Sleep
12(4):315–322, Raven Press, Ltd., New York

Polysomnographic Assessment of DIMS: Empirical Evaluation of Its Diagnostic Value

Jack D. Edinger, *Timothy J. Hoelscher, *Michael D. Webb, *Gail R. Marsh, *Rodney A. Radtke, and *C. William Erwin

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

Summary: This investigation examined the diagnostic value of polysomnography (PSG) for evaluating disorders of initiating and maintaining sleep (DIMS). The sample consisted of 100 outpatients who presented to the Duke Sleep Disorders Center with a complaint of chronic insomnia. All patients were given comprehensive medical, psychiatric, behavioral, and ambulatory PSG evaluations. Sleep disorder diagnoses were assigned using the criteria of the Association of Sleep Disorders Centers. Overall, PSG yielded important diagnostic information in 65% of the sample: 34% were given a primary sleep disorder diagnosis that was heavily dependent on PSG data [periodic movements of sleep (PMS) = 25%, apnea = 3%, and subjective insomnia = 6%]; 15% were given a secondary diagnosis of one of these three disorders; and PSG ruled out suspected PMS in 9% and sleep apnea in 7% of the sample. Patients >40 years of age had a significantly higher rate of positive PSG findings than younger patients. Using only the clinical exam, two experienced sleep clinicians were able to predict only 14 of 25 PMS cases and one of three cases of sleep apnea. Based on these data, we suggest using PSG routinely with older insomniacs and with younger patients who fail initial treatment. **Key Words:** Polysomnography—Disorders of initiating and maintaining sleep (DIMS)—Disorders of excessive somnolence (DOES)—Periodic movements of sleep (PMS)—Restless legs syndrome (RLS)—Insomnia—Apnea.

While polysomnography (PSG) is viewed as a critical diagnostic procedure in the evaluation of disorders of excessive somnolence (DOES), there is considerable disagreement regarding the necessity of PSG evaluations for disorders of initiating and maintaining sleep (DIMS). Kales and associates (1–3) have repeatedly asserted that medically-based sleep problems [e.g., sleep apnea, periodic movements of sleep (PMS)] are observed so infrequently in DIMS patients that PSG is rarely needed in the evaluation of chronic insomnia. Based on a series of 200 consecutive insomniac patients, Kales et al. (4) reported that none had sleep apnea and only 5% had PMS. These data,

Accepted for publication December 1988.
Address correspondence and reprint requests to Dr. J. D. Edinger at Veterans Administration Medical Center, 508 Fulton Street, Durham, NC 27705, U.S.A.

however, are in sharp contrast with the findings of other studies. In the National Cooperative Study of sleep disorders centers (5), 6.2% of 1,214 DIMS patients were given a primary diagnosis of sleep apnea and 12.2% were diagnosed as having PMS/restless legs syndrome (RLS). In a study of 84 insomniacs, Zorick et al. (6) found that 7% had sleep apnea and 22% had RLS/PMS.

The question of whether PSG should be used in the routine evaluation of chronic insomnia depends on the relative frequency of PSG-dependent diagnoses and the accuracy of the initial clinical impression. For patients with insomnia secondary to psychiatric disorder, psychophysiologic factors, or substance abuse, a diagnosis can usually be made based upon interview, history, and psychological testing. If the majority of insomniac patients fall into one of these diagnostic categories, then PSG may not add significantly to the diagnostic evaluation of most patients. In contrast, for insomniacs with significant sleep apnea, PMS/RLS, or subjective insomnia, PSG provides data that either cannot be obtained from the clinical history or is contrary to the patient's self-report. If these latter diagnostic categories account for a substantial proportion of patients presenting with DIMS complaints, then PSG would appear to be indicated in the routine evaluation of chronic insomnia.

This study was designed to evaluate the importance of conducting PSG evaluations of DIMS patients. A diagnostic work-up including PSG was performed on a series of DIMS outpatients, and a primary sleep disorder diagnosis was assigned for each patient using the criteria of the Association of Sleep Disorders Centers (ASDC) (7). To assess the representativeness of the current sample, diagnostic results from this sample were compared to the results of the National Cooperative Study of sleep disorder centers (5). The utility of PSG was evaluated by two methods. First, the proportion of patients who received a primary diagnosis that was largely dependent on PSG data (i.e., sleep apnea, PMS, or subjective insomnia) was determined. Second, for patients receiving these diagnoses, comparisons between initial clinical impression and final diagnosis (which incorporated PSG results) were made to determine the extent to which experienced sleep clinicians could predict the presence of these sleep pathologies in a DIMS population without the benefit of PSG.

METHOD

Subjects

All subjects were outpatients who presented to the Duke Sleep Disorders Center with DIMS complaints. Patients who presented with complaints of excessive daytime somnolence or other complaints unrelated to a DIMS were excluded from the study. In order to enroll 100 subjects, each patient in a series of 124 consecutive DIMS outpatients was considered for inclusion in this study. The 24 patients not enrolled were excluded because they did not receive a PSG evaluation (14 declined a PSG evaluation, six were referred for immediate treatment, two moved out of the geographic area and were referred to other sleep disorders centers, one patient was hospitalized, and one showed a phobic response to medical/dental procedures). The final sample consisted of 46 men and 54 women ranging from 21 to 85 years of age (mean, 46.1; SD, 15.6). The mean duration of insomnia was 9.3 years (SD, 10.4 years). Eighty-five percent had been previously treated for insomnia, and 50% were using sedative hypnotics at the time of their initial clinic visit.

Apparatus

Polysomnography was conducted using an Oxford Medilog 9000 (Oxford Medical, Inc., Clearwater, FL). This is an ambulatory cassette recording system with the capability of monitoring eight channels of electrophysiologic data, digital time recorded at 1-s intervals, and an event marker. Research with a large patient group (N = 224) from our sleep center revealed that the Medilog produces technically acceptable recordings in 90–97% of all studies and is well tolerated by most patients (8). Other investigators have found that the Medilog and standard laboratory PSG produce comparable estimates of standard sleep parameters including sleep-onset latency, wake time after sleep onset, total sleep time, total sleep period, sleep efficiency, sleep stage architecture, rapid-eye-movement (REM) sleep latency, and REM sleep activity (9,10). Further, one study (10) that employed simultaneous Medilog and laboratory PSG across 36 subjects demonstrated that the Medilog accurately identified all subjects (n = 14) suffering from PMS and produced only one false positive. Thus, the Medilog provides valid sleep data that can be used to accurately diagnose various DIMS disorders including PMS.

Procedure

All patients received a comprehensive sleep evaluation that included a clinical examination (sleep history, psychiatric evaluation, medical history, and physical examination), a behavioral evaluation (analysis of 2 weeks of sleep diaries and assessment of behavioral/sleep hygiene practices), a Minnesota Multiphasic Personality Index (MMPI), laboratory tests, and at least one night of PSG (84 patients were studied on one night only, 15 on two nights, and one on three nights). The clinical examination was conducted by an M.D. psychiatrist (M.D.W.) and the behavioral evaluation was performed by a Ph.D. psychologist (T.J.H.). Both clinicians have several years' experience in sleep disorders medicine, and the psychologist is an Accredited Clinical Polysomnographer (ACP). Prior to the PSG study, the psychiatrist and psychologist jointly formulated an initial diagnostic impression. This impression consisted of a single or multiple ASDC sleep disorder diagnosis (7) and was made a part of the patient's medical record.

Attempts were made to ensure that all patients were drug-free for at least 2 weeks prior to their diagnostic sleep study. However, 18 patients were studied on medications that were deemed necessary from a psychiatric standpoint. Seven of these patients suffered from bipolar disorder and were kept on Lithium, five were significantly depressed and were maintained on an antidepressant, four were severely anxious and taking low-dose anxiolytics, one was psychotic and taking a phenothiazine, and one patient refused to discontinue chloral hydrate (500 mg).

The sleep monitoring montage consisted of two electroencephalogram (EEG) channels (C_3-M_2, Oz-Cz), bilateral electrooculogram (EOG) (left eye-M_2, right eye-M_1), submental chin electromyogram (EMG), two channels of anterior tibialis EMG (right and left leg), and nasal-oral respiration (thermistor). The patients were scheduled for electrode attachment between 12:30 p.m. and 4:30 p.m. They then returned home or, if they were from outside the area, to their motel room. On awakening in the morning, the patients completed a standard sleep diary. They then returned to the laboratory to have the electrodes removed.

The taped PSG data were scored directly on the screen of the Medilog 9000 scanner using the scoring system of Rechtschaffen and Kales (11). In a previous validation study conducted in our laboratory, 16 (eight normals and eight DIMS patients) taped PSG studies were scored on the Medilog Scanner and were also printed on paper for

conventional scoring (12). The two scoring methods correlated at $r > 0.80$ ($p < 0.01$) across all sleep parameters, with the exception of stage 1% ($r = 0.73$, $p < 0.01$) and brief awakenings of <2 min in duration ($r = 0.66$, $p < 0.01$). For patients with PMS, movement and movement arousal indices were calculated according to the criteria of Coleman (13,14). A movement arousal index of ≥5.0 was used as the criterion for clinically significant PMS. Patients recently withdrawn from sedative/hypnotic or psychotropic medications and showing significant PMS on their first sleep study were restudied with PSG following an additional 2 weeks of drug abstinence (n = 6). This procedure was used in order to avoid diagnosing PMS as a primary sleep disorder when it was attributable to incomplete recovery from drug withdrawal. Patients showing evidence (periodic cessation of respiration) of possible sleep apnea on the ambulatory sleep study were referred for a second night of PSG conducted in the sleep laboratory (n = 4), which allowed for complete monitoring of respiratory parameters not available with the ambulatory unit. Both ambulatory and in-lab PSG studies were scored and/or interpreted by an ACP (T.J.H., R.A.R.).

Following the diagnostic sleep study and all other assessment procedures, a multidisciplinary treatment team reviewed each patient's case and assigned ASDC diagnoses (7). These final diagnoses were documented in the patients' medical charts. For patients having multiple diagnoses, the ranking procedure described in the National Cooperative Study of sleep disorders centers (5) was used to determine the primary sleep disorder diagnosis.

RESULTS

Diagnostic classification

Six primary sleep diagnoses were identified in our DIMS sample. Table 1 lists the proportion of patients in the Duke sample classified in each of the DIMS categories along with the proportions reported by Coleman et al. (5) in the National Cooperative Study of sleep disorder centers. Examination of Table 1 reveals that the Duke proportions fall within the percentage ranges reported for the 11 sleep centers comprising the national cooperative study. The greatest areas of discrepancy in the mean percentages were for psychiatric disorders and PMS/RLS.

In regard to the diagnoses most heavily dependent upon PSG findings, 34% of the Duke sample were given a primary diagnosis of either PMS/RLS (25%), sleep apnea

TABLE 1. *Diagnostic classification of DIMS patients*

	Duke[a]	Coleman et al.[b]	
Primary diagnosis	%	Mean %	Range/center
Psychiatric disorders	44	34.9	3.9–66.8
PMS/RLS	25	12.2	2.8–26.3
Psychophysiologic	16	15.3	1.0–32.9
Drug/alcohol dependency	6	12.4	2.9–25.2
No DIMS abnormality (subjective insomnia)	6	9.2	0–28.7
Sleep apnea	3	6.2	0–18.4

[a] Total Duke n = 100.
[b] National Cooperative Study of sleep disorders centers (5). Range/center, the range of diagnostic percentages across the 11 sleep centers participating in the study.

(3%), or subjective insomnia (6%). This compares with 27.6% in the National Cooperative Study. PSG data for the 25 PMS/RLS patients revealed an average movement index of 48.3 and an average movement arousal index of 23.3. The mean apnea index for the three patients with a primary diagnosis of sleep apnea was 22.2, with one of the three patients showing significant O_2 desaturation (from 97% to 84%). For the six patients with a primary diagnosis of subjective insomnia, PSG-derived total sleep time averaged 278.7 min, compared to a mean self-report (i.e., sleep diary) estimate of only 51.0 min. Four of these six patients reported obtaining no sleep on the night of the sleep study, though PSG revealed that their total sleep times ranged from 190 to 401 min. In addition to those patients receiving primary diagnoses of sleep apnea, PMS/RLS, and subjective insomnia, an additional 4% were given a secondary diagnosis of PMS/RLS, 1% sleep apnea, and 10% subjective insomnia.

The distribution of primary diagnoses of sleep apnea, PMS/RLS, and subjective insomnia across age groups is presented in Table 2. PMS/RLS shows a clear age relationship, with the prevalence being very high in patients 70 years of age and older. Age analysis for sleep apnea and subjective insomnia is difficult to interpret because of the small number of patients with these diagnoses. Only 15% of DIMS patients under the age of 40 were given a primary diagnosis of PMS/RLS, sleep apnea, or subjective insomnia, whereas 46% of the patients age 40 or older received one of these three diagnoses [$\chi^2(1) = 9.87$, $p < 0.01$].

To evaluate medication effects, the primary diagnoses of the 18 patients maintained on psychotropic medications at the time of the sleep study were also examined separately. The primary sleep diagnoses for the medication group were as follows: psychiatric disorder, 50% (n = 9); PMS/RLS, 28% (n = 5); psychophysiologic insomnia, 17% (n = 3); and drug/alcohol dependency, 6% (n = 1). Comparison of these data with those shown in Table 1 indicate that the diagnostic classification of the 18 medicated patients was highly similar to that of the total sample. Thus, inclusion of medicated patients appeared to have negligible effects on the results of this study.

Initial impression versus final diagnosis

The extent to which two experienced sleep clinicians could predict cases of sleep apnea, PMS/RLS, and subjective insomnia was evaluated by comparing initial clinical impression (without PSG) with the final diagnosis (including PSG). The data for PMS/RLS are presented in Table 3. As can be seen, the clinicians were able to identify only 14 of the 25 patients given a final diagnosis of PMS/RLS. The false negative rate for clinical impression was 11%, and the false positive rate was 9%. The data for clinical assessment of sleep apnea are presented in Table 4. Only one of the three documented

TABLE 2. *Primary diagnosis of PMS, apnea, and subjective insomnia by age*

Age (years)	Total n	PMS/RLS n	PMS/RLS %	Apnea n	Apnea %	Subjective n	Subjective %	Total n	Total %
20–29	16	1	6.2	1	6.2	0	0	2	12.5
30–39	23	4	17.4	0	0	0	0	4	17.4
40–49	19	4	21.1	0	0	2	10.5	6	31.6
50–59	17	5	29.4	1	5.9	2	11.8	8	47.1
60–69	18	6	33.3	1	5.6	2	11.1	9	50.0
70+	7	5	71.4	0	0	0	0	5	71.4

TABLE 3. *Clinical assessment of PMS/RLS*[a]

Clinical impression	Final diagnosis	
	Yes	No
Yes	14	9
No	11	66

[a] n = 100.

cases of sleep spnea was predicted on the basis of clinical impression. In seven cases, a clinical impression of sleep apnea was ruled out by PSG. In regard to subjective insomnia, only one of the six cases was predicted on the basis of the initial clinical exam. Furthermore, none of the 10 patients who received a secondary diagnosis of subjective insomnia was suspected of having a subjective component to their insomnia complaint.

DISCUSSION

Diagnostic classification of our DIMS sample revealed that 25% had a primary diagnosis of PMS/RLS, 3% had sleep apnea, and 6% had subjective insomnia. These three diagnoses are heavily dependent on PSG data. An additional 4% received a secondary diagnosis of PMS/RLS, 1% sleep apnea, and 10% subjective insomnia. Finally, PSG was useful in ruling out suspected PMS/RLS in 9% and sleep apnea in 7% of the sample. Combining across these different uses of PSG, 65% of our sample had sleep studies that yielded important diagnostic information. In regard to primary diagnoses of PMS/RLS, sleep apnea, and subjective insomnia, our cumulative total of 34% is quite consistent with the total of 27.6% reported by the National Cooperative Study of sleep disorder centers (5) and 48% in the Zorick et al. (6) study. These data suggest that PSG frequently results in important diagnostic information in the evaluation of chronic insomnia.

The necessity of conducting PSG evaluations for insomnia could be greatly curtailed if sleep clinicians could accurately predict cases of sleep apnea, PMS/RLS, and subjective insomnia based solely on a clinical exam. Unfortunately, our data suggest that experienced sleep clinicians have only modest success at predicting the presence of such sleep disorders. In our sample, only 14 of 25 (56%) cases of PMS were suspected on clinical impression. This finding is only somewhat more encouraging than a recent study that reported that only 33% of DIMS patients with PMS were predicted on the basis of the initial clinical examination (15). Furthermore, only one of three cases of sleep apnea and one of six patients with subjective insomnia in our sample were accu-

TABLE 4. *Clinical assessment of apnea*[a]

Clinical impression	Final diagnosis	
	Yes	No
Yes	1	7
No	2	90

[a] n = 100.

rately predicted. These results suggest that PSG often yields new findings in insomniac patients not suspected of having sleep apnea, PMS/RLS, or subjective insomnia.

Our data have important implications concerning the question of whether PSG should be used in the evaluation of chronic insomnia. DIMS patients showing clinical evidence of possible sleep apnea or PMS/RLS should clearly receive a PSG evaluation in order to confirm the clinical diagnosis. For patients not showing evidence of apnea or PMS/RLS, the decision to conduct PSG may be dependent on the chronicity and severity of the problem, the age of the patient, and the setting of the sleep center. Three approaches seem tenable. First, the sleep clinician could elect to formulate a diagnosis based solely on clinical impression and proceed with initial treatment. For patients who fail the first treatment, PSG could then be conducted in order to provide a more comprehensive diagnostic picture. Although this strategy would eliminate the expense of PSG for some patients, other patients will initially be inaccurately diagnosed and improperly treated. Of this latter group, some patients will likely drop out of treatment before a sleep study can be conducted and an accurate diagnosis ascertained. This approach would appear to be best suited for private practice settings with patients who are first presenting with insomnia and who have not failed previous treatment modalities.

A second possible approach would be to routinely use PSG in the evaluation of all chronic insomniacs. This strategy would provide the sleep clinician with important PSG data for many patients and would help reduce the proportion of inaccurately diagnosed patients. This approach seems best suited for sleep centers who frequently receive referrals from physicians following unsuccessful treatment of chronic insomniacs. The major disadvantage of this approach concerns those patients (35% in our sample) who will have sleep studies that yield no diagnostic information beyond the initial clinical impression.

A more pragmatic and cost-effective approach is one that considers the age relationship of sleep disorders. The results of this study, along with previous research findings (16), suggest that routine use of PSG is frequently justified in patients 40 years of age or older who have a relatively high incidence (46% in our sample) of sleep disorders requiring PSG for definitive diagnosis (sleep apnea, RLS/PMS, and subjective insomnia). For patients under the age of 40, the sleep disorders' clinician could provide initial treatment based solely on clinical impression. PSG could subsequently be used with younger patients if the initial treatment fails to produce significant improvement. This age-related approach may be the best compromise for sleep disorders centers in balancing cost-effectiveness with accurate diagnostic evaluations.

Our diagnostic data (see Table 1), based primarily on ambulatory PSG, compared quite favorably with the diagnostic results of previous studies (5,6) that employed laboratory PSG. This comparison provides initial evidence that the ambulatory cassette (AC) approach may serve as a viable alternative to laboratory procedures for the evaluation of DIMS patients. The AC allows for the monitoring of patients in a natural sleep environment (e.g., home, motel room) where relevant conditioned cues or well-established sleep disruptive behaviors are most likely to be present. Further, this apparatus permits the monitoring of sleep across 24 h, allows one daytime technologist to process several patients daily, and provides for efficient extended data storage.

However, the AC system employed herein has certain limitations. It currently includes no measure of oxygen desaturation and its oral-nasal respiratory measure may not be useful in the identification of all patients who would benefit by a laboratory study

for sleep apnea. Despite these limitations, the proportion of our patients receiving a final diagnosis of sleep apnea was comparable with the proportion found in the National Cooperative Study (5). This finding suggests that our use of the AC system likely did not result in a high false-negative rate for sleep apnea among our sample. Nevertheless, sleep disorders clinicians who typically encounter a larger proportion of apneics among their DIMS patients may find laboratory PSG more useful than ambulatory procedures.

REFERENCES

1. Kales A, Soldatos CR, Kales JD. Sleep disorders: evaluation and management in the office setting. In: Arieti S, Brodie HKH, eds. *American handbook of psychiatry*. New York: Basic Books, 1981;7:423–54.
2. Soldatos CR, Kales A, Kales JD. Management of insomnia. *Annu Rev Med* 1979;30:301–12.
3. Tan T, Kales JD, Kales A, Martin ED, Mann LD, Soldatos CR. Inpatient multidimensional management of treatment-resistant insomnia. *Psychosomatics* 1987;28:266–72.
4. Kales A, Bixler EO, Soldatos CR, Vela-Bueno A, Caldwell AB, Cadieux RJ. Biopsychobehavioral correlates of insomnia, part 1: role of sleep apnea and nocturnal myoclonus. *Psychosomatics*, 1981;23:589–600.
5. Coleman RM, Roffwarg HP, Kennedy SJ, et al. Sleep-wake disorders based on a polysomnographic diagnosis: a national cooperative study. *JAMA* 1982;247:997–1003.
6. Zorick FJ, Roth T, Hartze KM, Piccione PM, Stepanski EJ. Evaluation and diagnosis of persistent insomnia. *Am J Psychiatry* 1981;138:769–73.
7. Association of Sleep Disorders Centers. Diagnostic classification of sleep and arousal disorders, 1st ed. *Sleep* 1979;2:1–137.
8. Hoelscher TJ, Erwin CW, Marsh GR, Webb MD, Radtke RA, Lininger A. Ambulatory sleep monitoring with the Oxford Medilog 9000: technical acceptability, patient acceptance, and clinical indications. *Sleep* 1987;10:606–7.
9. 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.
10. Ancoli-Israel S, Kripe DF, Mason W, Messin S. Comparisons of home sleep recordings and polysomnography in older adults with sleep disorders. *Sleep* 1981;4:283–91.
11. 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.
12. Hoelscher TJ, McCall WV, Powell J, Marsh GR, Erwin CW. Two methods of scoring sleep with the Oxford Medilog 9000: comparison to conventional paper scoring. *Sleep* 1989;12:133–9.
13. Coleman RM. Periodic movements in sleep (nocturnal myoclonus) and restless legs syndrome. In: Guilleminault C, ed. *Sleeping and waking disorders: Indications and techniques*. Boston: Butterworth Publishers, 1982:265–95.
14. Radtke RA, Hoelscher TJ, Bragdon AC. Ambulatory evaluation of periodic movements of sleep. In: Ebersole JS, ed. *Ambulatory EEG monitoring*. New York: Raven Press, 1989:317–29.
15. Jacobs EA, Reynolds CF, Kupfer DJ, Lovin PA, Ehrenpreis AB. The role of polysomnography in the differential diagnosis of chronic insomnia. *Am J Psychiatry* 1988;145:346–9.
16. Coleman RM, Miles LE, Guilleminault CC, Zarcone VP, van den Hoed J, Dement WC. Sleep-wake disorders in the elderly: a polysomnographic analysis. *J Am Geriatr Soc* 1981;29:289–96.