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A Comparison of Reported and Recorded Sleep in Older Poor Sleepers

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Nocturnal sleep was monitored by both polysomnography (PSG) and sleep diaries in a community sample of nine older individuals (mean age = 68) complaining of disorders of initiating and maintaining sleep (DIMS). Comparisons on frequency and duration of nocturnal awakenings, total sleep time, and sleep efficiency indicate less reported awake time during the night and less frequent awakenings than PSG evaluation. There was also a trend for participants to report longer times to fall asleep than PSG evaluation indicated. Although physical disorders were screened using questionnaire and interview, PSG identified myoclonus in four subjects and obstructive sleep apnea in one. These results and low correlations between scores on the same sleep parameters using the two different measurement modalities emphasize (1) the importance of more extensive use of PSG monitoring for older individuals with insomnia, and (2) underscore the need for focused studies of time estimation of both sleep and wake time parameters in poor sleepers with sleep maintenance problems.

KEY WORDS: sleep; aging; polysomnography; self-report; insomnia; time estimation.

INTRODUCTION

Should physiological measures, such as polysomnography (PSG), be used in the routine evaluation of chronic insomnia in older individuals? A recent review of the insomnia literature concludes that conventional polysomnography may be of limited value (Reite, Buysse, Reynolds, & Mendelson, 1995). However, the utility of assessing physiological responses in the evaluation of a large variety of psychophysiological disorders continues to be debated in the psychological literature (e.g., Barlow, 1988). In the case of insomnia, the answer depends on the demonstration that PSG provides data that cannot be obtained from the clinical history.

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PSG is acknowledged as a valuable diagnostic procedure in the evaluation of disorders of excessive somnolence and medically based sleep problems (e.g., Edinger, Hoelscher, Webb, Marsh, Radtke, and Erwin, 1989; Reynolds, Coble, Black, Holzer, Carroll, and Kupfer, 1980) as well as hypnotic efficacy (Kryger, Siteljes, Pouliot, Neufeld, and Odgnoki, 1991). In the insomnia literature, however, the majority of psychological treatment outcome studies on disorders of initiating and maintaining sleep (DIMS) has relied exclusively on self-report measures. While one might argue that this is an appropriate form of evaluation, since it is the subjective perception of poor sleep which leads to presentation at a medical facility, there continues to be controversy as to the necessity of PSG evaluations for insomnia. A necessary step in establishing the importance of PSG data in the evaluation of DIMS is to compare recorded (PSG) and reported (self report) sleep, collecting data on the *same sleep parameters* and using these two modalities over the *same time periods*.

Because older individuals are more vulnerable to sleep disorders (Dement, Richardson, Prinz, Carskadon, Kripke, and Czeisler, 1985; Kales, 1975; Miles and Dement, 1980; Morin, 1993; Morin and Gramling, 1989; Prinz, Vitiello, Raskind, and Thorpy, 1990; Williams, Karacan, and Hursch, 1974) and because there are physical and psychosocial consequences, both of the sleep disturbance itself as well as of the usual pharmacological treatment (Ford and Kamerow, 1989; Mellinger, Balter, and Uhlenhuth, 1985; Pollak, Perlick, Linsner, Wenston, and Hsieh, 1990), our ongoing research has focused on evaluating various aspects of sleep in older individuals. In the context of this larger investigation, we examined the concordance between reported and recorded sleep parameters in a sample of older poor sleepers.

The goal of the present investigation was to compare the two measurement modalities—self-report and PSG—and evaluate the implications of similarities and differences between scores obtained when using these techniques for assessing and treating the complaint of insomnia in older individuals. While other studies have conducted such comparisons (e.g., Knab & Engel, 1988; Morin, Kowatch, Barry, and Walton, 1993), the important way in which our investigation differs from other published studies is that we collected PSG and self-report data on the *same sleep parameters*, for the *same two nights*, using *the same definitions of the sleep parameters*. Moreover, unlike the diversity typically found in other studies, our sample comprised a reasonably homogeneous group of individuals who had the same diagnosis (DIMS), whose sleep medication use was minimal, and who were of similar ages (60+).

The following questions are investigated: (1) How do scores on various sleep parameters compare when measured by self-report vs. polysomnography? (2) How does the individual's subjective perception of sleep quality relate to selected sleep parameters, as measured by self-report and PSG? (3) How does the sleep experience at home compare with sleep in a sleep laboratory? Since our participants all experienced difficulties both in falling asleep and in getting back to sleep after middle of the night and early morning awakenings, our data also provide information on over and underestimations of sleep onset latency as well as of the frequency and duration of nocturnal awakenings. It is notable that evaluation of the duration of nocturnal awake times is rarely reported in the literature; most studies focus on duration of nocturnal sleep time and on sleep latency.

METHOD

Subjects and Procedure

The sample consisted of nine older individuals, six women and three men (mean age = 68, range = 61–85) who were participating in a larger investigation of sleep and aging (Fichten, Creti, Amsel, Brender, Weinstein, & Libman, 1995; Libman, Amsel, Brender, and Fichten, in press). All nine subjects underwent two consecutive nights of sleep laboratory evaluation after completing a brief (2 week) psychological treatment for their sleep problem.

Participants were volunteers complaining of insomnia; they were recruited from the community through media publicity consisting of press releases, presentations to seniors' groups, advertisements, and notices in community clinics and residences for seniors. Potential participants were contacted by telephone and administered a short standardized insomnia screening. Those who appeared to meet the selection criteria were given an appointment where they were screened by members of the psychology research team to evaluate physical and psychiatric disorders related to sleep disturbance using the Structured Sleep History Interview described by Lacks (1987).

At the outset of the study, all nine subjects met the minimal research diagnostic criteria for psychophysiological insomnia (i.e., 30 minutes of undesired awake time at least 3 times per week, problem duration at least 6 months) and all requested treatment for their sleep problem. Subjects also met the following criteria: (a) sleep medication, if used, was not taken more than three nights per week (of the nine participants, in fact only one indicated current medication use); (b) no evidence of psychopathology or depression; (c) no major medical or psychiatric illness or drug use directly associated with sleep disturbance; and (d) no evidence of physically-based sleep disturbance (e.g., apnea, myoclonus, paresthesias, presence of sleep phase disorder) by history. Socioeconomic information collected in the larger investigation indicates that subjects were "middle class."

As part of the larger study, participants completed an extensive series of measures which evaluated their experienced sleep quality and associated distress levels (including the Sleep Questionnaire) at various times, (i.e., before and after a 2-week psychological intervention as well as at a 2-week follow-up). In addition, participants kept a daily log of their sleep experiences (Daily Sleep Diary) for a 2-week preintervention baseline period, during the 2-week treatment period, and for 2 weeks postintervention during the follow-up period.

During the follow-up period, 27 subjects participating in the larger investigation were offered a 2-night sleep lab evaluation. A two night protocol was selected because a "first night effect" may cause an atypical sleep pattern for some individuals (cf. Hauri and Olmstead, 1989). While elimination of a possible first night effect was pertinent for the treatment aspect of the larger study, it is not relevant for the present evaluation of the concordance between measures.

Eighteen of the 27 individuals were not evaluated, either because of refusal by the participant or scheduling difficulties. This left a sample of nine participants who underwent two consecutive nights of sleep laboratory evaluation at the Royal Victoria Hospital in Montreal during the first 2 days of the follow-up period. Upon awakening, they also completed the Daily Sleep Diary for each night.

Measures

Structured Sleep History Interview. We used a modified version of the clinical instrument developed by Lacks (1987). It provides information on selection and exclusion criteria (e.g., sleep apnea, nocturnal myoclonus, parasomnias, physical disorders, medication use, use of hypnotics, and sedatives). Most questions require a yes/no answer, with prompts in the case of suspected difficulty. The measure was administered by trained nonphysician members of the research team.

Daily Sleep Diary. This one page modification of Lacks' (1987, 1988) self-report instrument contains items which assess sleep quality (5-point scale) as well as the five specific sleep parameters of interest in the present investigation: (1) sleep onset latency (SOL), (2) frequency (FNA), and (3) duration of nocturnal arousals (WASO), (4) total sleep time (TST), and (5) sleep efficiency (a derived score).

Polysomnography (PSG). A standard PSG montage was used. This included electroencephalographic (EEG), electromyographic (EMG), and electro-oculographic (EOG) monitoring. Respiration (air flow, tidal volume, oxygen saturation) and anterior tibialis EMG were recorded to detect sleep apnea or periodic leg movements. Sleep stages were scored by experienced technicians at the Sleep Laboratory of the Royal Victoria Hospital in Montreal according to standardized criteria (Rechtschaffen and Kales, 1968). PSG data also included five specific sleep parameters examined using the Daily Sleep Diary. Two sleep lab procedures which differed from usual home sleep routines were: lights were turned off no later than midnight, and subjects were wakened by 6 a.m.

Sleep Questionnaire. This brief objective questionnaire inquires about typical sleep experiences. It has been validated in previous investigations of sleep parameters in older adults (Fichten *et al.,* 1995; Creti, Libman, Weinstein, Lennox, Gay, Bailes, Brender, Amsel, and Fichten, 1992; Libman et al., in press). The information provided permits the diagnosis of the presence or absence of a disorder of initiating or maintaining sleep (DIMS). The measure also provides data on the five sleep parameters examined using PSG and the Daily Sleep Diary.

Definitions

The following scores, based on the mean of the two nights in the sleep laboratory, were calculated for each subject:

Total Bedtime. PSG: lights off (latest at 12:00 AM) to lights on (latest at 6:00 AM); Sleep Diary: "What time did you turn off the lights?" and "What time did you wake up this morning?"

Total Sleep Time (TST). PSG: according to Rechtschaffen and Kales (1968); Sleep Diary: "Roughly how many hours did you sleep last night?"

Sleep Onset Latency (SOL). PSG: time between lights off and the first epoch of established stage 2 sleep; Sleep Diary: "How long did it take you to fall asleep last night?"

Frequency of Nocturnal Awakenings (FNA). PSG: number of waking periods lasting at least 2 epochs (60 sec); Sleep Diary: "How many times did you awaken during the night?"

Waking After Sleep Onset (WASO). PSG: Total Bedtime minus Total Sleep Time minus Sleep Onset Latency; Sleep Diary: after sleep onset, "Approximately what is the total number of hours and minutes you stayed awake during the night?"

Sleep Efficiency. Total Sleep Time/Total Bedtime.

Sleep Quality. Sleep Diary: "Rate the quality of last night's sleep" (1 = very poor; 5 = very good).

RESULTS

To evaluate recorded and reported sleep, we explored scores on the following five sleep parameters: sleep onset latency (SOL), duration (WASO) and frequency of nocturnal awakenings (FNA), hours slept during the night (TST), and sleep efficiency. Means of scores from the two nights at the sleep lab were used in the data analyses. Statistical analyses were performed with the Statistical Package for the Social Sciences (SPSS for Windows). Three kinds of analyses were carried out. First, paired two-tailed t-tests were carried out, with alpha level set at .05. Second, Chi-square (χ^2) was used to examine frequency data. Third, Pearson product–moment correlation coefficients were computed to examine the relationship between pairs of variables; here, marginally significant ($p < .10$) results are also highlighted because of our small sample size.

Comparison of Sleep Parameters: PSG vs. Daily Sleep Diary

To compare recorded (PSG) and reported (Sleep Diary) sleep parameters, paired t-test comparisons were conducted on the five pairs of Sleep Diary and PSG scores. Means and results are presented in Table I. These indicate significant differences on two variables: more frequent recorded than reported nocturnal arousals (FNA), and longer recorded than reported WASO (i.e., *worse* nocturnal awake experiences were obtained using PSG rather than self-report). The comparison on SOL approached significance ($t(8) = 1.89, p < .10$); this suggests longer reported than recorded sleep onset latency.

Another way to compare PSG and self-report is to examine the number of actual instances of either over or underestimation of sleep parameters on the Daily

Table I. Comparison of Sleep Parameters: PSG vs. Daily Sleep Diary

Sleep parameters	Means[a] PSG	Means[a] Diary	*t*-test $p<$	Correlation Pearson r^b
Sleep onset latency (SOL) (hr)	0.24 (0.16)	0.89 (0.98)	.10	−.19
Waking after sleep onset (WASO) (hr)	1.25 (0.56)	0.52 (0.67)	.05	−.12
Total sleep time (TST) (hr)	4.46 (0.78)	4.96 (1.12)	NS[c]	.48
Frequency of nocturnal arousals per night (FNA)	4.33 (1.90)	1.96 (0.76)	.01	.26
Sleep efficiency (%)	0.75 (0.10)	0.82 (0.19)	NS[c]	.49

[a]Scores are means; values in parentheses are standard deviations.
[b]None of these coefficients are significant.
[c]NS = not significant.

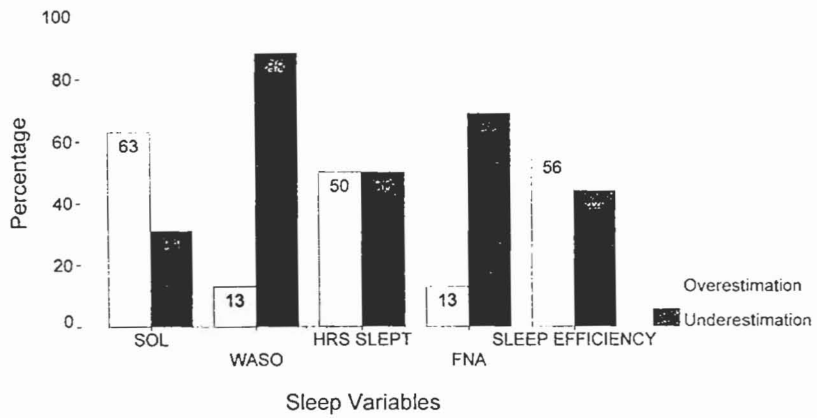

Fig. 1. Percentage of instances of over- and underestimation of sleep parameters on self-report compared to PSG.

Sleep Diary, relative to PSG. Scores from both nights were used. As is evident from Fig. 1, there was substantial overestimation of sleep onset latency (SOL), $\chi^2(1) = 5.00, p < .05$, and underestimation of time spent awake at night (WASO), $\chi^2(1) = 9.00, p < .01$, as well as of the frequency of nocturnal arousals (FNA), $\chi^2(1) = 6.24, p < .05$ (values in Fig. 1 do not equal 100 because some subjects had identical reported and recorded scores on some variables). Hours slept and sleep efficiency were each overestimated and underestimated approximately half of the time.

Table II. Correlations Between Overall Sleep Quality and Sleep Parameters: Pearson Product-Moment Correlation Coefficients

	Sleep lab PSG	Sleep lab Diary	Home diary
Sleep onset latency (SOL)	.44	−.57	−.52
Waking after sleep onset (WASO)	−.61*	−.11	−.45
Total sleep time (TST)	.28	.65*	.84**
Frequency of nocturnal arousals (FNA)	−.66*	−.29	−.40
Sleep efficiency	.52	.65*	.46

*$p < .10$.
**$p < .01$.

A third way of examining reported and recorded sleep is to examine correlations between equivalent Sleep Diary and PSG scores collected on the same night. Table I shows that while the relationship was strongest for the number of hours spent asleep and for sleep efficiency, none of the coefficients was significant.

Relationship Between Rated Sleep Quality and Sleep Parameters During the Sleep Lab Experience

To examine how participants' overall evaluation of the night is related to sleep parameters, sleep quality ratings (5-point scale) obtained from the Daily Sleep Diary were correlated with both self-report and PSG measures obtained at the sleep lab for each of the five sleep parameters of interest. As can be seen in Table II, overall sleep quality was associated with different variables depending on the modality of assessment. Better sleep quality was most closely, although not significantly, related to reported total sleep time and sleep efficiency. In contrast, for PSG, sleep quality was most closely related to fewer nocturnal arousals and to less time spent awake during the night; these are the same two variables which were underestimated on the Daily Sleep Diaries. Moreover, the relationship between overall sleep quality and total sleep time was the weakest for PSG scores.

Sleep at Home vs. at the Sleep Lab

To evaluate the representativeness of sleep at the sleep lab and to evaluate the utility of examining self-reported sleep in the home, we conducted two sets of analyses using data from the follow-up period. First, we used Sleep Diary scores from 1 week of monitoring at home and correlated overall sleep quality ratings with scores on the five sleep parameters of interest. Results on "Home Diary" in Table II show a pattern of coefficients which closely resembles that on Diary ratings at the sleep lab.

Second, we compared Sleep Diary scores on the five sleep parameters obtained in the sleep lab with Sleep Diary and Sleep Questionnaire scores based on evalu-

Table III. Comparison of Sleep Parameters: Sleep at Home vs. the Sleep Lab[a]

	Diary			t-tests: $p<$	
	Sleep lab	Home	Home quest.	Diary sleep lab vs. diary home	Home diary vs. home quest.
Sleep onset latency (SOL) (hr)	0.89 (0.98)	0.57 (0.53)	0.52 (0.46)	NS[b]	NS
Waking after sleep onset (WASO) (hr)	0.52 (0.67)	1.55 (1.16)	1.86 (1.99)	.01	NS
Total sleep time (TST)	4.96 (1.12)	5.64 (1.42)	5.58 (1.50)	NS	NS
Frequency of nocturnal arousals per night (FNA)	1.96 (0.76)	2.48 (1.11)	1.89 (1.17)	NS	NS
Sleep efficiency	0.82 (0.19)	0.79 (0.17)	0.70 (0.21)	NS	.05
Sleep quality rating (1–5)	2.94 (1.24)	3.24 (1.05)	—	NS	—

[a]Scores are means; values in parentheses are standard deviations.
[b]NS = not significant.

ations of sleep at home. Means and results of paired t-tests in Table III suggest that subjects' Sleep Diary evaluations of their sleep in the sleep lab are reasonably similar to their Sleep Diary evaluations of their sleep at home. Indeed, scores differed significantly on only one of the tests on the parameters of interest: WASO.

The data also suggest that the retrospective Sleep Questionnaire provides a reasonably accurate picture of sleep characteristics. As can be seen from Table III means and t-test results, Sleep Diary and Sleep Questionnaire scores on the five sleep parameters are very similar, with only one significant difference: Sleep Efficiency.

Incidence of Medically Based Sleep Disorders

The psychological team, using questionnaire and interview measures, attempted to screen out individuals with medically based sleep disorders. Nevertheless, PSG monitoring identified a high rate of undiagnosed medically-based sleep disorders: nocturnal myoclonus in four subjects and obstructive sleep apnea in one.

DISCUSSION

Our data suggest that PSG and self-report provide somewhat different evaluations of sleep parameters. Participants reported longer times to fall asleep, shorter amounts of time spent awake during the night, and fewer nocturnal awakenings compared with the polysomnographic evaluation. In addition, recorded and reported scores on sleep parameters were not significantly correlated with each other.

Perceived sleep quality, as it is related to specific sleep parameters, also differed depending on mode of measurement. For example, while sleep quality was most closely related to reported time spent asleep, it was most poorly related to this variable on PSG. Conversely, reported sleep quality was highly correlated with PSG measured frequency and duration of nocturnal arousals (i.e., reported number of awakenings and time spent awake), but weakly associated with these variables on self-report.

With respect to the comparison between sleep in the laboratory and sleep at home, perceived sleep quality seemed reasonably similar in these two settings. Sleep efficiency scores for sleep lab and home sleep were similar as well. Discrepancies noted in total sleep time and time spent in bed were probably due to our sleep lab's practice of waking participants no later than 6:00 a.m. That reported sleep experience in the laboratory seemed reasonably representative of sleep at home for our sample is consistent with the insomnia literature (Knab and Engle, 1988). Parenthetically, it should be noted that our data suggest that the less labour intensive questionnaire yields data similar to daily sleep diaries.

Our findings of overestimated sleep onset latency and underestimated nocturnal awakening frequency are not uncommon in studies comparing objective and self-report measurement (e.g., Carskadon, Dement, Mitler, Guilleminault, Zarcone, and Spiegal, 1976; Coursey, Frankel, Gaardner, and Mott, 1980; Frankel, Coursey, Buchbinder, and Snyder, 1976; Knab and Engel, 1988; Kryger *et al.*, 1991; Lichstein and Johnson, 1991; Morin *et al.*, 1993; Morin, Colecci, Stone, Brink, and Sood, 1994). There are a variety of possible explanations for such sleep onset latency results, including difficulties estimating unfilled and unpleasant time (Fichten and Libman, 1991), as well as problems with operational definitions. For example, Hauri and Olmstead (1989) postulated that the traditional EEG assessed measure of sleep onset (i.e., first epoch scored as stage 2 sleep) is inappropriate for insomniacs because of demonstrated random alpha rhythm activity in all sleep stages. As for the underestimation of the frequency of nocturnal arousals, Knab and Engle (1988) proposed that insomniacs do not perceive awakening after short sleep intervals because they are not aware of having slept. Of course, forgetting is another possibility, as reporting of nocturnal events has been related to retrograde and anterograde amnesia (Lichstein and Johnson, 1991; Wyatt, Bootzin, Anthony, and Bazant, 1994).

The finding that our older poor sleepers significantly underestimated the time they spent awake during the night is consistent with the amnesia hypothesis. It is also contrary to clinical lore, however, which states that insomniacs always exaggerate how poorly they sleep and how long they are awake. This belief may be based on the numerous published studies which do, in fact, indicate that the reported sleep of individuals suffering from insomnia is fairly consistently in the direction of poorer sleep than that indicated by PSG; however, these data typically do not reflect estimates of nocturnal *awake* times. Rather, total *sleep* times are used (Carskadon *et al.*, 1976; Coursey *et al.*, 1976; Coates, Killen, Silverman, George, Marchini, Hamilton, and Thoresen, 1983; Kryger *et al.*, 1991; Mendelson, James, Garnett, Sack, and Rosenthal, 1986). In contrast, in our investigation, as well as in studies by Coates *et al.* (1983), Lichstein and Johnson (1991), and Morin *et al.* (1994), older individuals reported better sleep than indicated by PSG when this was based on nocturnal *awake* times rather than on total sleep times (i.e., they *under*estimated sleeplessness after sleep onset).

In spite of systematic differences between reported and recorded sleep, many studies have found that self-report and objectively measured sleep parameters were, nevertheless, correlated both in unselected poor sleepers (e.g., Frankel *et al.,* 1976; Kryger *et al.,* 1991), as well as in healthy seniors who had no sleep complaints (Hoch, Reynolds, Kupfer, Berman, Houck, and Stack, 1987). By contrast, in the present investigation *none* of the relationships between self report and PSG was significant. This, along with the findings on underestimations of nocturnal awake times, suggests that clinical lore—and its presumed etiological significance—may have to be reformulated for older poor sleepers and/or for sleep maintenance insomnia. Clearly, more focused investigations of time estimation by older poor sleepers during nocturnal wakefulness—and of the factors influencing the perceived passage of time—would be useful to better understand the insomnia experience and to help develop more effective treatments.

If we assume that PSG is physiological "reality," then PSG measured frequency of nocturnal arousals and *time spent awake* are what determined our participants' subjective evaluation of sleep quality. According to their subjective experience, however, they judged sleep quality by the amount of time they *slept* during the night. This suggests that the perceived quality of the sleep experience is based, in part, on physiological events of which people are seemingly unaware. Therefore, both the objective and the subjective findings—and both time spent awake *and* time spent asleep—are important parameters, both to monitor when evaluating insomnia in older individuals as well as to change during interventions aimed at improving sleep quality. Perhaps, interventions for DIMS in older adults may have to independently target perceived hours slept and "physiological" frequency and duration of nocturnal awakenings.

Before concluding, certain methodological limitations in this investigation should be noted. The participants in this study had been monitoring their sleep experience for a period of 4 weeks and had been exposed to a brief psychological intervention at the time that PSG and self-report were compared. It has been shown that training subjective insomniacs to accurately perceive PSG monitored sleep onset improves subjective estimates of sleep onset latency and of perceived ability to fall asleep (Downey and Barnet, 1992). While it is difficult to see how separation of the subjective and objective aspects of the sleep experience could have come about as a result of our treatment intervention, nevertheless, the present procedure should be replicated with a larger sample of older individuals who present with DIMS, but who have not been exposed to experiences which might have altered their sleep patterns or their subjective perceptions. Furthermore, understanding the sleep experience in an aging population would be more comprehensive if a similar comparison of recorded and reported sleep in older individuals without DIMS were to be conducted. Such a study would clarify how typical discrepancies between measurement modalities are for older people in general, how common physically based sleep disorders are in older age, and to what extent physical disorders, such as nocturnal myoclonus and sleep apnea, influence subjective evaluation of sleep problem severity.

The finding of a high incidence of nocturnal myoclonus and obstructive sleep apnea is consistent with findings in the majority of studies which have included older individuals (e.g., Bliwise, 1996; Edinger *et al.,* 1989; Jacobs, Reynolds, Kupfer, Lovin, and Ehrenpreis, 1988; Reynolds *et al.,* 1980); this, too, highlights the existence of nocturnal physiological events of which the older individual is unaware. Our data lend support to the warning (cf. McCall and Edinger, 1991) that it is not possible to consistently predict the presence of disorders such as myoclonus or sleep apnea on clinical grounds alone, i.e., without using polysomnography. Although screening in this study was carried out by nonmedical personnel, this appears to be the case even when assessment is carried out by experienced sleep clinicians (e.g., Edinger *et al.,* 1989).

The high incidence of physiologically based sleep disruption, together with the discrepancies in recorded and reported sleep parameters, suggest that for older individuals with insomnia, conscious awareness of nocturnal events may not be necessary to the subjective experience of impaired sleep. Our results suggest that polysomnographic and self-report measures may reflect complementary aspects of the sleep experience, and this, coupled with finding a high incidence of undiagnosed nocturnal myoclonus and apnea, underscores the importance of PSG monitoring in the assessment of DIMS in older people. The current trend toward home monitoring—which is simpler and cheaper (Pack, 1993)—may be a step in the right direction.

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