Sleep, 18(4):232–239

Disorders of Initiating and Maintaining Sleep

The Distribution and Clinical Significance of Sleep Time Misperceptions Among Insomniacs

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Summary: It is well recognized that sleep time misperceptions are common among insomniacs, but little is known about the distribution and clinical significance of these subjective distortions. The current investigation was conducted to examine the distribution of sleep time misperceptions among a large (n = 173), diverse group of insomniacs and to determine if such misperceptions might relate to the patients' clinical characteristics. Consistent with previous studies, our subjects, as a group, produced sleep estimates that were significantly ($p < 0.0001$) lower than polysomnographically determined sleep times. However, patients' sleep time perceptions were widely distributed across a broad continuum, which ranged between gross underestimates and remarkable overestimates of actual sleep times. Results also showed that subgroups, formed on the basis of presenting complaints and diagnostic criteria (i.e. *International Classification of Sleep Disorders* nosology), differed in regard to the magnitude and direction of their sleep distortions. Moreover, these differences appeared consistent with the types of objective sleep disturbances these subgroups commonly experience. Hence, the tendency to underestimate actual sleep time is not a generic attribute of all insomniacs. Furthermore, it appears that the accuracy and nature of sleep time perceptions may relate to the type of sleep pathology underlying insomniacs' presenting complaints. **Key Words:** Insomnia—Sleep misperception.

Previous studies have demonstrated that insomniacs' reports of sleep difficulties are confounded by their sleep time misperceptions. In general, such studies have consistently shown that insomniacs, as a group, characteristically underestimate their nocturnal sleep time (1–4). However, one of these studies (4) also showed that some insomniacs accurately estimate sleep time, whereas others actually overestimate time spent asleep. Nevertheless, perhaps because the distribution of sleep time perceptions among insomniacs has yet to be thoroughly examined, these types of insomniacs have been largely ignored in both the clinical and research literature. As a consequence, many clinicians commonly assume that underestimation of sleep time is a "generic" attribute among all patients who present with insomnia complaints.

Despite this common assumption, the clinical significance of such misperceptions remains controversial. Whereas diagnoses such as Total Subjective Insomnia (5) and Sleep State Misperception (6) have been proposed for those insomniacs who grossly underestimate their sleep time, some sleep specialists have criticized such diagnostic labels. Reynolds et al. (7) have, for example, noted sleep time misperceptions are so ubiquitous among chronic insomniacs that it is highly questionable whether insomniacs should be subtyped purely on the basis of their sleep perceptions. Indeed, as Reynolds et al. argue, patients who produce gross underestimates of their actual sleep times may merely lie at the far end of what may be a qualitatively meaningless subjective continuum.

Unfortunately previous research has provided insufficient information to resolve this controversy. Many of the previous reports were based upon small or nonclinical insomniac samples, so their relevance to large, diverse clinical populations remains questionable. Furthermore, whether sleep time misperceptions might serve as the hallmark of specific diagnostic subtypes remains untested. Although Frankel et al. (2) did show that sleep perceptions reliably discriminated sleep-onset from sleep-maintenance insomniacs, no studies have examined the relationship between perceptions and the

Accepted for publication October 1994.
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insomnia diagnoses currently in use. Thus, additional research is needed to further explore both the range and the clinical significance of sleep time perceptions among insomnia patients.

The current investigation was conducted both to examine the distribution of sleep time misperceptions among a large, diverse group of insomnia outpatients and to determine the potential clinical relevance of these perceptions. As a first step, we derived descriptive statistics and constructed a frequency distribution to more fully characterize the range of sleep time misperceptions displayed by our sample. Subsequently, we examined the statistical relationship between these sleep misperceptions and specific presenting complaints. Finally, we tested whether specific diagnostic subgroups among these patients differed in regard to the nature and accuracy of their sleep time perceptions.

METHODS

Subjects

Subjects were selected from the population of all outpatient insomniacs who presented to the Duke University Medical Center's Sleep Disorders Center between September 1985 and December 1993. A patient was included in the current investigation if he/she: 1) presented with a complaint of nonrestorative sleep or a difficulty initiating and/or maintaining sleep, which lasted at least 3 months; 2) had undergone 1 night of ambulatory polysomnography with the monitoring montage described below (see *Polysomnography* section); 3) had completed a sleep diary on the morning following the night of sleep monitoring; and 4) had a minimum age $\geq$18 years. Patients who presented with a primary complaint of excessive daytime sleepiness or a parasomnia were excluded from the study. Also, prospective subjects who failed to provide sufficient information on their sleep diaries to allow for the derivation of a subjective sleep time estimate were also excluded.

On the basis of these selection criteria, a sample of 173 (106 females, 67 males) outpatient insomniacs was obtained. The mean age of this sample was 49.6 years (SD = 15.3 years), and their mean years of education was 15.1 (SD = 3.6 years). The sample was composed of 166 Caucasians, three African-Americans, two Hispanic-Americans and two Asian-Americans. The mean duration of insomnia complaints for these groups was 9.6 years (SD = 10.7 years).

Polysomnography

One night of ambulatory polysomnography (PSG) was conducted for diagnostic purposes on each subject. In each case, an Oxford Medilog® 9000 (Oxford Medilog, Inc., Clearwater, FL, U.S.A.) ambulatory recorder was used to conduct PSG. The monitoring montage consisted of two electroencephalogram channels (C_3-A_2, O_z-C_z), bilateral electrooculogram, submental electromyogram (EMG), two channels of anterior tibialis EMG (right and left leg) and a nasal-oral respiration thermistor. Patients reported to the sleep laboratory between 12:30 p.m. and 4:30 p.m. for electrode attachment, but they slept in their own homes (n = 169) or a motel (n = 3) on the study night. Patients were instructed to abstain from alcohol, refrain from caffeine after 6:00 p.m. and to adhere to normal bedtimes and waketimes on the night of monitoring. On the morning following the PSG night, patients provided a written estimate of their sleep time on a sleep diary and then returned to the sleep laboratory, both to have electrodes removed and to return the Medilog monitor.

All PSG records were scored by laboratory personnel (polysomnographer or sleep technician) who were kept blind to the study's objectives and primary dependent measure. Each taped PSG record was scored directly on the screen of the Medilog play back unit (PBU) using standard scoring criteria (8). The PBU or "scanner" projects typical waveform representations of all eight recording channels on a cathode-ray screen, which resembles a PC monitor. As we have previously noted (9), the Oxford screen scoring method allows human scorers to base their stage assignments upon both visual (i.e. waveforms shown on the PBU's screen) and auditory cues (i.e. sleep stage sounds that are audible when the PBU is run at high speed). For the purposes of this study, PSG scoring consisted of both rapid screen scanning, during which visual and auditory data were employed for sleep stage assignments, and screen-by-screen editing, during which visual data were used to assure the accuracy of these assignments and to quantify pathological sleep-related events (e.g. apneas, periodic limb movements). These on-screen scoring methods were used for convenience, because we have previously found they produce results comparable to those obtained from epoch-by-epoch scoring of paper records (10). In our most recent reliability test, we found an 89% agreement for sleep stage assignments between two of our scorers, who both independently scored a randomly selected subset (n = 38) of PSGs obtained from the patient population used herein.

Once the subjects' PSG records were scored, estimates of total sleep time, total sleep period, sleep onset latency, wake time after sleep onset, sleep efficiency %, minutes of stage 1, minutes of stage 2, minutes of slow-wave sleep, minutes of rapid eye movement (REM) and REM latency were derived. Also, the number of periodic limb movements per hour of sleep and the number of limb movement-related arousals were cal-

culated using standard scoring criteria for these phenomena (11,12). Finally, an apnea/hypopnea index was estimated on the basis of thermistor findings for patients who displayed sleep-related respiratory disturbances. Those few patients (n = 4) who displayed clinically significant respiratory events underwent a second, in-laboratory PSG with full respiratory montage to subsequently confirm a suspicion of sleep apnea.

Dependent measure

The accuracy of subjects' sleep perceptions was determined through a comparison of both estimated sleep times (obtained from sleep diary) and actual sleep times (derived from ambulatory PSG). The study's dependent measure, the percent of objective sleep time estimated (*OSE*), was calculated for each subject using the following formula: $OSE = (MSE/MAS) \times 100\%$. In this formula *MSE* represented minutes of sleep estimated and *MAS* represented minutes of actual sleep time obtained on the night of PSG monitoring. Thus, an *OSE* value of 100% indicated perfect prediction of objective sleep time. In contrast, an *OSE* value of 75% indicated the diary estimate of sleep time represented 75% of actual sleep time, whereas a value of 150% indicated that the subject's sleep estimate was 1.5 times the amount of actual time slept.

Procedure

As part of the routine intake procedures, all subjects completed a 10-page sleep history questionnaire, which elicited demographic information, details about their presenting sleep complaints, information about specific sleep symptoms and details about their medical and psychiatric histories. Each subject also underwent an intake interview with a sleep disorders clinician (psychiatrist or clinical psychologist), who further queried the subject about history and presenting symptoms and then dictated a report summarizing the findings of this interview. The patient was subsequently scheduled for an ambulatory PSG which, in most cases, was conducted within 4 weeks of the intake interview. If clinically appropriate, subjects who presented on psychotropic or hypnotic medications underwent a medication taper and were medication-free for at least 10 days prior to their PSG monitoring. However, such medications were deemed clinically necessary for 51 of the subjects, so these patients underwent PSG monitoring while on their customary doses of their respective medications.

Once subjects completed all of these evaluation procedures, they were assigned insomnia diagnoses using criteria provided in the *International Classification of Sleep Disorders* (ICSD) (6) manual. An experienced sleep disorders specialist (J.D.E.), blinded to subjects' *OSE* scores, reviewed the available clinical data (sleep history questionnaire, PSG, sleep clinician report) and assigned each subject an ICSD insomnia diagnosis. Cases meeting criteria for multiple insomnia diagnoses were assigned the one ICSD diagnosis that seemed most salient to the patient's presenting sleep complaint. To test the reliability of these diagnostic assignments, 31 cases were randomly selected from the entire subject sample. A second sleep clinician (A.I.F.), who was kept blind to the first clinician's diagnostic assignments, then reviewed the available clinical data for these subjects and assigned a primary ICSD insomnia diagnosis to each. The raw rate of agreement (% agreement) and kappa values were then calculated to determine the reliability of diagnostic assignments between these two clinicians.

Subsequently, sleep estimates and objective sleep times were compared via correlational analyses and dependent *t* tests. A frequency distribution of *OSE* values was then constructed in order to characterize the general trends and range of sleep misperceptions among our sample. Subsequently, subjects' responses were retrieved for each of the following sleep history questionnaire items: (a) "Please describe your sleep problem."; (b) "What do you feel is the major cause(s) of your sleep problem?"; (c) "Has anyone ever told you that you seem to stop breathing while you sleep or that you wake up gasping for breath?"; (d) "Has anyone ever noted your legs periodically twitching during the night?"; (e) "Have you noticed a deep creeping sensation inside your calves or thighs during the night?"; (f) "Currently, how many times during the month do you use medications to help you sleep?"; (g) "Have you ever been treated by a psychiatrist, psychologist or other mental health professional?"; (h) "How much difficulty do you have relaxing your body at bedtime?" (rated on a 10-point scale with a rating of "1" = "not at all" and "10" = "a very great deal"); (i) "How much difficulty do you have turning off your mind at bedtime?" (rated on a 10-point scale with "1" = "not at all" and "10" = "a very great deal"). Subgroups were formed for each of these items on the basis of subjects' responses, and the *OSE* scores of the resulting subgroups were statistically compared. Finally, *OSE* scores of ICSD diagnostic subgroups were compared to determine the relationship between the insomnia subtypes and sleep time perceptions.

RESULTS

Objective sleep time versus sleep estimates

A Shapiro-Wilk test (13) showed that the PSG-derived objective sleep times of the subjects were nor-

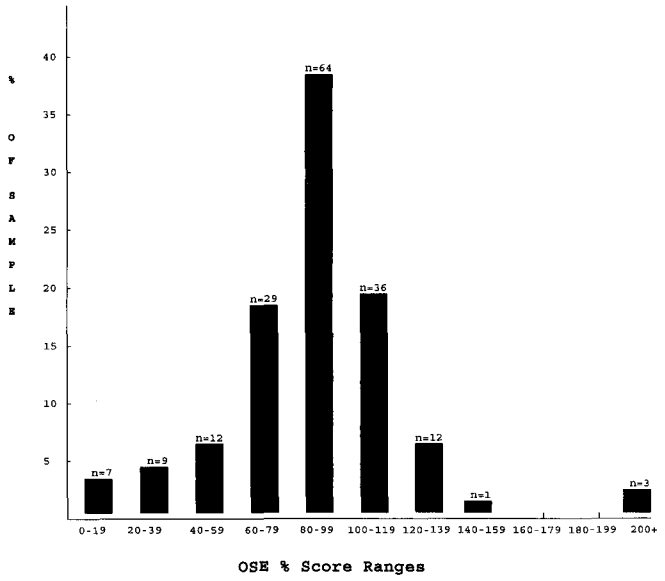

FIG. 1. Proportional distribution of *OSE* scores for entire insomniac sample.

mally distributed ($W = 0.97$, $p > 0.06$) and had a mean value of 355.0 minutes (SD = 85.5 minutes) and a median of 359.0 minutes. In contrast, the distribution of sleep estimates varied significantly ($W = 0.77$, $p < 0.001$) from normality and had a mean value of 305.4 minutes (SD = 128.2 minutes) and a median of 325.0 minutes. For the group as a whole, sleep estimates were significantly lower ($t_{dep} = -5.96$, $p < 0.0001$) than actual sleep times, although a Spearman correlational analysis showed the subjective and objective sleep measures were moderately, albeit significantly, correlated ($r = 0.58$, $p < 0.0001$).

The sample distribution for values of *OSE,* the percentage of actual sleep time estimated, is shown in Fig. 1. Descriptive statistics showed the distribution was positively skewed (skewness = 2.79), leptokurtic (kurtosis = 18.80) and had a median of 91.9% (first quartile = 68.9%; third quartile = 102.27%). Moreover, *OSE* values ranged from a low value of 0% to a high of 377.8%. Hence, the low and high extremes of this distribution represented gross under- and overestimates, respectively.

Relationship of sleep perceptions to demographic and PSG variables

Prior to our primary comparisons, we conducted a series of nonparametric analyses to determine whether differences in sleep time perceptions might merely be attributable to demographic characteristics (e.g. age, sex, education, etc.), current medication status or sleep/wake times recorded during PSG monitoring. A Spearman correlation analysis showed that subjects' *OSE* scores were not significantly correlated with their years of education, duration of sleep complaint, age, sleep expectancies (i.e. the amount of time subjects thought they should sleep per night) or PSG-derived measures of total sleep time, sleep onset latency, wake time after sleep onset or sleep efficiency % (all p's > 0.15). Moreover, Wilcoxon tests showed *OSE* scores of men and women did not differ ($p > 0.60$), nor did such scores of drug-free subjects and subjects who underwent PSG while taking their usual medication ($p > 0.45$). Hence, sleep time perceptions of our subjects apparently were unrelated to their demographic characteristics, medication status and both actual and expected sleep times.

Sleep perceptions and presenting complaints/symptoms

A series of nonparametric analyses (Wilcoxon or Kruksal-Wallis tests) were conducted to determine the relationship between sleep time perceptions and the nine selected sleep history questionnaire items. These analyses showed that subgroups formed on the basis of their presenting sleep complaints ($p < 0.025$) or admission/denial of bed partner-observed periodic leg movements ($p < 0.05$) differed significantly in regard to their sleep perceptions (i.e. *OSE* scores). Also, these analyses showed that the relationship between subjects' sleep perceptions (*OSE* scores) and the perceived cause(s) of their insomnia approached significance ($p < 0.07$). Table 1 contains descriptive statistics and nonparametric test results for these subgroup comparisons. These data show that patients with higher estimates of actual sleep time: 1) viewed their sleep problem as resulting from a physical/medical cause; 2) presented with complaints of nonrestorative sleep or daytime fatigue; and 3) reported periodic limb movements (PLMS) during their sleep. Patients who were unable to identify the cause of their insomnia, who reported no PLMS, and who had both sleep onset and maintenance complaints had the greatest tendency to underestimate sleep time. In contrast, statistical comparisons of subgroups formed on the basis of responses to the remaining six questionnaire items were all nonsignificant.

Sleep perceptions and insomnia diagnoses

Comparisons of clinician's diagnostic assignments showed that the two sleep specialists had a 74% agreement rate (Kappa = 0.68) for ICSD insomnia diagnoses within the randomly selected subset (n = 31) of subjects used to test diagnostic reliability. Considering the post hoc method used for diagnostic assignments, these agreement rates appeared acceptable and suggested the primary diagnostician (J.D.E.) was reliable in his di-

TABLE 1. *Descriptive statistics and nonparametric results for OSE score comparisons of subgroups formed on the basis of sleep questionnaire responses*

Subgroups	n	Median	1st Quartile	3rd Quartile	p
Nature of complaint					
Sleep onset	35	93.4%	70.0%	104.1%	
Sleep maintenance	60	94.4%	79.3%	102.9%	
Onset and maintenance	70	85.9%	60.1%	98.4%	<0.025
Other[a]	8	104.2%	93.1%	168.0%	
Observed PLMS[b]					
PLMS observed	57	95.4%	78.1%	105.8%	<0.05
No PLMS observed	113	89.5%	68.2%	98.7%	
Perceived cause					
Physical	25	101.3%	78.3%	110.1%	
Psychological	73	92.9%	74.9%	98.9%	
Both[c]	25	92.1%	83.9%	101.0%	<0.07
Unknown	48	78.3%	53.3%	98.7%	

[a] "Other" includes complaints of nonrestorative sleep or daytime fatigue but not excessive daytime sleepiness.
[b] PLMS = periodic limb movement during sleep.
[c] Both = a combination of psychological and physical/medical causes.

agnostic decisions. Hence, the diagnoses assigned by this clinician were used in the analyses described below.

Assignment of ICSD diagnoses resulted in the identification of a variety of subtypes. The most common diagnosis assigned was Insomnia Associated with Depression (32.4%). The other relatively common diagnoses, in descending order of prevalence, were Periodic Limb Movement Disorder and/or Restless Legs Syndrome (19.1%), Inadequate Sleep Hygiene (13.9%), Psychophysiological Insomnia (9.8%), Hypnotic Dependent Insomnia (4.0%), Idiopathic Insomnia (3.5%), Sleep State Misperception (2.3%) and Obstructive Sleep Apnea (2.3%). The remaining patients were assigned other miscellaneous diagnoses. To determine the relationship between insomnia diagnoses and sleep time perceptions, we first compared the *OSE* scores of the eight most common subtypes by means of a Kruskal-Wallis test. To further explore the relationship between sleep perceptions and these diagnoses, we determined the proportion of each of these subtypes having: 1) *OSE* scores between 0% and 50%, 2) *OSE* scores >50% and ≤100% and 3) *OSE* scores >100%. We subsequently performed a 3 (*OSE* score range) × 8 (diagnostic subtype) chi-square analysis.

Results of the Kruskal-Wallis test approached significance ($p < 0.095$), whereas the 3 (*OSE* score range) × 8 (diagnostic group) chi-square comparison was statistically significant ($\chi^2 = 26.2$, $p < 0.025$). Table 2 shows the *OSE* score comparisons for these diagnostic groups and Fig. 2 shows the proportions of each subtype falling in each of the three *OSE* score ranges. Both the table and figure suggest that patients with Sleep State Misperception, Psychophysiological Insomnia and Insomnia Associated with Depression were most prone to provide gross underestimates of sleep time, whereas those with Periodic Limb Movement Disorder/Restless Legs Syndrome were especially prone to overestimate the time they slept.

DISCUSSION

The current investigation was conducted to explore the nature and range of sleep perceptions among insomniacs and to determine the relationship between these perceptions and clinical characteristics of insomnia subtypes. Consistent with previous research, we found that insomniacs, as a group, produced subjective sleep estimates that were significantly lower than their actual sleep times. However, results also supported the

TABLE 2. *Descriptive statistics for OSE score comparisons of ICSD subgroups*

Subgroup	n	Median (%)	1st Quartile (%)	3rd Quartile (%)
Depression	56	86.3	50.6	100.5
Sleep Apnea	4	91.4	82.5	103.2
Inadequate Hygiene	24	88.7	75.0	98.3
Hypnotic Dependence	7	97.0	91.9	106.5
Idiopathic	6	84.6	69.9	104.2
Sleep Misperception	4	0.0	0.0	47.7
Psychophysiological	17	88.0	73.5	97.5
PLMD/RLS[a]	33	95.3	81.5	107.6

[a] Periodic Limb Movement Disorder and Restless Legs Syndrome.

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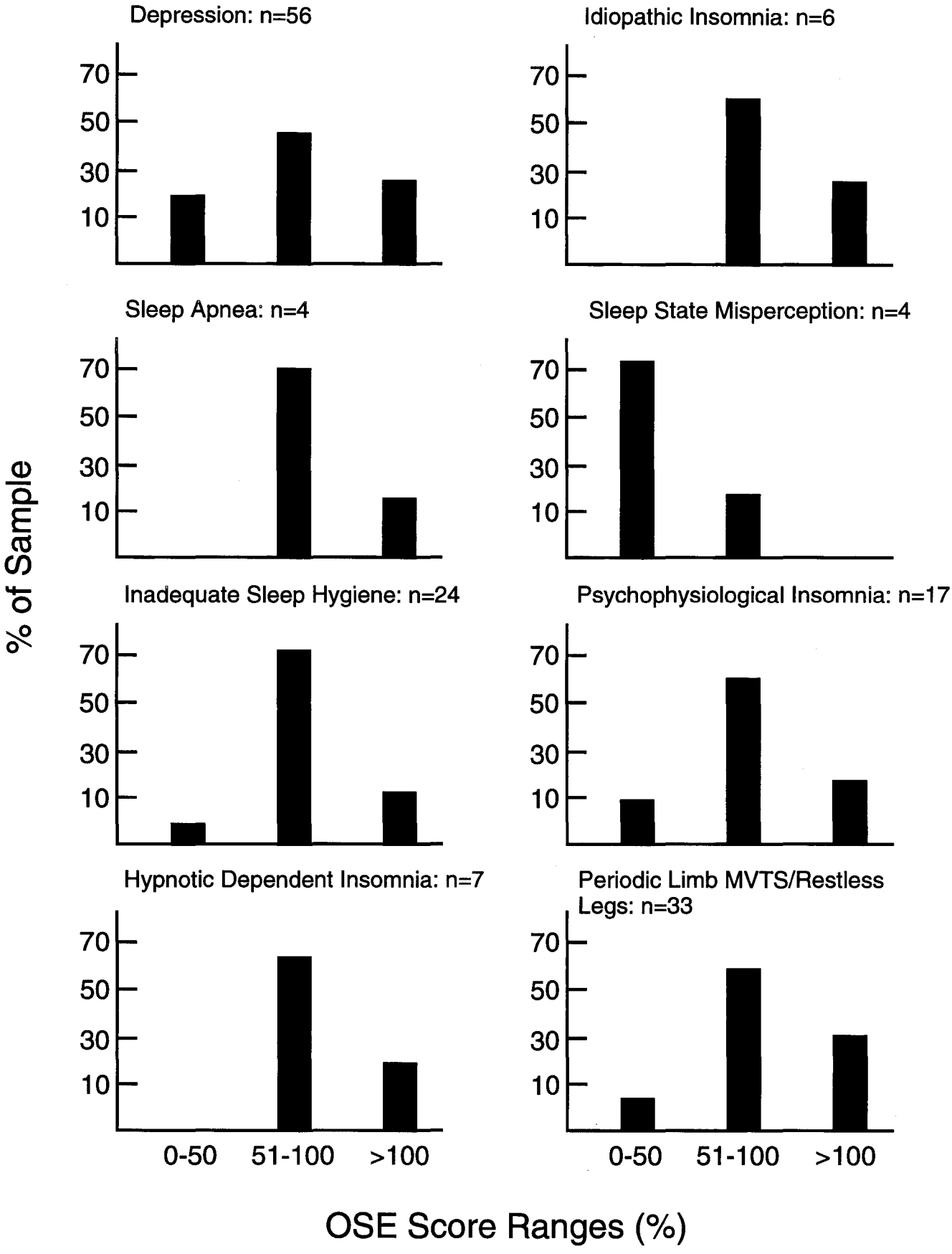
FIG. 2. Proportions of ICSD insomnia subtypes in each of three *OSE* score ranges.



recent hypothesis (7) that insomniacs' sleep misperceptions form a continuum, which we found to be leptokurtic and positively skewed. Moreover, although a large proportion of our subjects underestimated the amount of sleep obtained, over 20% produced overestimates of their actual sleep times. Given this latter finding, it would appear unwise to approach all insomnia patients with the assumption that their presenting sleep complaints overstate the severity of the actual sleep disturbance. Indeed, when ancillary information, such as that provided by a bedpartner, suggests otherwise, the clinician may need to suspect that the insomnia problem may actually be *worse* than the complaint presented by the patient.

Although it may not always be obvious when a patient's presenting complaint represents an understatement of his/her sleep problem, the findings noted herein suggest that certain presenting symptoms might lead to this suspicion. Specifically, results suggested that overestimates of objective sleep time were more common among those patients who complained of nonrestorative sleep or daytime fatigue, felt their sleep problems resulted from physical/medical causes and indicated that a bedpartner had observed periodic leg jerks during their sleep. In addition, findings showed insomnias associated with Periodic Leg Movements/Restless Legs Syndrome were more commonly associated with overestimates of actual sleep times than were many other insomnia subtypes. Admittedly, some significant findings would be expected given the number of statistical comparisons we conducted. However, our results seem consistent with intuition, inasmuch as the prolonged periods of wakefulness commonly endured in the beginning, middle and/or end of the night by some insomnia subtypes (e.g. those with depression or Psychophysiological Insomnia) likely produce a markedly different subjective sleep experience than the repeated, brief arousals suffered by those with periodic limb movements. Indeed, many patients with this latter disorder seem to have only a vague notion of the nature of their sleep problems and are usually unaware of their repetitive limb movements during sleep (14). In view of this consideration and our results, clinicians might consider specific presenting symptoms and preliminary diagnostic impressions to guide their clinical suspicions regarding the accuracy and nature of specific patients' sleep perceptions.

It is, of course, possible that sleep time misperceptions may relate as much to our current polysomnographic definition of sleep as to other, more clinically significant factors. However, it should be noted that normal sleepers typically produce relatively accurate sleep time estimates when compared to insomniac samples (3). Moreover, the relationships between our subjects' clinical characteristics and their sleep time perceptions noted herein further argue against this contention. Hence, it seems that the accuracy and nature of sleep time perceptions have important clinical implications among insomnia patients.

In considering our findings, it is important to consider the limitations of this investigation. Despite the relatively large sample employed, some of the specific (ICSD) insomnia subgroups were relatively small and other subgroups (e.g. environmental sleep disorder) were totally absent from the sample. Furthermore, only sleep center patients who had undergone a diagnostic PSG were included in our sample. Because we tend to conduct PSG studies primarily on certain insomnia subtypes (i.e. older patients or those in whom diagnoses of Sleep State Misperception, Periodic Limb Movements or Sleep Apnea are suspected), selection bias could have affected our findings. Hence, additional subjective sleep differences among insomnia subtypes might be found in larger samples, a multicenter study or primary care setting. Also, results reported herein are based on a single night's experience for each subject, so the findings provide little information about the consistency of sleep perceptions across nights. However, because various of our insomnia subgroups differed in regard to the magnitude and direction of their sleep time misperceptions, clinicians may wish to avoid the view that underestimation of sleep time is a generic characteristic of all insomniacs. Instead, it appears more appropriate to assume that sleep time misperceptions form a broad continuum which, in part, may relate to the range of pathologies that lead to insomnia complaints.

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