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Sleep Restriction in Adolescents: Forging the Path Towards Obesity and Diabetes?

Commentary on Beebe et al. Dietary intake following experimentally restricted sleep in adolescents. SLEEP 2013;36:827-834.

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There is mounting epidemiological data linking short sleep duration and obesity in children and adults.[1-4] Although not defining cause, these studies have raised questions that are beginning to be answered, albeit mostly in adults. Moderate (2 h per night) and severe (up to 4 h per night) sleep restriction in adults have been found to affect both food intake and appetite. Our laboratory[5] and others[6,7] have reported that restricting sleep in normal sleepers increases food intake, mostly by increasing intake of snacks[7] and fat.[5] However, despite clearer associations between short sleep duration and obesity in the pediatric than the adult epidemiological literature,[4] there is little clinical evidence for a causal effect in children.

To our knowledge, only one intervention study has assessed the impact of sleep restriction on energy balance in adolescents.[8] That study, conducted in 15- to 19-year-old boys, tested the effects of 3 nights of 4-h (i.e., restricted sleep) compared to 9-h bedtimes (i.e., longer sleep) on energy expenditure and energy intake. The results showed greater energy expenditure and lower energy intake at a test meal during restricted sleep relative to healthy sleep, contrary to the authors' hypotheses. Although this was a well-designed study, it may have failed to provide accurate information on the impact of sleep restriction on energy balance due to the limited extent of the sleep restriction, lack of ad libitum access to food and physical activity data, and restriction of assessments to only adolescent males.

In this issue of *SLEEP*, Beebe and colleagues[9] are to be commended for providing much needed information on the impact of sleep restriction, to an extent similar to what happens on school nights, in both adolescent boys and girls. They conducted a study with an innovative design in an attempt to reproduce real-life situations: teens spent 6.5 or 10 h time in bed (TIB) Monday through Friday, with free sleep times on weekend nights, in a crossover design. During the 5 controlled sleep nights, wake-up times were held constant between sleep conditions. This resulted in 6.3 h and 8.9 h of sleep under restricted sleep and unrestricted sleep, respectively, similar to the self-reported sleep times of 9.3 h on non-school nights and 7.1 h on school nights. In the restricted sleep condition, food intake, assessed by a single 24-h recall, tended to be higher than in the 10-h TIB sleep condition, which we speculate was accounted for by a greater intake of sweets and desserts.

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An important distinction between the intervention study of Beebe et al. and real-life sleep patterns of teenagers may be that sleep restriction was achieved by delaying bedtimes in the intervention study, whereas in real life, teens likely curtail their sleep by advancing wake-up times rather than bedtimes.[10,11] This may be an important distinction to consider in future studies. In fact, comparing restricted and healthy sleep episodes with bedtimes of 00:50-07:08 h and 22:21-07:11 h, respectively, as in the study by Beebe et al.,[9] may not be equivalent to sleep episodes of 00:50-07:08 h and 00:50-09:40 h for restricted and 10 h TIB sleep, respectively. Sleep architecture may be changed differently by these two sleep patterns, and although sleep is restricted by 2.5 h in both scenarios, food intake and metabolic and hormonal variables may not be similarly affected.

The well-characterized sleep-regulatory interaction between circadian and homeostatic mechanisms dictates that slow wave sleep (SWS) is highest at the start of the sleep episode (regardless of clock time), whereas REM sleep is highest during the early morning hours.[12] Depending on the specifics of the sleep manipulation, the expression of REM sleep may be selectively reduced while maintaining SWS, as may be the case when short sleep episodes are anchored at the start of habitual sleep and sleep time is eliminated from the latter portion of the sleep episode. Accordingly, the current manipulation by Beebe et al.[9] may have resulted in a different sleep architecture profile than what normally occurs in adolescents. For example, Schmid and colleagues[13] conducted separate studies in which they restricted sleep to ~4.5 h versus 8.5 h by either delaying bedtimes or advancing wake-up times.[14] When early morning sleep was cut, percent total sleep time spent in REM sleep was significantly reduced[15]; percent REM sleep was not different when bedtimes were delayed.[13] This sleep timing-dependent difference in sleep architecture may have implications for food intake regulation, as we have shown that REM sleep expression in particular is inversely related to hunger, and the consumption of fat and carbohydrates.[16] This implies that the real-life case for adolescents, who may experience even larger REM sleep deficits, may in fact be worse than what is demonstrated by Beebe and colleagues.[9] Nonetheless, the extent of overeating observed by Beebe et al. is equivalent to that of others.[17]

The issue of when to restrict sleep is important in light of emerging information suggesting that the sleep and meal timing may play a role in the relationship between sleep and obesity. In fact, the timing of the sleep episode itself, irrespective of its duration, may have important implications for energy balance regulation. Adolescents who have earlier sleep episodes (morning oriented) have healthier diets than adolescents with later sleep episodes,[18] and mice subjected to light at night are heavier than those who are not.[19] Moreover, Roenneberg et al.[20] coined a term "social jetlag" to characterize the discrepancy between circadian and social clocks in which individuals shift the timing of their sleep episode between weekdays and weekend days to accommodate work, school, or social demands. Individuals with a larger discrepancy between weekday and weekend sleep are heavier than those with regular sleep patterns. Obviously more needs to be done to examine such behaviors relating sleep and eating patterns. The study by Beebe et al.[9] is a good first step in this direction in the adolescent population, which is well known to have erratic sleep and meal schedules.

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DISCLOSURE STATEMENT

The authors have indicated no financial conflicts of interest.

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