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Disorders of Excessive Daytime Somnolence: Polygraphic and Clinical Data for 100 Patients

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Summary: A consecutive series of 100 sleep apnea free patients with the complaint of excessive daytime somnolence (EDS) were evaluated; data from medical histories, physical examination, personality inventories, and polysomnography [nocturnal polysomnography (NPSG) and daytime multiple sleep latency testing (MSLT)] were tabulated. Significant differences were found between narcoleptic and non-narcoleptic patients in a number of parameters, including EDS severity, mean sleep latency on MSLT, sleep latency on NPSG, latency to REM sleep at night, number of REM sleep segments throughout the night, the total number of nocturnal myoclonic jerks (as well as the number occurring per hour of NREM and REM sleep), and the number of arousals and wake periods preceded by a myoclonic jerk. Significant differences in sleep latency during MSLT and NPSG testing were found between different EDS diagnostic groups of non-narcoleptic patients. The majority of patients in the MSLT group with long sleep latencies were in the diagnostic groups of EDS associated with psychophysiological and/or psychiatric problems or with drug abuse; patients with a diagnosis of idiopathic central nervous system hypersomnia or EDS associated with disturbed nocturnal sleep formed the majority of the MSLT group with short sleep latencies. The non-narcoleptic patients in a MSLT group with short sleep latencies had significantly shorter sleep latencies at night, more sleep cycles, higher sleep efficiency, and earlier REM sleep than patients with long sleep latencies. **Key Words:** Narcolepsy—Sleepiness—Nocturnal myoclonus—Sleep latency test.

The complaint of excessive daytime somnolence (EDS) is frequently encountered by clinicians and poses diagnostic and treatment problems. It was the primary complaint in 58% of the 270 patients seen at the Stanford Sleep Disorders Center in 1977.

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This report presents medical histories and physical examination and personality inventory results, as well as polysomnographic findings from 100 patients who presented EDS as their primary complaint and who did not have a sleep apnea syndrome. All of these patients underwent a nocturnal polysomnographic study, followed the next day by a multiple sleep latency test (MSLT). This type of multiple nap procedure has been shown to be a sensitive indicator of daytime sleepiness resulting from experimental sleep deprivation (Carskadon et al., 1978; Carskadon and Dement, 1979), from narcolepsy (Richardson et al., 1978), and from sleep apnea (Dement et al., 1978); it is a useful technique to check for abnormal transitions to rapid eye movement (REM) sleep indicative of narcolepsy (Mitler et al., 1979).

SUBJECTS AND METHOD

One hundred sleep apnea free patients with the complaint of EDS who were consecutively seen between August 1977 and July 1978 were evaluated; 54 were male; 46 were female. The age range was 14–72 years of age (mean, 41).

Diagnostic testing included nocturnal polysomnography and a MSLT. As a clinic policy, patients are to refrain from taking sedative or stimulant medications for a minimum of 1 week prior to tests. However, not all these 100 patients complied; 9 were recorded while still using stimulant medication. The bedtimes and lights-on times for the nocturnal polysomnogram varied, but the mean total dark time was 533 min (SD 80 min), and no patient was awakened later than 8:00 a.m. During the night, polysomnographic variables included the C_3/A_2 or C_4/A_1 and O_1 or O_2 electroencephalogram (EEG), electro-oculogram (EOG) from the right and left outer canthi, and the electromyogram (EMG) from chin muscles, as well as respiratory effort measured by thoracic and abdominal strain gauges and nasal and oral thermistors, lead II electrocardiogram, and leg movements measured by surface electrodes on the tibialis anterior muscles of both legs. Records were scored by 30 sec epochs using standard criteria (Rechtschaffen and Kales, 1968). Standard measures of sleep latency were performed at 10:00 a.m., 12:00 noon, and 2:00, 4:00, and 6:00 p.m. Throughout this daytime procedure, carried out in a quiet hospital room darkened with shades, only the EEG, EOG, chin EMG, and ECG data were recorded. On each of the five tests, patients were asked to close their eyes and to try to fall asleep. If no sleep occurred after 20 min, the test was concluded. If a patient fell asleep, he was allowed to sleep for 10 min. Sleep was defined as two consecutive 30 sec epochs of stage 1 or any single epoch of stages 2–4 or REM sleep. Between sleep latency tests the subjects were out of bed and instructed not to sleep.

Four physicians were involved in the evaluation of these 100 patients. Clinical data obtained from review of consultation and questionnaire data included age, weight, and height. The severity of EDS (judged from chart review by one of us, JvdH) on a seven-point scale (7 = severe EDS), the extent of past and present use of stimulant medication (judged by the same physician on a seven-point scale; i.e., 7 = severe drug use), history of cataplexy, sleep paralysis, hypnagogic hallucina-

tions, usual total sleep time, family history of EDS, abnormalities on physical examination, and Minnesota Multiphasic Personality Inventory (MMPI) variables (the score on the scale for depression, and the total number of scores two or more deviations from the mean) were noted.

Fifty-three variables derived from clinical symptoms, polysomnographic variables, and MMPI scales were analyzed with tabulation routines and stepwise (forward) linear multiple regression.

Diagnoses

We used the final diagnosis recorded in the patient's chart for partitioning the case series. Diagnoses were made according to the best information available for classification of sleep disorders (Association of Sleep Disorders Centers, 1979). Below is a list of the diagnostic categories represented in our case series:

A. Narcolepsy: diagnosed on the finding of two or more sleep-onset REM periods during the MSLT (Mitler et al., 1979) and/or a history of cataplexy.

B. Idiopathic central nervous system (CNS) hypersomnia: characterized by recurrent daytime sleepiness; lengthy, non-refreshing naps; no "sleep attacks"; and an absence of respiratory problems during sleep.

C. EDS associated with psychophysiologic and/or psychiatric problems: chronic disposition of excessive sleepiness, bed rest, daytime napping when confronting stress and when the coping capabilities are overwhelmed; association with minor and major depressive mood disorders, and the nonaffective psychiatric disorders.

D. EDS associated with irregular sleep-wake patterns, and insufficient (disturbed) nocturnal sleep: includes patients with a history of chronic sleep deprivation, very irregular sleep-wake patterns, and disrupted sleep (frequent arousals) for unknown reasons.

E. EDS associated with use (abuse) of stimulant drugs: physiological dependence or psychological habituation to stimulant drugs.

F. EDS associated with neurological conditions: diverse category. A neurological problem was considered to be the primary cause of the complaint of EDS.

G. EDS associated with no objective abnormality: no abnormality found on physical examination, polysomnography, or psychological examination.

Drug Use

Nine patients were polysomnographically recorded while taking stimulant medication. Since this report is on a consecutive series of patients seen in our clinic, we have not excluded data from these people, but certain of their data are interpreted with caution.

RESULTS

Diagnoses for the 100 patients made after complete evaluations are summarized in Table 1.

TABLE 1. *Clinical diagnoses for 100 patients with excessive daytime somnolence (EDS)*

Group	Number
A. Narcolepsy	46
B. Idiopathic CNS hypersomnia	17
C. EDS associated with psychophysiological and/or psychiatric problem	18
D. EDS associated with irregular sleep/wake pattern ($n = 5$); EDS associated with insufficient (disturbed) nocturnal sleep ($n = 4$)	9
E. EDS associated with use (abuse) of stimulant drugs	3
F. EDS associated with neurological conditions	2
G. EDS associated with no objective abnormality	5

Interdiagnostic Category Comparisons

We performed an analysis of variance (ANOVA) (Kruskal-Wallis one-way rank test) (Hollander and Wolfe, 1973) on the 53 selected parameters across the selected diagnostic categories. Table 2 presents the means and standard deviations for those parameters that were significant at at least the $p < 0.05$ level; the two patients with neurological disorders were excluded from this analysis because of the small group size. Most of the difference was due to narcoleptic versus non-narcoleptic difference, which is discussed below. Contrasting statistics between the other diagnostic groups are presented later in the paper.

Narcoleptic Versus Non-Narcoleptic Patients

1. Almost half (46 of 100) of the patients in this series were diagnosed as having narcolepsy.

2. Forty-one narcoleptic patients had a clear history of cataplexy, with the typical muscle inhibition induced by emotion. (Several non-narcoleptic patients gave vague reports of periodic muscular weakness, which the physician judged as not cataplexy, or as very equivocal, emotionally induced cataleptic-like muscle weakness).

3. Thirty-nine of the 46 narcoleptics presented two or more sleep-onset REM periods during the MSLT (REM onsets defined as REM sleep occurring within 10 min after sleep onset, since only 10 min of sleep was allowed).

4. Five patients were diagnosed as narcoleptics only on the basis of two or more sleep-onset REM periods.

5. Finally, 7 patients who did not present two or more sleep-onset REM periods during the MSLT were diagnosed as narcoleptics because of their overall clinical picture, which included a typical history of cataplexy. It is noteworthy that one sleep-onset REM period was observed during the recordings in 5 of them.

Of the nine patients who took stimulant medication during the polysomnographic recordings, 7 were diagnosed as narcoleptics because of their history and because they presented two or more sleep-onset REM periods despite the medication. The other 2 patients who took stimulants were diagnosed as idiopathic CNS hypersomnia.

TABLE 2. *Statistically significant parameters (Kruskal-Wallis ANOVA) between diagnostic categories*[a]

	n	Age (yr)	EDS Severity (scale)	Stimulant medication (scale)	MSLT Sleep latency (min)	Sleep latency at night (min)	REM latency at night (min)	Myoclonic jerks at night (number)	MMPI depression scale
Narcoleptics	46	44.2 ± 12.1	5.0 ± 0.6	3.5 ± 1.5	3.3 ± 3.3	6.2 ± 10.9	71.4 ± 74.5	95.0 ± 144.2	66.7 ± 15.7
CNS hypersomnia	17	42.3 ± 12.0	4.1 ± 0.6	2.7 ± 1.3	6.5 ± 3.2	5.6 ± 5.8	103.9 ± 73.1	11.3 ± 18.4	63.4 ± 14.1
EDS associated with psychophysiological and/or psychiatric problems	18	34.1 ± 9.0	3.5 ± 1.0	2.6 ± 1.4	10.6 ± 5.2	20.8 ± 21.7	130.2 ± 74.2	18.6 ± 31.4	71.3 ± 15.8
EDS associated with erratic sleep-wake schedule and disrupted nocturnal sleep	9	41.9 ± 12.4	3.7 ± 1.0	2.2 ± 1.0	6.0 ± 2.3	10.5 ± 13.8	136.4 ± 96.1	32.4 ± 50.3	53.8 ± 7.6
EDS associated with drug abuse	3	34.3 ± 3.8	3.3 ± 0.6	4.7 ± 1.5	18.7 ± 2.0	80.1 ± 104.3	135.7 ± 27.9	14.0 ± 24.2	70.7 ± 7.6
EDS associated with no objective abnormality	5	27.6 ± 15.7	3.2 ± 0.8	2.8 ± 0.8	10.9 ± 3.9	5.0 ± 1.9	126.4 ± 61.2	29.7 ± 31.2	63.5 ± 10.4
df		5	5	5	5	5	5	5	5
χ^2		15.04	46.38	12.89	47.91	22.10	14.25	17.02	11.28
p		<0.05	<0.001	<0.05	<0.001	<0.001	<0.05	<0.01	<0.05

[a] The 2 patients with neurological abnormalities are not included.

Means ± SD are given. Abbreviations: EDS, excessive daytime somnolence; MSLT, multiple sleep latency test; MMPI, Minnesota Multiphasic Personality Inventory; CNS, central nervous system.

Significant differences between the 46 narcoleptics and the 54 non-narcoleptic EDS patients are reported in Table 3. A history of cataplexy and the number of sleep-onset REM periods are not included in this analysis because they are an integral part of our definition of narcolepsy (Guilleminault et al., 1976; Mitler et al., 1979). Multiple t-tests adjusted for unequal variances were performed, as well as nonparametric χ^2 tests, if indicated. However, one should keep in mind that the multiple comparisons between two groups might lead to some false-positive findings. [To evaluate this effect, note that a conservative Dunn Bonferroni test (Miller, 1966) would consider a t-value of greater than 3.44 to be statistically significant at the 0.05 level.]

No significant differences were found in total sleep time, stages 2–4 sleep time, REM sleep time, percentage REM sleep of total sleep time, wake time after sleep onset, number of body movements, sleep efficiency (defined as total sleep time divided by total dark time, multiplied by 100), number of apneas during sleep, or MMPI data.

The 7 narcoleptic patients who took some stimulant medication during the tests did not differ substantially from the other 39 narcoleptic patients in the main

TABLE 3. *Parameters with significant differences between narcoleptic and non-narcoleptic patients*

Parameter	Narcoleptics (n = 46)	Non-narcoleptics (n = 54)	t
Age (yr)	44 ± 12.1	38 ± 12.6[a]	−2.33
Weight (lb)	180 ± 36.4	160 ± 31.0[a]	−2.81
Duration (number of years since onset of EDS)	22.6 ± 13.7	14.8 ± 12.1[b]	−2.98
EDS severity (7-point scale)	5.0 ± 0.6	3.7 ± 0.9[c]	−8.8
Use of stimulant medication (7-point scale)	3.5 ± 1.5	2.6 ± 1.3[c]	−3.09
Usual total sleep time at home (hr)	7.5 ± 1.1	8.2 ± 1.7[a]	2.41
Sleep latency on MSLT (min)	3.3 ± 3.3	9.0 ± 4.9[c]	6.88
Sleep latency on nocturnal polysomnography (min)	6.2 ± 10.9	16.7 ± 30.5[a]	2.35
Number of REM segments throughout the night[d]	14.7 ± 8.3	10.8 ± 5.4[a]	−2.63
REM percentage in first third of the night	21 ± 12	15 ± 12[a]	−2.43
Latency to REM at night (min)	71.4 ± 74.5	123.4 ± 74.5[c]	3.40
Number of myoclonic jerks during sleep	95.0 ± 144.1	19.4 ± 31.2[b]	−3.29
Stage 1 sleep (min)	22.8 ± 41.0	7.2 ± 17.4[a]	−2.33
			χ^2
History of sleep paralysis (%)	67	37[b]	7.98
History of hypnagogic hallucinations (%)	56	24[b]	8.34

[a] $p < 0.05$, [b] $p < 0.01$, [c] $p < 0.001$ (two-tailed t-test, unequal variances).

[d] A REM segment is a period of REM sleep uninterrupted by more than 15 sec of another sleep state or wakefulness.

Means ± SD are presented. Abbreviation: EDS, excessive daytime somnolence; MSLT, multiple sleep latency test.

parameters; e.g., their mean sleep latency was 2.0 min on the MSLT and 6.4 min at night, and their mean number of myoclonic jerks was 98.0.

The stepwise (forward) linear multiple-regression analysis (Kerlinger and Pedhazar, 1973) was used to assess the usefulness of variables in distinguishing the groups. The 7 patients who were diagnosed as narcoleptic, but who did not have two or more sleep-onset REM periods on the MSLT, were entered as a separate group. The narcoleptics were given a value of +1; the group of 7 patients, 0; and the non-narcoleptics, −1.

Results showed EDS severity, use of stimulant medication, number of myoclonic jerks at night, and mean sleep latency on the MSLT contributed significantly in distinguishing the groups; no other variables contributed further significant information. Use of this set of predictors correctly classified 88% of the narcoleptic patients and 93% of the non-narcoleptics. Of the 7 patients entered as a separate group, 3 had weighted scores similar to those seen in narcoleptics. The mean sleep latency on the MSLT alone correctly classified 82% of the narcoleptics and 84% of the non-narcoleptics. In the group of 7 patients, the scores of 2 resembled those of the narcoleptics. Because of the *post hoc* nature of these data, a predictive cross-validation study is needed to establish the validity of these findings.

The mean sleep latency values on the MSLT at the different test times are shown in Fig. 1.

Figure 2 shows the sleep latency values on the MSLT of all the different diagnostic groups. Using a survival curve methodology (Brown and Hollander, 1977), we calculated the proportion of subjects who remained awake from the start of the test to consecutive 30 sec intervals. Statistical comparisons of the cumulative distribution curves (by the nonparametric Kolmogorov-Smirnov test (Seigel, 1956)) showed no significant differences between patients with idiopathic CNS hypersomnia (group B of Table 1) and the group with insufficient sleep (group D), whose graphs completely overlapped. A similar overlap was noted for the group with EDS associated with psychophysiological or psychiatric problems (group C) and patients with no objective abnormality (group G). The data of these groups were pooled (B with D, C with G) for illustration purposes, which does not imply any common pathogenesis. All other comparisons between the different diagnostic groups were significant below the $p < 0.05$ level.

Nocturnal Myoclonus

There was a highly significant difference between narcoleptics and non-narcoleptics in the number of leg jerks recorded from the anterior tibialis muscles and defined as "nocturnal myoclonus" by Symmonds (1953) and Lugaresi et al. (1956). Nocturnal myoclonus has been further evaluated in subgroups of 28 narcoleptic and 38 non-narcoleptic patients seen consecutively since January 1978, for whom anterior tibialis muscle recording data were tabulated in relation to sleep states; prior to that date, only the total number of myoclonic jerks during sleep was noted. Myoclonic jerks were scored if they lasted between 0.5 and 5 sec and

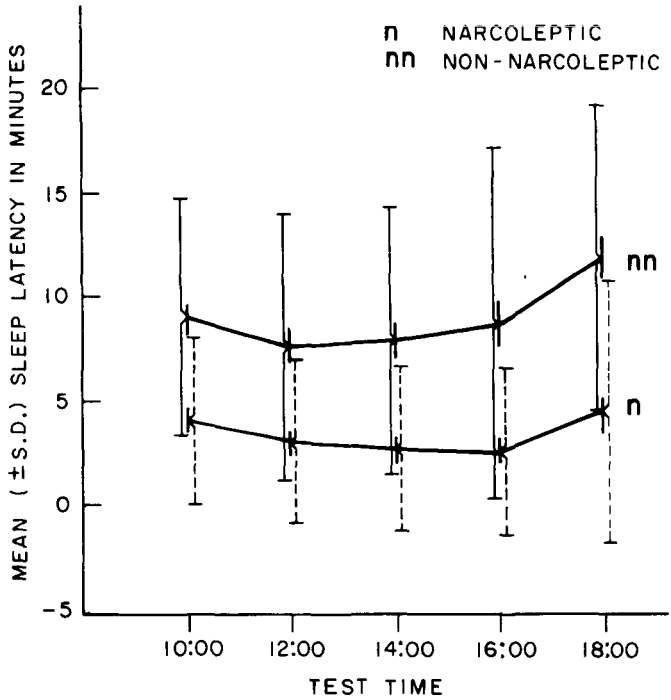

FIG. 1. Mean sleep latencies (min) and standard errors of the mean on the multiple sleep latency test for narcoleptic (n) and non-narcoleptic (nn) patients are indicated at different test times. The difference between the two groups was significant at all test times ($p < 0.001$).

occurred in sequences of three or more, with intervals between jerks shorter than 120 sec. Arousals and wake periods preceded by these jerks were also noted.

The number of myoclonic jerks was calculated as the number per hour during NREM sleep and number per hour in REM sleep (see Table 4). The narcoleptics presented a significantly higher number of leg jerks in both REM and NREM sleep and a significantly higher number of arousals and wake periods preceded by a myoclonic jerk.

Interdiagnostic Comparisons Between Different Non-Narcoleptic Groups

A nonparametric ANOVA (Kruskal-Wallis) between the different non-narcoleptic groups yielded the statistically significant differences shown in Table 5 (the 2 patients with neurological abnormalities were excluded from this analysis). Contrast statistics (Mann-Whitney *U*-test) showed significant differences in nocturnal sleep latency between patients with CNS hypersomnia and psychophysiological and/or psychiatric problems ($p < 0.01$), and significant differences in the MMPI depression scale between patients with psychophysiological and/or psychiatric problems and those with disturbed nocturnal sleep ($p < 0.02$). The statistical differences on the MSLT between the different diagnostic groups have already been discussed (see also Fig. 2). No contrast statistics were performed for

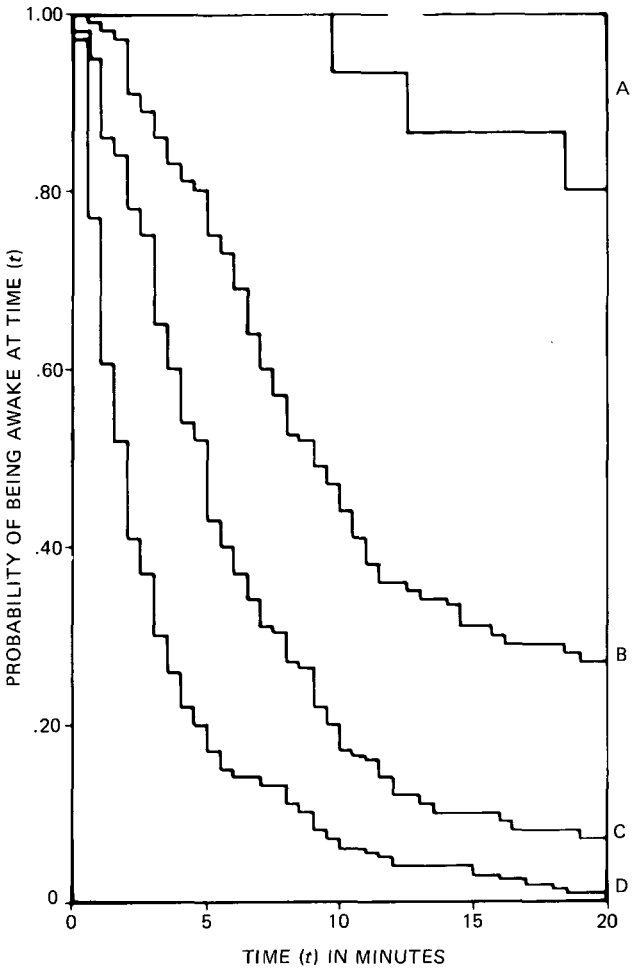

FIG. 2. Probability of being awake at time t (min) after lights out for the different diagnostic groups. A indicates abuse of stimulant drugs; B, psychophysiological and/or psychiatric problems and no objective abnormality; C, central nervous system hypersomnia and irregular and/or insufficient sleep; D, narcolepsy. Data for patients in categories B and C have been pooled for illustrative purposes.

the other two diagnostic categories (EDS associated with drug abuse, and EDS associated with no objective abnormality), because the sample size was too small.

Short Sleep Latency on MSLT

Patients with narcolepsy generally had short sleep latencies on the MSLT (for 83% the mean sleep latency was less than 5 min). To further evaluate this variable in the non-narcoleptic group of patients, we divided them according to mean sleep latency on the MSLT (regardless of their clinical diagnoses). Patients with a short sleep latency (<5 min) (25th percentile) (group 1) were compared with those with moderately long (5–11 min) (25th–75th percentiles) (group 2) and long (>11 min)

TABLE 4. *Nocturnal myoclonus: comparisons between narcoleptic and non-narcoleptic patients*

Group	*n*	Number of jerks/hr		Total number of arousals	Total number of wake periods
		NREM sleep	REM sleep		
Narcoleptics	28				
Median		3.4	3.9	18.5	0
Range		0–90	0–148	0–183	0–11
Non-narcoleptics	38				
Median		0	0	2	0
Range		0–29.4	0–9.3	0–79	0–2
Mann-Whitney *U*-tests		$p < 0.01$ 2.66	$p < 0.01$ 2.74	$p < 0.01$ 2.62	$p < 0.1$ 1.58

(75th percentile) (group 3) mean sleep latencies. Results are summarized in Table 6.

In summary, patients with short sleep latencies during the day (MSLT) generally presented a short sleep latency at night, shorter sleep cycles, higher sleep efficiency, and earlier REM sleep than the patients with long sleep latencies during the MSLT. The total sleep time tended to be longer and the number of sleep cycles higher in patients with short sleep latencies during the day, although these differences were not significant below the 0.05 level. Contrast statistics showed a significant difference ($p < 0.05$) between groups 1 and 3 in nocturnal sleep la-

TABLE 5. *ANOVA (Kruskal-Wallis) between non-narcoleptic diagnostic groups*[a]

Diagnostic group	*n*	MSLT sleep latency (min)	Nocturnal sleep latency (min)	MMPI depression scale
Idiopathic CNS hypersomnia	17	6.5 ± 3.2	5.6 ± 5.8	63.4 ± 14.1
EDS associated with psychophysiological/ psychiatric problems	18	10.6 ± 5.2	20.8 ± 21.7	71.3 ± 15.8
EDS associated with disturbed nocturnal sleep	9	6.0 ± 2.3	10.5 ± 13.8	53.8 ± 7.5
EDS associated with drug abuse	3	18.7 ± 2.0	80.1 ± 104.3	70.7 ± 7.6
EDS associated with no objective abnormalities	5	10.9 ± 3.9	5.0 ± 1.9	63.5 ± 10.4
X	17.17	14.84	11.23	
df	4	4	4	
p	<0.01	<0.01	<0.05	

[a] The 2 patients with neurological abnormalities are not included.

Only significantly different variables are presented. Means ± SD are given. Abbreviations: MSLT, multiple sleep latency test; MMPI, Minnesota Multiphasic Personality Inventory; CNS, central nervous system; EDS, excessive daytime somnolence.

TABLE 6. *ANOVA (Kruskal–Wallis, nonparametric) between different MSLT groups (non-narcoleptic patients)*

Parameter	Mean sleep latency on MSLT			X1	*df*	*p*
	Group 1 <5 min	Group 2 5–11 min	Group 3 >11 min			
Number	13	27	14			
Nocturnal sleep latency (min)	5.3 ± 3.4	10.0 ± 10.2	40.4 ± 52.3	9.46	2	<0.05
Total sleep time (min)	461 ± 89	417 ± 121	390 ± 126			ns
Number of REM periods	4.9 ± 1.1	4.4 ± 1.6	3.5 ± 1.4			ns
Mean cycle length[a] (min)	106 ± 22	122 ± 43	154 ± 88	6.24	2	<0.05
REM percent 1st third of night	15 ± 10	16 ± 11	14 ± 15			ns
REM percent 2nd third of night	39 ± 14	38 ± 20	22 ± 16	6.77	2	<0.05
REM percent 3rd third of night	46 ± 12	47 ± 19	64 ± 23			ns
Sleep efficiency (percent)	88 ± 11	79 ± 18	70 ± 18	8.47	2	<0.05
Total dark time (min)	525 ± 71	527 ± 96	548 ± 80			ns

[a] A cycle is the time period from the end of one REM period to the end of the next REM period. The first cycle is the period from sleep onset to the end of the first REM period.

Significantly different variables, together with some others of interest, are presented. Means ± SD are given. MSLT, Multiple Sleep Latency Test; ns, not significant.

tency, sleep efficiency, and mean cycle length, and between groups 2 and 3 in nocturnal sleep latency and REM percent in the second third of the night.

Table 7 shows the percentage of the different diagnostic groups in each of the MSLT groups. We then compared narcoleptic patients with the group of patients with a short mean sleep latency (<5 min) on the MSLT. These results are summarized in Table 8.

In addition to the history of cataplexy and REM-sleep-onset periods integral to the diagnosis of narcolepsy, narcoleptics showed a shorter REM latency at night, more myoclonic jerks, and higher scores for EDS severity and stimulant medication use. No other significant differences in clinical, polysomnographic, or MMPI data were found.

DISCUSSION

Our diagnostic procedures have been uniform since August 1977. The polysomnographic data in this report were all accumulated in a clinical setting, which poses some limitations: the total dark time and lights out time at night were not controlled, but depended on the patient's preference, and there were sometimes disturbing noises from nursing services. However, these confounding factors could not have operated systematically on our data. For example, no significant differences were found in total dark time among the different groups. Confounding influences notwithstanding, certain conclusions seem valid.

TABLE 7. *Percentage of patients of different diagnostic categories in each MSLT group*[a]

Diagnostic group	*n*	Percentage in MSLT group: Group 1 <5 min	Group 2 5–11 min	Group 3 >11 min
CNS hypersomnia	17	41%	53%	6%
EDS associated with psychological and/or psychiatric problems	18	11	50	39
EDS associated with insufficient sleep	9	44	56	0
EDS associated with drug abuse	3	0	0	100
EDS associated with no objective abnormality	5	0	60	40

[a] The 2 patients with neurological abnormalities are not included.
Abbreviations same as in Table 5.

The results show a very homogeneous group of patients with narcolepsy. Narcoleptic patients differed from the other patients in sleep latency on the MSLT, histories of hypnagogic hallucinations and sleep paralysis, sleep latency on the nocturnal polysomnogram, REM latency on the nocturnal polysomnogram, REM latency at night, number of REM segments, and number of arousals greater than 2 min; no significant differences were found in total wake time after sleep onset. This confirmed previous studies that compared patients with narcolepsy with normal controls (Montplaisir et al., 1978). More striking is the highly significant difference between the two groups in the number of leg jerks measured from the anterior tibialis muscles during sleep. The rhythmicity of these jerks, and the fact that there was an equally significant difference when the number of jerks was calculated per hour of NREM sleep, probably indicates a similar, though un-

TABLE 8. *Comparisons between patients with narcolepsy and non-narcoleptic patients with short mean sleep latency on the MSLT (means ± SD)*

Variable	Narcoleptics, $n = 46$	Patients with MSLT sleep latency <5 min, $n = 13$	t
EDS severity	5.0 ± 0.6	3.9 ± 1.0[b]	−3.85
Use of stimulants	3.5 ± 1.5	2.6 ± 1.3[a]	−2.14
Number of nocturnal myoclonic jerks	95.0 ± 144.2	16.3 ± 28.1[b]	−3.29
REM latency at night (min)	71.4 ± 74.5	117.4 ± 58.2[a]	2.33
Wake after sleep onset (min)	88.8 ± 60.4	50.9 ± 33.3[b]	−2.91
Sleep efficiency (%)	80 ± 11.4	88 ± 11.5[a]	2.70
REM efficiency	74.6 ± 17.8	83.5 ± 9.4	2.31
Sleep latency at night (min)	6.2 ± 10.9	5.3 ± 3.4	ns
Total sleep time (min)	426 ± 72.6	461 ± 88.7	ns

[a] $p < 0.05$, [b] $p < 0.01$ (two-tailed t-test corrected for unequal variances).

known, mechanism to that seen in many other sleep disorders (Coleman et al., in press). A high percentage of narcoleptic patients with nocturnal myoclonus has also been reported by Rosa et al. (1980) and Zorick et al. (1980). Overall, sleep of narcoleptics was more disrupted than that of the other patients with a complaint of EDS. This might be at least partly related to the high number of myoclonic jerks.

The possibility exists that sleep disruption due to a high number of myoclonic jerks might lead to sleep-onset REM periods during daytime naps. Sleep-onset REM periods have been reported due to disrupted sleep, without further clinical significance (Weitzman et al., 1974; Carskadon and Dement, 1975). However, all but one of the narcoleptic patients with serious nocturnal myoclonus and two or more sleep-onset REM periods during the MSLT presented also a history of cataplexy, which makes this hypothesis less likely.

The data in this report differ from previously reported statistics (Guilleminault and Dement, 1977). Of 235 EDS patients in their study, 44 presented a sleep apnea syndrome. (Patients with this syndrome were excluded from our study.) Of the 191 remaining, 155 (81%) were diagnosed as having narcolepsy. The difference might be due to the increase in the total number of patients seen in our clinic. That referring physicians may be more aware of the disabling effect of EDS and the existence of sleep clinics is another factor. Finally, patients may frequently request referrals after reading about sleep disorders centers in the lay press. These trends could cause increased heterogeneity of the clinic population. The sleep latency values on the MSLT were helpful in differentiating between diagnostic groups. As shown in Table 5, MSLT mean sleep latency value, the nocturnal sleep latency, and the MMPI depression scale are the only variables that differentiated objectively between different non-narcoleptic groups of EDS patients. In a previous paper (Richardson et al., 1978), the MSLT values of patients with narcolepsy and normal controls were compared, and based on those data, a tentative cutoff point of 5 min mean sleep latency value on the MSLT was proposed for pathological sleepiness. If we use this cutoff point, 83% of the narcoleptics were "pathologically sleepy," compared with 25% of the non-narcoleptic patients. A further analysis of our data shows that the narcoleptics had a mean MSLT sleep latency of 3.3 min (SD $\pm$ 3.3); patients with idiopathic CNS hypersomnia (which diagnosis implies pathological sleepiness, as judged by the physician) had a mean sleep latency of 6.5 min (SD $\pm$ 3.2); and patients with psychological disturbances and those with no objective abnormalities had mean sleep latencies of 10.6 min (SD $\pm$ 5.2) and 10.9 min (SD $\pm$ 3.9), respectively. Based on these data, one might propose the following: a mean sleep latency $\leq$5.5 min would, in all likelihood, indicate pathological sleepiness with MSLT. A value between 6 and 10 min would be the diagnostically "gray area," and a mean sleep latency value of $\geq$10 min would indicate that pathological sleepiness is unlikely, suggesting other (psychophysiological, psychiatric, drug abuse) problems. In addition to its value as a means of quantification of the sleepiness, the MSLT is most useful as a test for narcolepsy because of the opportunity for sleep-onset REM periods to occur. This can occasionally give false-negative results. For example, one of the narcoleptic patients who presented an unequivocal history of cataplexy initially showed no sleep-onset REM period on a nocturnal recording or MSLT, but when he was

reevaluated by MSLT a few weeks later, four sleep-onset REM periods were recorded. A specific study to appreciate the chances of obtaining false-negative recordings for narcolepsy with the MSLT is needed. In general, however, the MSLT certainly gives fewer false-negative results and more quantifiable objective data than the previous tests used in our clinic (e.g., nocturnal polysomnogram and/or one nap recording) (Wilson et al., 1973). The MSLT can be helpful to clinicians, but our data indicate that we need to diminish the limits of the "gray area." In all probability, this could be obtained by a large normal control study with large numbers in specific age groups (particularly between 30 and 50 years of age), rather than by studies of patients with EDS. As normative data in large amounts are difficult to obtain, a cooperative study with different centers would be the best approach.

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REFERENCES

Association of Sleep Disorders Centers. *Diagnostic Classification of Sleep and Arousal Disorders.* First Edition, prepared by the Sleep Disorders Classification Committee, HP Roffwarg, Chairman. *Sleep* 2:1–137, 1979.

Brown WB and Hollander M. *Statistics: A Biomedical Introduction.* Wiley, New York, 1977.

Carskadon M and Dement W. Sleep studies on a 90-minute day. *Electroencephalogr Clin Neurophysiol* 39:145–155, 1975.

Carskadon M and Dement W. Effects of total sleep loss on sleep tendency. *Percept Mot Skills* 48:495–506, 1979.

Carskadon M, Harvey K, and Dement W. Total sleep loss in children: Sleep tendency and performance. *Sleep Res* 7:128, 1978.

Coleman R, Pollak C, and Weitzman E. Periodic movements in sleep (nocturnal myoclonus): Relation to sleep-wake disorders. *Ann Neurol* (in press).

Dement W, Carskadon M, and Richardson G. Excessive daytime sleepiness in the sleep apnea syndrome. In: C Guilleminault and W Dement (Eds), *Sleep Apnea Syndromes*, Alan R Liss, New York, 1978, pp 23–46.

Guilleminault C and Dement W. 235 cases of excessive daytime sleepiness. *J Neurol Sci* 31:13–27, 1977.

Guilleminault C, Dement W, and Passouant P (Eds). *Narcolepsy.* Spectrum, New York, 1976.

Hollander M and Wolfe DA, *Nonparametric Statistical Methods.* Wiley, New York, 1973, pp 115–120.

Kerlinger FN and Pedhazar EJ. *Multiple Regression in Behavioral Research.* Holt, New York, 1973.

Lugaresi E, Coccagua G, Gambi D, Berti-Ceroni G, and Poppi M. A propos de quelques manifestations nocturnes myocloniques (nocturnal myoclonus de Symonds). *Rev Neurol* 115:547–555, 1966.

Miller Rupert G Jr. *Simultaneous Statistical Interference.* McGraw-Hill, New York, 1966, p 8.

Mitler M, van den Hoed J, Carsakdon M, Richardson G, Park R, Guilleminault C, and Dement W. REM sleep episodes during the multiple sleep latency test in narcoleptic patients. *Electroencephalogr Clin Neurophysiol* 46:479–481, 1979.

Montplaisir J, Billiard M, Takahashi S, Bell I, Guilleminault C, and Dement W. Twenty-four-hour recording in REM-narcoleptics with special reference to nocturnal sleep disruption. *Biol Psychiatry* 13:73–89, 1978.

Rechtschaffen A and Kales A (Eds). *A Manual of Standardized Terminology, Techniques and Scoring System for Sleep Stages of Human Subjects.* Brain Information Service/Brain Research Institute, UCLA, Los Angeles, 1968.

Richardson G, Carskadon M, Flagg W, van den Hoed J, Dement W, and Mitler M. Excessive daytime sleepiness in man: Multiple sleep latency measurement in narcoleptic and control patients. *Electroencephalogr Clin Neurophysiol* 45:621–627, 1978.

Rosa R, Kramer M, and Ebright P. Narcolepsy: Symptoms frequency and associated disorders. *Sleep Res* 8:213, 1980.

Siegel S. *Nonparametric Statistics for the Behavioral Sciences*. McGraw-Hill, New York, 1956.

Symonds CP. Nocturnal myoclonus. *J Neurol Neurosurg Psychiatry* 16:166–171, 1953.

Weitzman ED, Nogeire C, Perlow M, Fukushima D, Sassis J, McGregor P, Gallagher T, and Hellman L. Effects of a prolonged 3 hour sleep wake cycle on sleep stages, plasma cortisol, growth hormone and body temperature. *J Clin Endocrinol Metab* 38:1018–1030, 1976.

Wilson R, Raynal D, Guilleminault C, Zarcone V, and Dement W. REM sleep latencies in daytime sleep recordings of narcoleptics. *Sleep Res* 2:166, 1973.

Zorick F, Piccone P, Hartse KM, Zammit G, and Roth T. Disturbed nocturnal sleep in narcolepsy. *Sleep Res* 8:223, 1980.