

DOSSIER ON n°96: Sleep and weight regulation

An increasingly common phenomenon, the reduction in sleeping hours is affecting all age groups in all industrialised countries. Over the second half of the twentieth century, the rapid rise in the prevalence of obesity in the United States developed alongside the progressive fall in the time spent sleeping. Epidemiological and experimental studies from the last fifteen years suggest that a short night of sleep could be a behavioural and environmental risk factor for metabolic diseases (obesity, diabetes and metabolic syndrome) in the same way as an unhealthy diet or lack of physical activity. It appears essential therefore to make the public, particularly the overweight, aware of the effects of lack of sleep.

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The cause of the reduction in sleeping hours in adults is essentially professional and social. In the young, it is linked to the development of the Internet and the increase in television programmes. Televisions, computers, videogames and mobile telephones should have no place in the bedrooms of children and teenagers.

The French National Institute of Sleep and Alertness (INSV) has made a “sleep passport” providing advice for better sleep available on its highly educational website (www.institutsommeil-vigilance.org). It also enables general practitioners and specialists to assess the sleep habits of their patients.

The reduction in sleeping hours is affecting all age groups in all industrialised countries. In the United States, the time set aside for sleep has fallen by approximately ninety minutes over the last fifty years and nearly 30% of adults aged between 30 and 64 sleep for fewer than six hours per night. Although the need for sleep does not change over the course of adolescence (approximately nine hours), American teenagers sleep for an average 8.4 hours when aged 11–12 and 6.9 hours when aged 17–18. In France, 17% of people aged between 25 and 45 accumulate a chronic sleep debt corresponding to the weekly loss of a full night of sleep and 33% of 18–55 year olds sleep for six hours or fewer on weeknights. Finally, 78% of French teenagers sleep for eight hours or fewer during the week.

EPIDEMIOLOGICAL STUDIES

After adjustment for confounding factors, numerous epidemiological studies (cross-sectional and longitudinal) report an association between a low amount of sleep and high body mass index (BMI) (42 of the 47 studies investigating the link). The impact of insufficient sleep on the risk of obesity appears to be greater in children than adults, and greater in younger adults than older adults. Of the 38 cross-sectional studies, 34 found an association between short sleeping time and high BMI (21 in 25 in adults and 13 in 13 in children). Cross-sectional studies do not make it possible to determine if lack of sleep is a cause or effect of excess weight.

Longitudinal studies suggest a causal link (eight positive studies in nine: four in five in adults and four in four in children). They show that people who sleep little gain more weight than people who sleep for seven to eight hours per night.

Length of sleep as compared to the recommendations					
Excessively short (minus more than two hours)		Very short (minus one to two hours)		Moderately short (minus zero to one hour)	
RR	CI 95%	RR	CI 95%	RR	CI 95%
1.92	1.15, 3.20	1.60	1.22, 2.10	1.43	1.07, 1.91

RR: relative risk CI: confidence interval

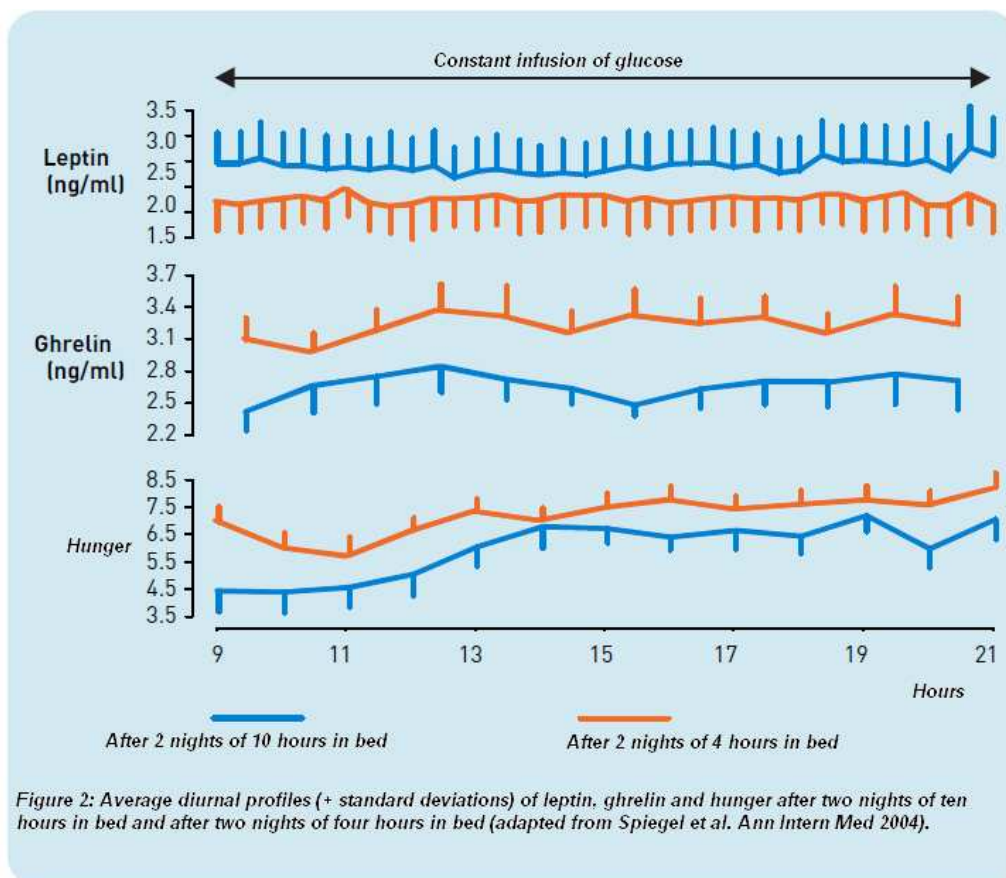
Figure 1: Relative risk of obesity in accordance with the length of sleep in children (according to Chen et al.)

Two meta-analyses have attempted to quantify the link between short sleep and risk of obesity by analysing the data collected from 600,000 adults and 30,000 children from various industrialised countries. The first reports an overall relative risk of 1.89 in children sleeping for ten hours or fewer and 1.55 in adults sleeping for five hours or fewer. The second reports an increased relative risk of obesity in children with short sleep duration, which rises when the length of sleep falls (Figure 1). These results suggest the existence of a dose-effect relationship between length of sleep and risk of obesity.

EXPERIMENTAL STUDIES

• Leptin and ghrelin

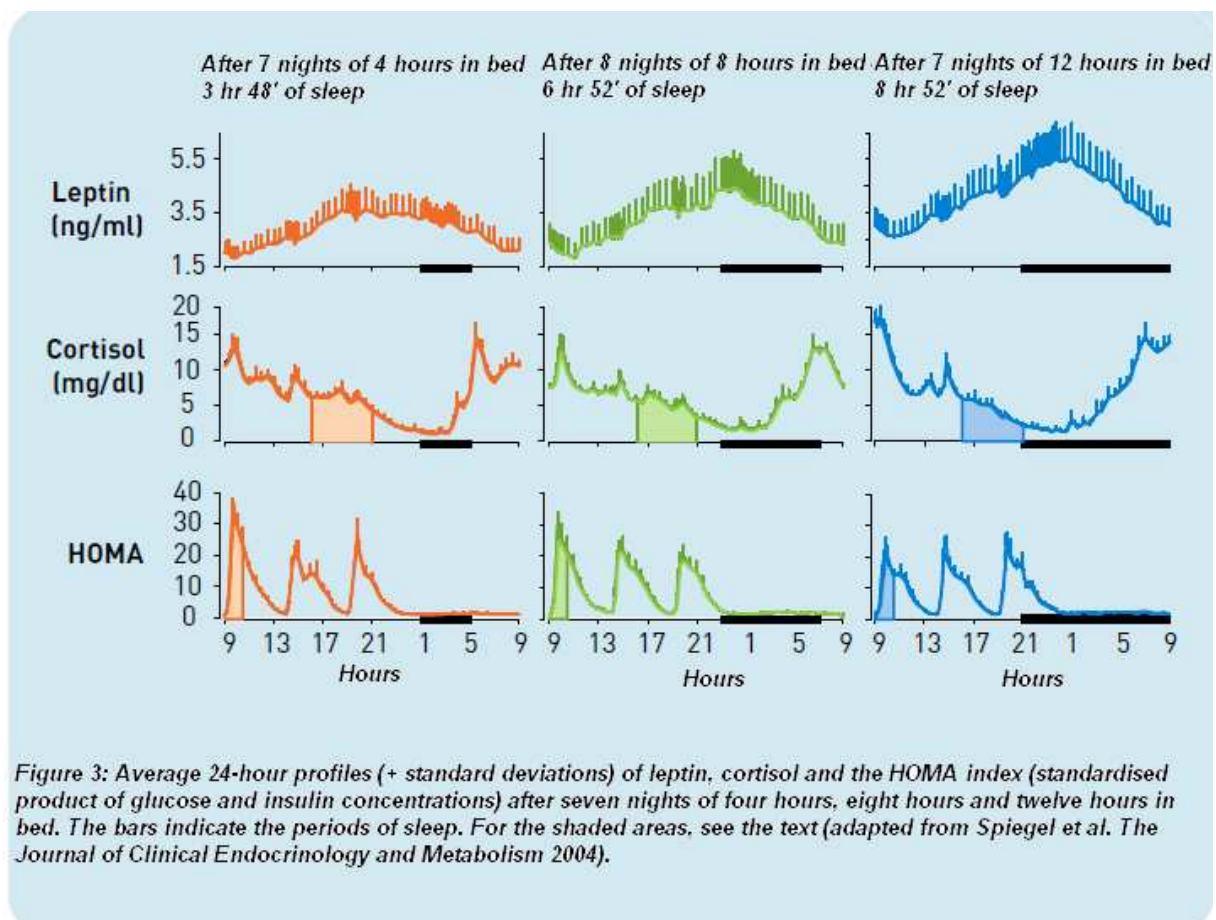
A number of experimental studies have recently assessed the impact of partial repeated sleep deprivation on the concentrations of hormones involved in regulation of the energy balance: leptin (hormone secreted primarily by the fat cells) which suppresses the appetite and stimulates energy expenditure, and ghrelin (hormone secreted essentially by the stomach) which stimulates the appetite and the formation of fatty tissue. Figure 2 shows the diurnal profiles of these hormones in young, healthy men after two nights of four hours in bed and after two nights of ten hours in bed. Although calorie intake, physical activity and weight were identical in the two experimental conditions, the concentrations of leptin were lower in 18% of the subjects who had had the opportunity for four hours of sleep as compared to ten hours, whereas the concentrations of ghrelin were higher in 28%. In restricted sleep conditions, hunger was increased by 24% and the appetite for foods rich in fat and carbohydrates by over 30%. These studies suggest that a sleep debt alters the hormone regulation mechanisms designed to inform the brain of energy requirements.



Recently, a randomised crossover clinical study in overweight adults studied after two weeks of sleep extension (+1.5 hours per night) and after two weeks of sleep restriction (-1.5 hours per night) showed an increase in calorie intake from snacking with restricted sleep.

According to a study in young, healthy subjects studied after six nights of four hours, eight hours and twelve hours, all the characteristics of the 24-hour profile of leptin increase progressively with the duration of sleep (average concentrations, night-time peak, amplitude of the rhythm) (Figure 3). These results indicate that length of sleep modifies the neuroendocrine regulation of appetite by a dose-response effect. A study assessing the appetite and morning rates of leptin and ghrelin after a night of total sleep deprivation and after a night of 4.5 hours and 7 hours of sleep has also reported a dose-response effect between severity of lack of sleep and increase in appetite and ghrelin. However, the rates of leptin were unaffected.

The long-term effects of lack of sleep on neuroendocrine regulation of appetite appear similar. Two epidemiological studies, the Wisconsin Sleep Cohort Study in the United States and the Québec en Forme study in Canada, have reported a reduction in leptin, after control for BMI or adiposity, and an increase in ghrelin in people who normally sleep little.



WEIGHT AND SLEEP APNOEA SYNDROME (SAS)

A disorder characterised by pauses in breathing during sleep, SAS leads to intermittent hypoxia and hypercapnia, sleep disturbance and a significant reduction in sleep. As being overweight is a major risk factor for SAS, the current obesity epidemic is being accompanied by a SAS epidemic, which is in turn recognised as a risk factor for hypertension and diabetes.

The effective treatment of SAS by continuous positive pressure improves carbohydrate metabolism and energy balance. It is therefore desirable that practitioners pay particular attention to the sleep of overweight patients and offer them appropriate testing when they suspect a sleep disorder.

• Cortisol and HOMA

Other mechanisms can contribute to weight gain in the case of reduced sleep. Cortisol increases the appetite and can encourage the development of abdominal obesity and insulin resistance. The 24-hour profiles of cortisol and the HOMA index (the standardised product of insulin and glucose concentrations) after six nights of four hours, eight hours or twelve hours show (Figure 3) that, although the average 24-hour rates of cortisol are unaffected by the length of sleep, the rates at the end of the day (shaded in the figure) are high for a four-hour night, low for a twelve-hour night and intermediate for an eight-hour night. The fasting HOMA index reflects insulin resistance: high values correspond to low sensitivity to insulin. Here the production of HOMA profiles has enabled analysis of the integrated response of glucose and insulin to three identical, carbohydrate-rich meals at 9.00 am, 2.00 pm and 7.00 pm. At breakfast, this HOMA index (shaded in Figure 3) is increased by 56% when subjects have had seven four-hour nights as compared to seven twelve-hour nights. Lower sensitivity to insulin has recently been highlighted after a less severe (5.5 hours) but longer (two weeks) sleep debt. Reduction in insulin sensitivity is therefore another mechanism whereby a sleep deficit could favour weight gain.

Finally, it has also been shown that a restriction in sleep causes an elevation in pro-inflammatory blood markers. These latest results take new shape in view of the role recently attributed to the chronic inflammatory state that characterises obesity and is acknowledged to be implicated in dyslipidaemia, insulin resistance, diabetes and certain cardiovascular diseases.

CONCLUSION

The reduction in sleeping time, which is widely observed in modern societies, could be an environmental and behavioural risk factor implicated in the pathophysiology of obesity. Some authors have suggested that increasing the length of sleep in people reducing it voluntarily would contribute to slowing the obesity epidemic. Critics have been opposed to this suggestion as the impact of a sleep deficit on the risk of obesity is relatively limited (longitudinal studies report excess weight gain of 1 to 7 kg over a ten-year period in people with short nights). Nonetheless, the difference in weight gain between people sleeping little and people sleeping sufficiently (7–8 hours) is similar to the weight loss obtained by pharmacological treatments. It appears, therefore, essential to make the overweight aware of the effects of lack of sleep in order to enable them to make an enlightened choice as to changing their hours of sleep. This information appears to be particularly crucial in the case of low-calorie diets as reducing or controlling calorie intakes when the body complains of hunger due to lack of sleep can prove to be especially difficult.

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