3	16.5	10.1
Stage 1 (%)	7.3	6.6	5.3	3.3	5.5	4.5
Stage 2 (%)	58.3	11.0	59.6	8.5	56.7	9.2
Slow-wave sleep (%)	9.8	6.2	11.5	8.1	10.6	7.1
REM sleep (%)	24.7	6.8	23.1	5.4	26.9	7.3
Latency to stage 1 (min)	18.6	36.3	10.7	8.2	16.2	12.9
Latency to stage 2 (min)	43.4	65.5	19.2	26.2	30.8	39.0
REM latency (min)[a]	63.5	44.4	44.3	28.6	42.4	25.3
Sleep onset difficulty rating[b]	3.4	1.4	3.3	1.2	2.8	1.3
Sleep maintenance difficulty rating[b]	2.3	1.1	2.7	1.0	2.6	1.1
Sleep quality rating[c]	2.6	1.1	2.9	1.1	2.7	1.1
PSG disturbance rating[d]	3.6	0.9	3.8	0.7	3.6	1.0

[a] REM latency was defined as the time between the beginning of the first 10 min of stage 2 sleep (which was interrupted by no more than 2 min of stages 1 or W) and the first 3-min period of REM (subtracting out intervening time awake). This conservative definition and the mean age of the sample likely contributed to the relatively short REM latencies reported.
[b] Ratings of 1 = extremely difficult and 5 = very easy.
[c] Ratings of 1 = very poor and 5 = excellent.
[d] Ratings of 1 = a very great deal and 5 = not at all.

isons of MMPI scores from the nine subjects within each subgroup who had completed a pre-PSG MMPI showed a number of statistical differences. Subjects with few or no FNE scored significantly ($p < 0.05$) higher on scales F (52.6T vs. 50.3T), K (58.6T vs. 54.7T), and 6—paranoia (59.4T vs. 56.7T) than did subjects with multiple FNE. In contrast, subjects with multiple FNE scored significantly higher on scales 7—psychasthenia (59.9T vs. 53.6T) and 0—social introversion (57.4T vs. 53.2T) than did subjects showing few FNE. Thus, personality factors appeared to play a role in the occurrence of FNE.

Evaluation of intrasubject variability

Intrasubject variability was evaluated by computing the difference between the highest and lowest value of each sleep parameter observed for each subject across nights. Mean intrasubject differences for each sleep parameter were then computed and *t* tests for paired observations were used to test the significance of these mean intrasubject differences. Table 2 shows the mean intrasubject differences observed for each parameter, the ranges of these intrasubject differences, and the *t*-test results. Inspection of this table shows that considerable intrasubject variability was observed for each sleep parameter across nights. Further, the mean intrasubject difference (high vs. low value) observed for each parameter was significantly greater than zero. Hence, our sample, as a whole, displayed significant night-to-night variability in both their objective and subjective sleep measures.

TABLE 2. *Means, ranges, and* t *values for the intrasubject comparisons of the highest and lowest values observed for each sleep parameter across nights*

Parameter	Mean	Range	t^a
Total sleep time (min)	97.5	15–182.3	8.90***
Sleep efficiency (%)	15.3	1.6–38.9	6.68***
Wake time after sleep onset (%)	11.2	1.4–21.7	10.64***
Stage 1 (%)	3.9	0.4–17.3	4.94***
Stage 2 (%)	11.2	3.2–26.2	7.89***
Slow-wave sleep (%)	8.8	1.3–17.3	7.91***
REM sleep (%)	9.5	0.4–27.5	6.79***
Latency to stage 1 (min)	22.2	0.3–133.5	2.81*
Latency to stage 2 (min)	40.3	3.0–219.5	3.24**
REM latency (min)	43.2	4.7–175.7	4.47***
Sleep onset difficulty rating	1.5	0–4.0	6.32***
Sleep maintenance difficulty rating	1.0	0–3.0	4.88***
Sleep quality rating	1.2	0–2.0	6.62***
PSG disturbance rating	0.9	0–3.0	5.36***

[a] *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

DISCUSSION

This investigation was undertaken, in part, to evaluate FNE shown by a mixed group of older DIMS patients studied in their homes with ambulatory PSG. Consistent with the results of Sharpley et al. (8), our patient group showed no systematic FNE. However, inspection of sleep data from each individual patient showed that half of our sample did evidence multiple signs of sleep disruption on the first PSG night. MMPI scores suggested these patients were more anxious (higher scale 7—psychasthenia scores) and withdrawn (higher scale 0—social introversion scores) and were less externally vigilant (lower scale 6—paranoia scores), less willing to report psychological symptoms (lower scale F scores), and less psychologically defended (lower K scores) than were those with few FNE. Our results, in conjunction with those reported by Sharpley et al.,

suggest that ambulatory PSG may be an effective means of reducing adaptation effects in certain patient and normal sleeper subgroups. Nevertheless, our findings also suggest that many DIMS patients may manifest FNE even when studied at home with ambulatory monitors. Given the relationship between MMPI scores and FNE observed herein, further empirical investigation of personality factors that contribute to these adaptation effects seems warranted.

In addition to evaluating FNE, this study was conducted to examine the night-to-night sleep variability shown by our patient sample. Our analyses showed statistically and clinically significant intrasubject variability across nights for each sleep parameter we measured. This finding is particularly striking when it is considered that the night-to-night sleep variability observed occurred in the patients' usual home sleep environments.

This degree of variability within subjects differs markedly from the night-to-night consistency found by Sharpley et al. (8) among young, normal sleepers. The variability we found is likely, in part, attributable to the ages of our subjects. Whether similar results would be found among a group of young DIMS patients is questionable. However, the variability shown by our subjects is very similar to that found by Coates et al. (19) within a diverse (age range = 23–60 years) sample of sleep-maintenance insomniacs studied at home with telediagnostic methodology. Both the Coates et al. findings and ours suggest that night-to-night variability in sleep may be at least as important to consider in evaluating DIMS patients as are FNE. In this regard Hauri (5) has recently concluded that night-to-night variability, perhaps more than other indices, discriminates DIMS patients from normal sleepers.

In view of this variability, a single night of ambulatory PSG may not provide representative sleep data even if no FNE are observed. The appropriateness of a single night of ambulatory monitoring would seem to depend on the purpose of the PSG study. In those clinical and research situations where it is necessary to document the night-to-night variability in a patient's sleep pattern, multiple PSG studies would be required. Documenting the effects of a treatment regimen, for example, might best be accomplished through multiple PSG studies performed both before and after treatment. Also, when unexpected environmental/situational factors interfere with sleep on the first PSG night, a second night may be needed. In contrast, our experience with over 200 DIMS outpatients suggests that a single night of ambulatory PSG, when combined with other clinical data, usually is sufficient for diagnostic purposes. In the current sample, those PSG findings that contributed to each patient's sleep diagnosis were apparent on the first night and each subsequent night of monitoring. Thus, a single ambulatory study would seem sufficient for the diagnosis of most DIMS patients. However, as we have noted previously (12), one or more nights of ambulatory PSG may be less satisfactory than laboratory PSG for the evaluation of apnea patients who present with DIMS complaints.

REFERENCES

1. Rechtschaffen A, Verdone P. Amount of dreaming: effect of incentive and adaptation to laboratory and individual differences. *Percept Mot Skills* 1964;19:947–58.
2. Agnew HW, Webb WB, Williams RL. The first night effect: an EEG study of sleep. *Psychophysiology* 1966;2:263–6.
3. Mendel J, Hawkins DR. Sleep laboratory adaptation in normal subjects and depressed patients ("first night effect"). *Electroencephalogr Clin Neurophysiol* 1967;22:556–8.
4. Schmidt HS, Kaelbling R. A differential laboratory adaptation of sleep parameters. *Biol Psychiatry* 1971;3:33–45.
5. Hauri PJ. New approaches to sleep hygiene interventions for insomnia. Washington, DC: Annual Meeting of the Association of Professional Sleep Societies, 1989.
6. Frankel BL, Coursey RD, Buchbinder R, Snyder F. Recorded and reported sleep in chronic primary insomnia. *Arch Gen Psychiatry* 1976;33:615–23.
7. Mosko SS, Dickel MH, Ashurst J. Night to night variability in sleep apnea and sleep-related periodic leg movements in the elderly. Sleep 1988;11:340–8.
8. Sharpley AL, Solomon RA, Cowen PJ. Evaluation of first night effects using ambulatory monitoring and automatic sleep stage analysis. *Sleep* 1988;11:273–6.
9. Hoelscher TJ, Erwin CW, Marsh GR, Webb MD, Radtke RA, Lininger AL. Ambulatory sleep monitoring with the Oxford Medilog 9000: technical acceptability, patient acceptance, and clinical indications. *Sleep* 1987;10:606–7.
10. Sewitch DE, Kupfer DJ. A comparison of the telediagnostic and Medilog systems for recording normal sleep in the home environment. *Psychophysiology* 1985;22:718–26.
11. Ancoli-Israel S, Kripke DF, Mason W, Messin S. Comparison of home sleep recordings and polysomnography in older adults with sleep disorders. *Sleep* 1981;4:283–91.
12. Edinger JD, Hoelscher TJ, Webb MD, Marsh GR, Radtke RA, Erwin CW. Polysomnographic assessment of DIMS: empirical evaluation of its diagnostic value. *Sleep* 1989;12:315–22.
13. Rechtschaffen A, Kales A. *A manual of standardized terminology, techniques, and scoring system of sleep stages of human subjects.* Los Angeles: UCLA Brain Information Service/Brain Research Institute, 1968.
14. Erwin CW, Ebersole JS. Data reduction of cassette-recorded polysomnographic measures. In: Ebersole JS, ed. *Ambulatory EEG monitoring.* New York: Raven Press, 1989, pp 257–67.
15. Hoelscher TJ, McCall WV, Powell J, Marsh GR, Erwin CW. Sleep scoring with the Oxford Medilog 9000: comparison to conventional paper scoring. *Sleep* 1989;12:133–9.
16. Association of sleep disorders centers. Diagnostic classification of sleep and arousal disorders. 1st ed. *Sleep* 1979;2:1–137.
17. Coleman RM. Periodic movements in sleep (nocturnal myoclonus) and restless legs syndrome. In: Guilleminault C, ed. *Sleeping and waking disorders: indications and technique.* Boston: Butterworth Publishers, 1982, pp 265–95.
18. American Psychiatric Association. *Diagnostic and statistical manual of mental disorders.* 3rd ed., revised. Washington, DC, 1987.
19. Coates TJ, George JM, Killen JD, Marchini E, Hamilton S, Thorensen CE. First night effects in good sleepers and sleep maintenance insomniacs when recorded at home. *Sleep* 1981;4:293–8.