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COMMENTARY

How Much Day-To-Day Variability in Sleep Timing Is Unhealthy?

Commentary on Taylor et al. Bedtime variability and metabolic health in midlife women: the SWAN Sleep Study. *SLEEP* 2016;39(2):457–465.

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The times that we choose to go to bed and wake up are rarely fixed. As with any behavior, sleep timing is variable and influenced by a host of biological and environmental factors. Presumably, the circadian system and sleep homeostat evolved to cope with day-to-day changes in sleep timing within a certain range, beyond which maladaptive responses occur. For example, in shift workers there is often a large mismatch between their daily activity patterns (e.g., sleeping and eating) and the timing of their circadian system. This misalignment contributes to sleep disturbances and is associated with impaired glucose tolerance.[1,2] Epidemiological studies have shown that chronic exposure to shift work is associated with increased risk of obesity, metabolic syndrome, and type 2 diabetes.[3,4] These findings suggest that keeping a highly irregular sleep-wake schedule contributes to poor metabolic health.

Shift work is unhealthy, but most of us in the general population are not regularly exposed to the large degree of circadian misalignment experienced by shift workers. Nevertheless, non-shift workers and students often show substantial day-to-day variability in their sleep timing. Young adults and adolescents typically go to bed later but spend more time in bed for sleep on free days compared to work days.[5] Similarly, following the transition to retirement, older individuals tend to go to bed later and sleep longer than when they were working,[6] suggesting that the discrepancy in sleep behavior between work days and free days cuts across most of the lifespan. The magnitude of the difference in sleep timing between work days and free days associates with increased body mass index, fat mass, and insulin resistance.[7–9] Hence, irregular sleep-wake timing can potentially impact metabolic health, even in individuals who have never worked a night shift.

In the current issue of *SLEEP*, Taylor and colleagues[10] examined the relationship between variability in sleep timing and metabolic health in non-shift workers. As part of the Study of Women's Health Across the Nation (SWAN) Sleep Study, sleep behavior was assessed in midlife women (aged 48–58 years) using diary-reported bedtimes and wake times. After adjusting for covariates, the authors found that higher bedtime variability and the occurrence of large deviations in bedtime (i.e., greater than one standard deviation later than a person's mean bedtime) were associated with increased insulin resistance. In prospective analyses, bedtime delay also predicted the increase in insulin resistance assessed about 5 years later. The cross-sectional and prospective associations between these measures were significant only when both weekdays and weekends were included in the analysis, suggesting that large deviations in bedtime between work days and free days contributed to impaired glucose regulation.

The findings by Taylor et al. suggest that moderate variation in sleep timing can potentially influence metabolic health outcomes, but the underlying mechanisms remain to be elucidated. Sleep schedule irregularity can give rise to sleep disturbances due to misalignment between sleep-wake timing and the circadian system.[11] The resultant reduction in sleep and its continuity could lead to impaired glucose regulation.[12,13] However, in the study by Taylor[10] associations between bedtime variability and insulin resistance were observed even after adjusting for differences in sleep duration. Although not tested, more variable sleep timing could result in more variable eating patterns, including increased food intake during the biological night. Prior work has shown that late bedtimes combined with sleep curtailment results in increased caloric intake in the late evening hours, as well as increased appetite for foods that are calorie-dense.[14,15] Late and irregular bedtimes could therefore lead to weight gain and metabolic dysregulation by facilitating excess energy intake at an adverse circadian phase. Exposure to irregular sleep-wake schedules and light-dark cues could also impair glucose regulation by altering the phase and amplitude of the liver clock, which is required for normal glucose tolerance.[16]

Growing evidence indicates that irregular sleep is unhealthy. Why, then, do people keep irregular sleep-wake schedules? To be sure, work and school commitments are major determinants of a person's sleep pattern. Early start times can result in waking during the late part of a person's biological night, and when combined with short sleep during the week, insulin sensitivity is reduced.[17] This could increase risk for metabolic dysregulation in evening types, including adolescents who prefer later rise times than what is possible based on their school schedule. Based on the negative mental and physical consequences of reduced sleep, the American Academy of Pediatrics recommends that middle schools and high schools start no earlier than 8:30 am.[18] In principle, delaying school start times should increase the opportunity for weekday sleep, while also reducing the discrepancy in sleep behavior between school days and free days. Irrespective of work and school schedules, however, many individuals adopt an irregular sleep-wake pattern due to social activities and lifestyle choices, and are willing to trade sleep for other late-night activities. Individuals who engage in such behaviors often believe that they can catch up on their sleep on weekends, but it remains unclear whether the mind and body recover fully after extended sleep on free days.

Looking forward, how do we measure and address the impact of irregular sleep-wake behavior on metabolic health? To be sure, more studies are needed that examine the effects of repeated exposure to sleep restriction with intermittent recovery sleep, as typically occurs in social jet lag. To date, most laboratory studies have examined the effects of severe sleep restriction (≤ 5 h of time in bed) on glucose regulation over a week or less, whereas little is known about the effects of moderate sleep restriction and variability in sleep timing across longer time scales. There is also a need for large-scale prospective studies that examine the interrelationships between mealtimes and their macronutrient composition, the timing and duration of sleep, and circadian rhythms on metabolic health outcomes. This seemed like a distant possibility just 10 years ago, but our scientific toolbox has since grown. The rise of wearable technologies in the consumer market has made it possible to monitor rest-activity patterns in a large number of users simultaneously, and the cost of doing so has steadily declined. Additionally, smartphone applications have been developed that allow for tracking and analysis of eating behavior. Such technologies have already been used to demonstrate that erratic daily eating patterns are widespread, and that restricting the window of daily food intake can help sustain weight loss.[19] With the implementation of technologies that allow for noninvasive and continuous monitoring of human behavior, coupled with periodic assessments of metabolic health and cognitive performance, we will be in a much better position to define the limits of "normal variability" in sleep timing that are consistent with a healthy lifestyle. Such studies are important for establishing evidence-based recommendations for improving sleep behavior and metabolic health.

CITATION

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DISCLOSURE STATEMENT

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