Expanding investigations on the relation between sleep restriction and energy balance

Dear Sir:

Klingenberg et al (1) recently presented an innovative study from the University of Copenhagen entitled “Sleep restriction is not associated with a positive energy balance in adolescent boys” investigating the relation between sleep restriction and energy balance in male adolescents. The authors make a marked effort in their protocol design to encompass all aspects of energy balance, measuring both energy expenditure (EE) and energy intake (EI) through a variety of tests and analyses to assess changes in physical activity, appetite, and hormones. Because previous studies have observed conflicting results with regard to the effect of sleep deprivation on EE, showing either an increase or no effect on EE (2, 3), findings from this study, although interesting, do not completely ascertain the actuality of this relation.

The authors observed an increase in 24-h EE after shortedn sleep, contradicting their original hypothesis that EE would be unaffected. In addition, they observed a decrease in motivation to eat and subsequent EI, which was also contrary to results from previous studies. With these results, future research can be expanded with the use of different approaches. Most notably, the study could be developed further to include not only adolescent boys but girls as well. With this, sex-related differences in energy balance can be explored, especially bearing in mind that adolescent girls present an extra experimental variable: the menstrual cycle. We also highlight that additional investigations to broaden our knowledge of this highly relevant topic.

Further topics that should be discussed in future studies include the criteria for the exclusion of the volunteers. Volunteers were excluded if they showed signs of metabolic disease, eating disorders, self-reported sleeping problems, etc. However, they were not submitted to a polysomnography, a gold-standard method in sleep research, before being included in the study, which could greatly alter the results. If the subjects had any previous sleep problems (of which they were unaware), such as obstructive sleep apnea, it could alter their sleep quality and lead to differences in EI and EE. Of note, in a large population sample one study observed a high prevalence (32.9%) of obstructive sleep apnea syndrome, including in subjects aged from 20 to 80 y (5).

With respect to measuring EE, the authors used a “whole-body calorimetric chamber,” which was left open during the first 2 nights so that the subjects could adapt. In the subsequent 24 h, EE was measured by submitting the subjects to light cycling and walking and with a standardized period of breakfast, lunch, dinner, and snack during the day. These activities are forms of exercise, but do they represent the physical activity of an adolescent on a day-to-day basis?

Another point of concern is that during the first 2 days of the study, the subjects slept in the laboratory, with the rest of the day designated as “free-living.” The boys were asked to abstain from heavy exercise and were sent text messages to eat on time, with food provided by the researchers. Although the food provided was not chosen by the adolescents, as a means to standardize the ad libitum EI, it was not representative of their everyday diet, leaving the question of whether different food would cause alternate effects on energy balance.

The study also measured appetite with the visual analog scale, but this test was only performed periodically at around breakfast in the morning and at around the ad libitum lunch (to measure ad libitum EI). The visual analog scale would have also needed to be tested on the subjects at around dinner, especially because it is known that adolescents have a tendency to eat later at night (which may lead to obesity) (6). Also, the ad libitum lunch was a large portion of spaghetti Bolognese, with a serving size greater than what was expected that the adolescents would consume. Although serving a larger portion allows subjects to eat more if they desire, thus measuring their ad libitum EI, if it is not a food they are particularly fond of, their appetite and consequently their EI would appear misleadingly low.

In today’s modern society, adolescents are constantly and excessively exposed to the unhealthy temptations of food advertisements and spend exorbitant amounts of time on the Internet. In this sense, high-calorie diets and loss of sleep that result from these events have become increasingly frequent in the lives of young adults. Klingenberg et al’s study is greatly welcomed for addressing the impact that this shortened sleep can have on the energy balance of adolescent boys and for subsequently encouraging further investigations to broaden our knowledge of this highly relevant topic.

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Dear Sir:

We thank Bennedsen et al for their letter regarding our study (1), which explains possible mechanisms behind the association between short sleep duration and obesity in male teenagers. We agree that our results of increased energy expenditure (EE) and decreased drive to eat combined with decreased spontaneous energy intake are not supportive of the current evidence in the field, especially in younger populations (2). Bennedsen et al in their letter raise some important methodologic considerations in this regard.

We found that the difference in EE between sleep conditions (ie, 4 h compared with 8 h of sleep/night) was fully explained by the prolonged wakefulness in the short sleep condition. We agree that there are conflicting results regarding the impact of sleep restriction on EE, but a total sleep-deprivation protocol was applied in the study by Jung et al (3) as well as in the study by Benedict et al (4). This crucial methodologic difference prevents any direct comparison with our study. Also, the study by Benedict et al (4) did not measure 24-h EE. In the study by Bosy-Westphal et al (5), individual regression lines of VO2 compared with heart rate were used to calculate total EE. This method to determine 24-h EE under mainly sedentary conditions is far from optimal (6). Thus, in line with the results from our study we do not believe that acute partial sleep restriction brings about intrinsic physiologic changes in EE, which has also been reviewed by our group previously (7). Future studies will nevertheless be needed to confirm this observation, with careful attention to the sleep-restriction protocol and methods used.

We are well aware that pretrial sleep habits or even sleep-related conditions such as obstructive sleep apnea syndrome (OSAS) can differ between and within individuals and thus potentially interfere with the results. We also acknowledge the fact that OSAS can affect children and teenagers without either the children or their parents being aware of this. Consequently, we did submit the subjects to polysomnographic assessment the 2 nights before the 24-h measurement of EE. Furthermore, we evaluated pretrial sleeping habits by using the Pittsburgh Sleep Quality Index and also questioned the participants about potential sleep-related illnesses. Neither screening assessment of sleep nor polysomnographic measurements raised ground for concern regarding pretrial sleeping habits or OSAS among these lean and healthy boys. Furthermore, we conducted a crossover trial to limit the effects of any between-subject differences.

In the present study we confined the subjects in respiration chambers and strictly controlled their food intake to be able to detect subtle physiologic effects on energy metabolism. Bennedsen et al comment on the discrepancy between assessing energy balance in this controlled setting compared with assessing energy balance under free-living conditions. We agree that a controlled setting does not translate to real-life conditions; however, experimental studies are more robust than observational studies and are instrumental in understanding mechanisms under standardized conditions. We agree that food intake as well as physical activities were both dictated by protocol and restricted by the chamber and, as such, not comparable to free-living conditions. However, we do believe that this approach is suitable for the purpose of the study and can answer critical questions and provide an interesting addition to the current literature.

We also acknowledge that inducing sleep restriction for a few days does not mimic the mild chronic sleep deprivation in habitual short sleepers. The aim of the present study was to evaluate potential mechanisms involved in the sleep-obesity relation, and this requires strictly controlled conditions, which, for obvious reasons, cannot be carried out for long durations. Nevertheless, Bennedsen et al raise an important question as to whether the putative causes of the sleep-obesity association are related to behavioral aspects rather than intrinsic physiologic changes. Strictly controlled trials are not suitable for addressing behavioral aspects but are necessary to evaluate potential mechanisms. Future studies that use a different approach will have to be conducted to elucidate the question as to whether changes in food choice or timing of food intake (eg, late-night snacking) after sleep restriction would cause alternate effects in energy balance and thus help explain the gap between experimental studies and the unequivocal epidemiologic evidence.

Although we agree with Bennedsen et al that further experimental studies are needed to draw any definitive conclusions on the behavioral aspects potentially underpinning the sleep-obesity relation, we do believe that our study has provided important findings that may even help to develop future studies such as those outlined by Bennedsen et al. In our opinion, a primary target of future studies should be the nonhomeostatic, reward-driven regulation of eating behavior that could be affected by sleep restriction. A better characterization of short sleepers will also be needed, because it appears that only some of these individuals are likely to overeat in response to sleep restriction.

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