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PRO/CON DEBATE

The MSLT and MWT Should Not Be Used for the Assessment of Workplace Safety

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There is good evidence that the Multiple Sleep Latency Test (MSLT) and, to a lesser extent, the Maintenance of Wakefulness Test (MWT) are both reliable and valid measures of changes in sleep tendency in individuals exposed to sleep deprivation. The MSLT has been used extensively in both research and clinical settings for almost 30 years. It is only natural to wish to extend the use of these tests to other environments in which determination of alertness is essential.

In research settings, group differences, often based upon large numbers of individuals, are identified at given levels of probability. However, in clinical practice, the focus is on the individual patient, and group information may be limited by individual variability. When one considers public safety, the focus shifts even more to include not only individuals, but also occupational groups, legislative bodies, employers, and unions. Even the most elegant test of alertness will be of no use in the face of work schedules that violate circadian adaptation or require chronic sleep deprivation or exempt themselves as too important or not subject to universal physiologic rules. A safe workplace requires the presence of specific items such as fire extinguishers and the absence of specific items such as fire arms and alcohol. Unfortunately, society has not accepted that sleepiness has no place in a safe workplace. Necessary evidence of such understanding would include consistent application of already published peer-reviewed empirical research to design work schedules and limit errors; provision of approved areas for naps (the fire extinguisher for mild sleep deficits); provision of sleepiness counseling as a part of employee orientation, continuing education, safety, and health services; and design of the workplace to maximize employee alertness.

Acceptance of the importance of sleepiness evaluations will require public and professional education similar to that common for the negative impact of alcohol. Education programs stressing poor productivity and increased medical costs associated with sleepiness need to be directed toward government and corporate entities so that they recognize that improving alertness would pay tremendous monetary dividends in addition to improved health and would lessen the need for workplace tests of alertness. Remarkably, and regrettably, many sleep medicine practitioners have not followed their clinical wisdom into their own sleep schedule and the work-sleep schedule of their students and employees and can also benefit from education. Development times for recognition, treatment, and sanctions for alcohol use and smoking have shown that behavior change in society is a slow process that takes many years. Acceptance of sleepiness as an equally important medical and social problem will require the concentrated effort of our entire field for an extended period. Society now accepts the value of tests of breath alcohol in and out of the workplace. Significant education remains until there is a similar acceptance of the negative consequences of sleepiness. Such acceptance presages evaluations of alertness aimed at the patient (employee) rather than the disease (required working conditions).

When given the mandate to evaluate alertness, our research must provide a reliable, valid test and appropriate norms for the group to be examined. Acceptance of the MSLT or MWT as a valid measure of alertness in normals and then in patients would be important first steps. Unfortunately, recent work suggests that our understanding of the relationship between sleep and alertness is still at a relatively rudimentary level. Additional empirical work is needed to properly place tests of alertness within sleep disorders medicine. Obviously, even more understanding will be required to extrapolate those links to the workplace.

Reliability and Validity of MSLT and MWT

Substantial data have been collected with the MSLT in normals and in patients with sleep disorders. This evidence has been recently reviewed by the American Academy of Sleep Medicine (AASM),[1] and the AASM has also published practice parameters for the use of the MSLT and MWT in patients with sleep disorders.[2] The review and practice parameters both give a clear message that, due to numerous limitations, the MSLT and MWT are not clearly indicated, even in patients with sleep disorders, with the exception of narcolepsy. The problems resulting in the limited clinical utility of these tests have been discussed at length elsewhere.[3] These problems extend in their entirety to the consideration of the use of these tests for assessment of safety. A few of the salient points from these reviews that will be discussed in more detail are listed below.

1. The large variability in normal groups limits the establishment of norms.[1]

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2. The MSLT is indicated only "as a part of the evaluation of patients with suspected narcolepsy."[2p116]
3. The MSLT is specifically not indicated for patients with sleep apnea.[2]
4. The MSLT is specifically not indicated in medical and neurologic disorders (other than narcolepsy), insomnia, or circadian rhythm disorders.[2]
5. The practice parameter paper does not state that the MWT is indicated for any sleep disorder. The practice paper does state that the MWT "may" be used to assess the ability to remain awake in situations in which there may be a public or personal safety issue. However, the text clearly indicates that even this statement was based upon subjective consensus in the face of lacking objective data.[2]

Norms

True age-, sex-, and pathology-related norms have never been developed for the MSLT or MWT. The recent AASM review combined data from a large number of published studies in an effort to provide some normative information. The task was a difficult one (and not universally supported by the committee members) because methodology has never been truly standardized for either test. This means that, for example, in the MSLT, the definition of sleep onset varies across studies, the amount of sleep allowed after sleep onset varies, the timing and number of tests performed during a day varies, patient activity levels and exposure to external stimulation varies, and prior sleep amount varies. Sufficient data existed for the AASM committee to test the significance of some of these methodologic differences, and it was found that MSLT values varied significantly based upon the definition of sleep onset, the number of naps performed (4 naps versus 5 naps), and how long patients had slept on the previous night.[1] It was also found that the MSLT varied significantly as a function of age.[1] However, the most important finding was that, even within age groups, the variability of the MSLT results was so high that constructing a norm table based upon a range of 2 standard deviations around the mean (95% of cases) always included almost the entire range of the test. For example, for the overall mean for the 5-nap MSLT (11.6 ± 5.2 minutes), the normal range was from 1.2 to 20 minutes.[1] This means that, with our current wisdom, it is extremely difficult to find an MSLT result that does not fall within the normal range.

Normative data from the MWT are much more limited. The test also suffers from a lack of consistent methodology (primarily how long the test should last if participants do not fall asleep). Findings that could be tested were similar to those for the MSLT (changes with age). A mean and standard deviation for the 40-minute test recommended by the practice parameter paper was 30.4 ± 11.2 minutes (range for 2 standard deviations was 8-40 minutes).

These data are best summarized by Dr. Arand in the AASM review: "MSL [mean sleep latency] on both the MSLT and MWT does not discriminate well between patients with sleep disorders and normal populations . . . ."[1p139] It is obvious that if we cannot distinguish patients referred for clinical evaluation for overwhelming sleepiness from normals with some degree of certainty using these tests, then we are not ready to try workplace assessments that could place employment in jeopardy for innocent employees.

Narcolepsy

The AASM review found the strongest evidence to support the use of the MSLT in the evaluation of narcolepsy, based on several studies that compared patients with narcolepsy with controls and showed significant differences in sleep latency and rapid eye movement (REM) onsets in the patients. However, the mean sleep latency of 3 minutes for 245 narcolepsy patients would be within the range of values for normal individuals listed above. Further, despite the fact that patients with narcolepsy have significantly more REM onsets than do normal subjects in matched studies, Bishop et al[4] have reported that 17% of their sample of 139 normal young adults had 2 or more REM onsets in their MSLT. Of course, this means that the odds of finding REM onsets in a random normal individual are much higher (17% of the population) than finding a patient with narcolepsy (.05%). Of more importance, such data state that the MSLT simply cannot be used in isolation to identify narcolepsy, or, as stated by Dr. Arand, " MSL should not be the sole criterion for determining sleepiness or for certifying a diagnosis or response to treatment."[1p140] Again, if the MSLT, which provides 2 separate markers for identification of patients with narcolepsy, cannot be used as the sole criterion for identifying these severely afflicted patients, it is just not possible to use it as the sole criterion to try to assess alertness in the workplace.

Sleep Apnea

As indicated earlier, the AASM practice parameter paper has concluded that the MSLT is not indicated in patients with sleep apnea.[2] Such a statement certainly seems remarkable because sleep clinicians routinely identify these patients based upon their history of excessive sleepiness and base their evaluation of treatment success on improvement in daytime alertness. Our clinical training has been based upon the assumption that the severity of obstructive sleep apnea should correlate with level of sleepiness. Unfortunately, this has not been clearly shown. Sauter[5] found no difference in MSL on the MWT between patients with moderate or severe sleep apnea. It is known that patients with sleep apnea are prone to car accidents, but patients with apnea who have had car accidents do not have shorter MSL on the MSLT (8.0 versus 7.8 minutes) or even rate themselves as sleepier.[6,7]

The belief that MSLT will normalize with successful treatment of sleep apnea has also not been upheld. Only 2 of 4 placebo-controlled studies of patients effectively treated with continuous positive airway pressure found improvement on MSLT after treatment. Combined mean data from the 4 studies showed the MSLT to be 9.8 ± 4.5 versus 8.3 ± 4.7 minutes on continuous positive airway pressure versus placebo.

Inability to find convincing relationships with severity indexes or with effective continuous positive airway pressure therapy in patients suggests that something is missing from our understanding of either sleep apnea or the MSLT. One example of what could be missing is a report that MSL is shorter in obese individuals without obstructive sleep apnea.[8] This implies that metabolic disorders or habitual activity levels may also contribute to sleepiness.

Insomnia

The MSLT is not recommended by the AASM for use with patients with insomnia for the simple reason that MSLT findings in patients with insomnia are paradoxical. These patients apparently suffer from chronic partial sleep loss but, despite poor sleep at night, have increased sleep latency on the MSLT.[9-12] Such findings cannot be explained by the traditional understanding of the MSLT. However, the result has been replicated in a meta-analysis of 20 studies that reported both nocturnal total sleep time and MSLT findings in normal subjects. Studies were split into a group in which sleep on the prior night was 435 or more minutes (451 subjects) and a group in which sleep on the prior night was less than 435 minutes (397 subjects). In agreement with the data from patients with insomnia, normal subjects who slept less at night had significantly longer MSL than did subjects who slept longer on the prior night.[1]

In the insomnia literature, longer MSLT values in patients are attributed to increased physiologic activation overriding mild sleep deprivation.[13-15] Such a conclusion is directly supported by the finding that heart rate, used as a measure of arousal, is positively correlated with sleep latency in normal subjects, in patients with insomnia, and in both groups exposed to a standard arousal manipulation (5 minutes of walking prior to an MSLT evaluation). The clinical MSLT data form patients with insomnia are also supported by an examination of MSLT results in normal subjects. When a large group of normal adults were split based upon their MSLT results (greater than 10 minutes in 1 group compared with less than 7 minutes in a second group following baseline normal sleep), it was found that normals with longer latencies on the MSLT had a higher heart rate and increased sympathetic nervous system activity (based upon spectral analysis of their heart period).[16] These findings indicated that trait level of arousal is an important determiner of sleep latency on the MSLT. However, there is currently no way to control for arousal level in the assessment of sleepiness.

The MSLT Measures More Than Sleepiness

These numerous studies of level of physiologic arousal, as indexed by cardiac measures in patients and normal subjects, offer a compelling picture of sleep latency being dually determined by the sleep system and the arousal system. Historically, the finding of rapid sleep onset in an MSLT evaluation in a normal adult has been attributed as evidence of partial sleep deprivation (regardless of data suggesting otherwise). However, studies have now shown that some normal young adults continue to repeatedly fall asleep in 8 minutes or less on the MSLT even after 2 weeks of sleep extended to 10 or more hours per night.[17,18] The indication is that, when the sleep system is at basal levels, physiologic arousal will determine sleep latency. Any reader who believes that this statement is heretical need only consider the 20-minute difference in MSL on the MSLT versus the MWT (both measured to the same sleep-onset criterion) that can only be based on the arousal components added to the MWT.[19] Unfortunately, recognition of the role of arousal in sleep tendency opens a world of possible influence. There are underlying differences in trait level of arousal sufficient to have significant influence on the MSLT documented both in comparisons of patients with insomnia with normal controls[20] and even within groups of normal young adults.[16] There are also many sources of state arousal that can have a significant influence on the MSLT. For example, the simple physiologic activation associated with a self-paced 5-minute walk around the hospital had a greater impact on the MSLT than a 4-hour reduction in time in bed,[21] and the impact lasted for at least 100 minutes.[22] Another example is that the common observation of the longest sleep latency on the final nap in the MSLT actually demonstrates competing demands[3] rather than a circadian effect.

From this discussion, it follows that numerous (and still frequently untested) arousing stimuli such as bright light, noise, social interaction, temperature, motivation, boredom, test anxiety, general anxiety, and pain have an impact on level of arousal and therefore will also have an influence on MSLT over and above any impact that these stimuli might have on sleep during the preceding night. All of these state and trait arousal factors carry over to any safety or workplace application and are magnified in that environment by additional situational factors such as reward, interest, personality, and fear.

Sleep and Arousal

Sleep deprivation has consistent effects on measured sleepiness, but there is also significant variability in response to sleep deprivation. One explanation for this is that each of us has an individual sleep need, and this need can vary substantially from the number of hours typically slept each night. There is really no good way to easily determine sleep need and, therefore, to know whether an individual habitually sleeping 8 hours per night is chronically sleep deprived, because his real need is 10 hours, or sleep satiated, because his need is actually 7 hours. Isolation studies suggest that underlying sleep need is probably greater than sleep typically obtained (8.5 hours or greater on average, see reference 23), but even these findings are open to the explanation that sleep length in isolation increases because sources of arousal decrease. Relatively little is known about sleep need and how it is determined. Lack of knowledge here makes specific admonitions (i.e., sleep hygiene or "work rules") difficult to formulate for the individual.

Given a complex interaction between both internal and external sources of arousal and MSLT and MWT results, should it be expected that these tests would be correlates of real world alertness? To the extent that these tests presumably measure the same underlying dimension, one would expect their results to be highly correlated. Unfortunately, several studies report that the correlation between the MSLT and the MWT is relatively low.[19,24,25] It has been hypothesized that the correlation between these tests is low because the MWT inherently incorporates independent sources of arousal (posture, light, motivation) that interact with the sleep system to produce different results. Are results with these estimators of arousal sufficient to model sources of arousal in the real-world environment?

There is no question that appropriate measures of functional alertness are essential. However, the "functional" modifier is not well accepted or explored. Numerous studies have begun to identify some of the variables that modify alertness, but it is simply not known whether a simple test, such as the MWT, is a reliable predictor in a complex environment such as flying an aircraft. In a recent editorial ("Staying awake for safety sake: a dream not yet realized" see reference 26), a study examining the relationship between the MWT and simulated driving performance after sleep deprivation and alcohol use was reviewed. The good news is that the MWT did have some predictive power in these extremely impaired individuals in a laboratory environment.[27] However, application to the real world is still problematic. Another study that compared performance on a driving simulator to real-world driving found that measures such as line crossings increased with sleep deprivation for both conditions, but the number of line crossings was 50 times greater in the simulator, and the simulator and real-driving results were not correlated in the group of 12 subjects.[28] As such, it will be very difficult for standard laboratory experiments to have the scope necessary to be accepted where there may be large economic costs in the balance.

Major groups such as the Federal Aviation Administration and the Department of Transportation are appropriately and crucially interested in the ability to objectively quantify alertness. The AASM could play a major role in the development of a standard that could also validate the MWT by working interactively with the Department of Transportation or Federal Aviation Administration to encourage or design research that could follow the extended process necessary to identify and validate real-world measures that correlate with either simulator measures such as the line crossing measure described above or the more general MWT measures. At this point, it is clear that these studies must start with recording and analysis of electroencephalogram and performance of drivers driving in the real world and pilots actually flying while alert and after sleep loss. The hope is that significant correlation with simulator performance or more general MWT measures will be found, but current data suggest that this may be difficult. For this reason, it is equally important to develop and validate automated real-time performance monitors for use in the transportation industry so that behavior, such as inadvertent line crossing, can be identified in real time and fed back to the driver, pilot, or safety control system. Regardless, it is obvious that the gulf between current knowledge and such measures is enormous and that the development of a coherent strategy could save years of scattered work in addition to lives.

The recent AASM review paper and practice parameters on the use of MSLT and MWT have served to remind us of the rudimentary status of our knowledge. The importance of alertness to society demands our attention. Perhaps we are too sleepy to comprehend the commitment of time and resources necessary to understand and measure alertness.

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