

## Sleep Fragmentation, Sleep Deprivation, or Both

Edward J. Stepanski, Ph.D.

*Accelerated Community Oncology Research Network, Memphis, TN*

*J Clin Sleep Med 2006;2(4):479*

### To the editor:

I applaud the efforts of Schwartz and Moxley to explore ways to achieve greater understanding of the role of arousals in producing daytime impairment.<sup>1</sup> This area of research has great clinical relevance, but has been largely neglected in recent years. Schwartz and Moxley distinguish short arousals (3-15 secs) from long arousals (15-60 secs) and wake events (>60 secs). They found that long arousals have higher correlations with the Epworth Sleepiness Scale (ESS) than do short arousals.

I wish to provide some context for understanding work in this area. Our original work in the area of sleep fragmentation at Henry Ford Hospital was aimed at determining if very short disruptions to the sleep EEG would produce daytime impairment.<sup>2-4</sup> At the time, partial or total sleep loss was thought to be the main determinant of daytime sleepiness. With the observation that patients with obstructive sleep apnea experienced daytime sleepiness even after accruing normal total sleep time, there was a need to expand our understanding of causes of daytime sleepiness. The only standard sleep parameter available at the time to characterize sleep fragmentation was "number of awakenings." These events were scored with a minimum of 16 secs of wakefulness (if lined up at the beginning of an epoch), and might require 29 secs of wakefulness (if lined up just after the mid-point of an epoch, but continuing to the next epoch). No sleep parameter was designed to measure disruptions of sleep continuity that were shorter than these awakenings as there was no compelling reason to do so. Carskadon showed that "brief arousals" correlated with the MSLT in older adults.<sup>5</sup> Short arousals less than 15 secs in duration were then shown to correlate with the MSLT in patients with sleep apnea.<sup>2</sup> Further, experimental sleep fragmentation paradigms causing "micro" arousals in normal sleepers showed increased sleepiness on the MSLT the following day.<sup>3</sup> In conjunction with Bonnet's work (summarized in Stepanski<sup>6</sup>), these data supported the notion that disruptions in the continuity of sleep would undermine the restorative value of sleep, even with normal total sleep

time. Therefore, inclusion of a measure of these very brief arousals was deemed important in understanding one cause of sleepiness that was of particular interest in patients with obstructive sleep apnea.

The long arousal measure described by Schwartz & Moxley would be expected to be sensitive to both sleep fragmentation and sleep deprivation. That is, while brief arousals measure disruption to sleep continuity, independent of how much total sleep is accumulated, the definition of long arousal includes events that would be traditionally classified as awakenings. This measure is therefore more likely to indicate increased wakefulness over the night than would the traditional measure of brief arousals. The standard measure of arousals was hypothesized to be a pure measure of sleep fragmentation, and the definition was designed not to overlap with existing measures of wakefulness.

The intent of this discussion is to provide a theoretical context for a measure of long arousals to explain how it may vary from traditional definitions of arousals. An arousal measure that incorporates both sleep loss and sleep fragmentation into a single metric may well have clinical utility in the evaluation of patients with obstructive sleep apnea. Future work should seek to understand if this combined measure provides unique information not contained in traditional measures of total sleep time and sleep fragmentation. Additionally, as acknowledged by Schwartz & Moxley, use of an objective measure, such as the MSLT or MWT, would add to our understanding of the importance of long arousals.

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### Disclosure Statement

Dr. Stepanski has indicated no financial conflict of interest.

Address correspondence to: Edward J. Stepanski, Ph.D. Accelerated Community Oncology Research Network, 1770 Kirby Parkway, Suite 400, 4th Floor, Memphis, TN 38138; Tel: (901) 435-5570; Fax: (901) 259-8293; E-mail: estepanski@sosacorn.com