Sleep
9(4):519–524, Raven Press, New York

Guidelines for the Multiple Sleep Latency Test (MSLT): A Standard Measure of Sleepiness*

Chairman:
Mary A. Carskadon

Committee Members:
William C. Dement, Merrill M. Mitler, Thomas Roth, Philip R. Westbrook, Sharon Keenan

INTRODUCTION

The multiple sleep latency test (MSLT) is used in the assessment and diagnosis of disorders of excessive somnolence and to evaluate daytime sleepiness in relation to various therapeutic or experimental manipulations, such as administering drugs and altering the length or timing of nocturnal sleep. The repeated measurement of sleep latency across a day provides direct access to the diurnal fraction of the sleep/wake interaction, which is of fundamental concern to the sleep specialist. Objective laboratory documentation of the clinical symptom of sleepiness (1) as well as abnormal sleep structure (2) has greatly facilitated the diagnosis of narcolepsy, in particular, and has also been useful to determine the severity of somnolence (3–6) and therapeutic response (6–9) in other disorders. At the current level of clinical experience, a diagnosis of narcolepsy or other disorders of excessive somnolence usually has lifelong consequences for the patients, for example, chronic chemotherapy with psychoactive compounds, legal proscription from driving, or surgery. It therefore is incumbent upon the clinical sleep specialist to achieve as much diagnostic precision as possible. The MSLT greatly enhances the accurate diagnosis of disorders of excessive somnolence.

OVERVIEW OF THE MSLT

The MSLT is designed to provide information about sleepiness and about the presence of abnormal sleep-onset REM episodes. A series of opportunities to sleep is administered at 2-h intervals across a day using standard procedures; sleepiness is measured as the speed of falling asleep, and the presence of REM sleep is noted. Exhaustive series of studies in nonpatient groups have shown MSLT scores to be related to amount of sleep on one or several preceding nights (10–14), to maturation (15), age (16), continuity of sleep (17,18), time of day (19), and ingestion of drugs (20–22). A daily score on the MSLT of <5 min includes a range found to be associated with performance decrements and unintentional episodes of sleep in sleepy patients and in sleep-deprived nonpatient groups (6,10,12,13,23). Thus, this "pathological" level on the MSLT is a direct indication of vulnerability to falling asleep in low-stimuli situations and, as such, reflects a measurable liability for the patient or sleep-deprived subject. The physiological sleepiness measured by the MSLT cannot be reliably introspected by most patients. This is particularly true when comparing pretreatment and post-treatment symptoms. In other words, a patient may perceive an improvement in alertness as very substantial, whereas an MSLT may reveal that the vulnerability remains (7).

The abnormally premature occurrence of REM sleep in narcolepsy was first noted by Vogel (24) and first linked descriptively to the narcolepsy symptom cluster by Rechtschaffen et al. (25). The First International Symposium on Narcolepsy, held in 1975, established a clear consensus definition of the disorder (26), which included REM abnormalities, and thereby opened the way for the development of a diagnostic laboratory test. A single daytime nap was used initially by a number of groups but was found wanting, primarily because of a rather high potential for false negative results (27). The MSLT, first used in 1976 strictly to assess sleepiness or sleep tendency in experimental settings (28), readily came to be viewed as a valuable test for sleep-onset REM episodes as well (2).

* Developed by the Association of Sleep Disorders Centers Task Force on Daytime Sleepiness

TABLE 1. *General considerations for multiple sleep latency test (MSLT)*

1–2 weeks of sleep diaries preceding MSLT
1 night polysomnography on habitual schedule
Careful consideration of drug schedule (Note: Urine screen may help to identify unreported drug use.)
Skilled, rested polysomnographic technologist
Dress in street clothes before MSLT begins
A minimum of four tests at 2-h intervals beginning 1.5–3 h after wake-up
Quiet, dark, temperature-controlled room
No alcohol or caffeine (Note: Acute withdrawal from moderate to high caffeine use is problematic.)

METHODS FOR ADMINISTERING MSLT

General considerations (Table 1)

The MSLT is generally performed on a day following a clinical polysomnographic recording to provide accurate documentation of the preceding night's sleep. If possible, nocturnal sleep should be undisturbed by experimenter intervention and should approximate the patient's habitual sleep. In addition, the patient or subject should have completed sleep diary forms for 1–2 weeks before the sleep study, since the MSLT values may be influenced by sleep for up to 7 nights beforehand (13). A careful consideration of drug use must be made. Drugs known to affect sleep latency (e.g., sedatives, hypnotics, antihistamines, stimulants) or REM latency (e.g., tricyclic antidepressants, monoamine oxidase inhibitors, amphetamines) will influence the test results and should be withdrawn for 2 weeks before MSLT testing. Chronic usage, acute administration, or acute withdrawal of any of these compounds may affect the test in different ways. A urine drug screen on the morning of the MSLT is helpful to identify patients in whom drug effects are suspected. A well-controlled and consistent procedure facilitates interpretation of test results as well as retest comparisons. Skilled, experienced, well-rested technicians are recommended to perform the MSLT because of the on-line decision making the test requires.

MSLTs are routinely performed at 2-h intervals, beginning 1.5 to 3 h after the end of the nocturnal recording. The typical schedule begins at 0930 or 1000, and the standard study includes a minimum of four tests. Since the goal of the MSLT is to measure speed of falling asleep in a sleep-inducing environment and *in the absence of competing stimuli*, a number of precautions are important. First, bedrooms should be quiet and dark. Particularly to be avoided are intermittent noises (e.g., elevator, toilet, sirens) that are likely to abort a sleep onset. When such circumstances cannot be avoided, it is very important to document the noise on the polysomnographic chart recording and to use this information as an aid in the interpretation of the test. The light level in the bedroom should be very low and should not vary with time of day. This usually requires that any bedroom windows be well shielded. Room temperature should also be kept constant at a comfortable level. In general, the patient/subject is prohibited from ingesting alcohol or caffeine on the day of the test. Acute withdrawal from moderate to high doses of caffeine, however, may produce symptoms that will affect the test results.

Recording montage (Table 2)

The standard montage includes the routine Rechtschaffen and Kales (29) leads: central referential electroencephalogram (EEG) (C3 or C4), two horizontal (or oblique) referential eye movement leads [right and

TABLE 2. *Recording montage for multiple sleep latency test*

Referential central electroencephalogram (EEG) (C3 or C4)
Referential occipital EEG (01 or 02)
Right horizontal (or oblique) electro-oculogram (EOG)
Left horizontal (or oblique) EOG
Vertical EOG
Mental/submental EMG
Electrocardiogram
Respiratory flow
Respiratory sounds

left outer canthus electro-oculogram (EOG)], and a mental/submental electromyogram. Strongly recommended additions to this montage include an occipital referential EEG (O1 or O2), a vertical EOG, and an electrocardiogram lead. In patients known to snore, measures of respiratory flow and respiratory sounds may be helpful to identify occasions when snoring affects the sleep onset. The occipital EEG is frequently useful to visualize alpha rhythm and its disintegration at sleep onset. The vertical EOG lead occasionally provides sufficient additional information (i.e., a clear-cut eye movement) to change an otherwise equivocal REM onset to unequivocal. A time constant slow enough to pass slow eye movements (e.g., 250 ms) is recommended for EOG channels, since slow eye movements also help to distinguish sleep onset. As with all polysomnographic recordings, electrode impedance <10 kΩ is desirable, and the impedance levels should be checked before each test.

Specific procedures (Table 3)

Except in the case of bedridden inpatients, the patient/subject should dress in street clothes before the day's first MSLT. Between tests, the patient/subject should be out of bed and prevented from sleeping; in most cases this requires continual observation by a laboratory staff member. If the patient smokes, smoking should be avoided for 30 min before each test. Vigorous activity by the patient/subject should be suspended 15 min before each test. At this time, impedance may be checked and the patient/subject should be encouraged to use the restroom.

The patient/subject should remove shoes, loosen constricting clothing, and be hooked up in bed by 5 min before the scheduled start of the test. At this point, a standard series of instructions is given ("calibrations"), which serves not only to test the hookup and equipment, but also to establish a standard "lead-in" to the test. (Table 4 gives a sample calibration series.)

At the end of calibrations, the patient/subject may be asked for a subjective rating of sleepiness (30) and is encouraged to assume a comfortable position for falling asleep, e.g., roll onto side, curl up. (NOTE: This is done *before* test instructions are given.) The patient/subject is then given a standard instruction, which is repeated verbatim for every MSLT, for example: "Please lie quietly, keep your eyes closed, and try to fall asleep," or "Please lie still with your eyes shut and do not resist falling asleep," or ". . . let yourself fall asleep." The essential features are to reduce tossing and turning (lie still), to reduce looking around the room (close eyes), to encourage falling asleep, and to give the identical instructions every time. Immediately after these instructions are given, bedroom lights are turned off, signaling the start of the test, from which time (zero) sleep onset latency is calculated.

Ending a test (Table 3)

The standard MSLT is terminated 20 min after lights-out if there has been no sleep or after three consecutive epochs of stage 1 sleep or the first epoch of another sleep stage. In an experimental study, during which REM sleep is not at issue, the three-epoch criterion primarily avoids the inadvertent "early awakening" of a subject. In order to assess the occurence of REM sleep in subjects or patients, the test should continue for 15 min after the first epoch of sleep.

Measuring latencies (Table 3)

A 30-s scoring epoch is recommended. *Sleep latency* is the elapsed time from lights-out to the first epoch scored as sleep. With a 30-s scoring epoch, this criterion is reached when sleep occupies $>50\%$ of any 30 s. This definition of sleep latency requires careful scoring of the sleep records with very close attention to the standard sleep stage criteria (29). *REM sleep latency* is taken as the time from the beginning of this defined sleep onset to the beginning of the first epoch of REM sleep.

A report of MSLT scores usually includes a test-by-test listing of latency from lights-out to the first sleep epoch, presence or absence of REM sleep, and the REM sleep latency. A single summary value for daily sleep latency (average or median sleep latency across a day's tests) is frequently used. These values are accompanied by a summary of sleep on the preceding night.

Interpreting the MSLT

A fundamental underlying assumption of the MSLT is that lower scores indicate greater sleepiness and vice versa. A generally accepted rule of thumb for interpreting the MSLT has evolved from the recommendations first made by Richardson et al. (1); to wit, a mean daily score of <5 min indicates a pathological level of daytime sleepiness. This level is also associated with impaired performance in patients and in sleep-deprived normal controls (6,10,12,13,23). Adult normal control volunteers usually score in the range of 10–20 min (1,2,19,31–35), so that scores between pathological and normal ranges have become known as a diagnostic gray area (4).

Early recommendations held that two sleep-onset REM episodes in a series of five sleep latency tests across a day were diagnostic of narcolepsy (2,34). Many reports have confirmed that such abnormal REM episodes are exceptional in normal individuals tested in the standard manner (33,36,37). In the case of patients with sleep apnea syndrome, sleep-onset REM episodes are occasionally recorded on MSLT (3,5). These REM episodes may reflect a chronic pattern of disturbed or fragmented sleep (38) or may indicate the

TABLE 3. *Specific procedures for multiple sleep latency test (MSLT)*

Measure	Time	Procedure
	Prior to testing	
	30 min	Suspend tobacco smoking
	15 min	Suspend vigorous physical activity
	10 min	Prepare for bed
		Remove shoes
		Loosen constricting clothing
	5 min	In bed hooked up
		Calibration series[a]
	45 s	Introspective sleepiness measure
	30 s	Assume comfortable position for falling asleep
	5 s	"Please lie quietly, keep your eyes closed, and try to fall asleep."
	Following lights out	
Sleep latency	0 min	LIGHTS-OUT
	$+x_1$ min	First epoch of sleep
	$+x_2$ min	Unequivocal sleep, e.g., 3 consecutive epochs, end the test for experimental MSLT
REM latency	$+x_3$ min	First epoch REM sleep
	$x_1 + 15$ min	End the test for clinical MSLT
	+20 min	If no sleep to this point, end the test

[a] See Table 4.

TABLE 4. *Sample calibration procedure for multiple sleep latency test (MSLT)*

Lie on back, relax
Eyes open for 60 s
Eyes closed (but remain awake) for 60 s
With eyes open, look left, right, left, right, straight; look down, up, down, up, straight.
Blink 5 times
Grit teeth (or yawn)

coexistence of narcolepsy and sleep apnea, estimated to occur in 10–15% of narcolepsy cases (39). In these instances, confirmation of narcolepsy requires reevaluation following the normalization of nocturnal sleep.

As with any clinical tool, medical judgment—rather than absolute values or test scores—must weigh significantly in diagnostic assessments and interpretations.

REFERENCES

1. Richardson GS, Carskadon MA, Flagg W, van den Hoed J, Dement WC, Mitler MM. Excessive daytime sleepiness in man: multiple sleep latency measurement in narcoleptic and control subjects. *Electroencephalogr Clin Neurophysiol* 1978;45:621–7.
2. Mitler MM, van den Hoed J, Carskadon MA, et al. REM sleep episodes during the multiple sleep test in narcoleptic patients. *Electroencephalogr Clin Neurophysiol* 1979;46:479–81.
3. Reynolds CF, Coble PA, Kupfer DJ, Holzer BC. Application of the multiple sleep latency test in disorders of excessive sleepiness. *Electroencephalogr Clin Neurophysiol* 1982;53:443–52.
4. Van den Hoed J, Kraemer H, Guilleminault C, et al. Disorders of excessive daytime somnolence: polygraphic and clinical data for 100 patients. *Sleep* 1981;4:23–37.
5. Zorick F, Roehrs T, Koshorek G, et al. Patterns of sleepiness in various disorders of excessive daytime somnolence. *Sleep* 1982;5:S165–74.
6. Dement WC, Carskadon MA, Richardson GS. Excessive daytime sleepiness in the sleep apnea syndrome. In: Guilleminault C, Dement WC, eds. *Sleep apnea syndromes*. New York: Alan R. Liss, Inc., 1978:23–46.
7. Zorick F, Roehrs T, Conway W, Fujita S, Wittig R, Roth T. Effects of uvulopalatopharyngoplasty on the daytime sleepiness associated with sleep apnea syndrome. *Bull Eur Physiopathol Respir* 1983;19:600–3.
8. Wittig R, Zorick F, Conway W, Ward J, Roth T. Normalization of the MSLT after six weeks of CPAP for sleep apnea syndrome. Presented at the first annual meeting of the Association of Professional Sleep Societies, Columbus, Ohio, June 20, 1986.
9. Mondini S. Weight reduction therapy as a treatment for obstructive sleep apnea syndrome (OSAS). Presented at the first annual meeting of the Association of Professional Sleep Societies, Columbus, Ohio, June 20, 1986.
10. Carskadon MA, Dement WC. Effects of total sleep loss on sleep tendency. *Percept Mot Skills* 1979;48:495–506.
11. Carskadon MA, Harvey K, Dement WC. Acute restriction of nocturnal sleep in children. *Percept Mot Skills* 1981;53:103–12.
12. Carskadon MA, Harvey K, Dement WC. Sleep loss in young adolescents. *Sleep* 1981;4:299–312.
13. Carskadon MA, Dement WC. Cumulative effects of sleep restriction on daytime sleepiness. *Psychophysiology* 1981;18:107–13.
14. Carskadon MA, Dement WC. Sleep loss in elderly volunteers. *Sleep* 1985;8:207–21.
15. Carskadon MA, Harvey K, Duke P, Anders TF, Litt IF, Dement WC. Pubertal changes in daytime sleepiness. *Sleep* 1980;2:453–60.
16. Carskadon MA, van den Hoed J, Dement WC. Sleep and daytime sleepiness in the elderly. *J Geriatr Psychiatry* 1980;13:135–51.
17. Carskadon MA, Brown ED, Dement WC. Sleep fragmentation in the elderly: relationship to daytime sleep tendency. *Neurobiol Aging* 1982;3:321–7.
18. Stepanski E, Lamphere J, Badia P, Zorick F, Roth T. Sleep fragmentation and daytime sleepiness. *Sleep* 1984;7:18–26.
19. Richardson GS, Carskadon MA, Orav EJ, Dement WC. Circadian variation of sleep tendency in elderly and young adult subjects. *Sleep* 1982;5:S82–94.
20. Dement WC, Seidel W, Carskadon M. Daytime alertness, insomnia, and benzodiazepines. *Sleep* 1982;5:528–45.

21. Roth T, Roehrs T, Koshorek G, Sicklesteel J, Zorick F. Central effects of antihistamines. *Sleep Res* 1986;15:43.
22. Roehrs T, Lumly M, Asker D, Zorick F, Roth T. Ethanol and caffeine effects on daytime sleepiness. *Sleep Res* 1986;15:41.
23. Carskadon MA, Littell WP, Dement WC. Constant routine: alertness, oral body temperature, and performance. *Sleep Res* 1985;14:293.
24. Vogel G. Studies in the psychophysiology of dreams III. The dreams of narcolepsy. *Arch Gen Psychiatry* 1960;3:421–8.
25. Rechtschaffen A, Wolpert E, Dement W, Mitchell S, Fisher C. Nocturnal sleep of narcoleptics. *Electroencephalogr Clin Neurophysiol* 1963;15:599–609.
26. Guilleminault C, Dement WC, Passouant P, eds. *Narcolepsy*. (Weitzman ED, ed. Advances in sleep research; vol 3). New York: Spectrum Publications, 1976.
27. Wilson R, Raynal D, Guilleminault C, Zarcone V, Dement W. REM latencies in daytime sleep recordings of narcoleptics. *Sleep Res* 1972;2:166.
28. Carskadon MA, Dement WC. Sleep tendency: an objective measure of sleep loss. *Sleep Res* 1977;6:200.
29. Rechtschaffen A, Kales A, eds. *A Manual of standardized terminology, techniques and scoring system for sleep stages of human subjects*. Los Angeles: BIS/BRI, UCLA, 1968.
30. Hoddes E, Zarcone V, Smythe H, Phillips R, Dement WC. Quantification of sleepiness: a new approach. *Psychophysiology* 1973;10:431–6.
31. Carskadon MA, Dement WC. Nocturnal determinants of daytime sleepiness. *Sleep* 1982:S73–81.
32. Hartse K, Roth T, Zorick F. Daytime sleepiness and daytime wakefulness: the effect of instruction. *Sleep* 1982;5:S107–18.
33. Carskadon MA. The second decade. In: Guilleminault C, ed. *Disorders of sleeping and waking: indications and techniques*. Menlo Park, California: Addison-Wesley, 1982:99–125.
34. Mitler M. The multiple sleep latency test as an evaluation for excessive somnolence. In: Guilleminault C, ed. *Disorders of sleeping and waking: indications and techniques*. Menlo Park, California: Addison-Wesley, 1982:145–153.
35. Browman C, Gujavarty K, Yolles SF, Mitler MM. Forty-eight-hour polysomnographic evaluation of narcolepsy. *Sleep* 1986;9:183–8.
36. Roth T, Hartse KM, Zorick F, Conway W. Multiple naps and the evaluation of daytime sleepiness in patients with upper airway sleep apnea. *Sleep* 1980;3:425–39.
37. Carskadon MA, Orav EJ, Dement WC. Evolution of sleep and daytime sleepiness in adolescents. In: Guilleminault C, Lugaresi E, eds. *Sleep/wake disorders: natural history, epidemiology, and long-term evolution*. New York: Raven Press, 1983:201–16.
38. Carskadon MA. The role of sleep onset REM periods in narcolepsy. In: Guilleminault C, Dement WC, Passouant P, eds. *Narcolepsy*. New York: Spectrum, 1976:499–517.
39. Guilleminault C, Dement W. 235 cases of excessive daytime sleepiness. *J Neurol Sci* 1977;31:13–27.