

## Invited commentary

### Energy balance as a function of adjustment of energy intake

Humans maintain a perfect energy balance as shown by a constant body weight in adult life. However, energy intake does not balance energy expenditure on a daily basis, as in small animals. Humans can afford to rely on body reserves while smaller species show signs of energy shortage sooner, as expressed in a lowered body temperature and reduced physical activity. Thus, a mouse cannot survive 3 days without food, while a normal adult human can survive more than 30 days. In man, Edholm *et al.* (1955) showed large discrepancies on a daily basis between intake and expenditure, especially when days with a high energy expenditure were alternated with quieter intervals. Energy intake strongly correlated with energy expenditure on a weekly basis.

The accurate compensation of a one-day, covertly-imposed, mild energy deficit on the next day, as shown by Goldberg *et al.* (1998) in this issue, is an example of intake adjustment within 24 hours. It elegantly shows the short-term regulation of energy balance. The strong point of the study is the careful design with a 3-day protocol, including a maintenance day in a metabolic suite followed by a manipulation day and an outcome day in a respiration chamber, for each treatment. Food intake was quantified over 24-hour intervals and could be compared with simultaneously-measured energy expenditure over the last 2 days, to assess energy balance accurately. The design of the study with respect to choice of subjects, choice for intake manipulation by intake reduction, and the choice for a fixed activity protocol, might have facilitated the excellent and quick intake compensation.

The subjects, though not explicitly mentioned, were probably unrestrained eaters. They were all males without a history of fluctuating body weight and with an actual body weight in the lower range for height and age. Unrestrained eaters have been shown to compensate for a reduction in energy intake with products with a lower energy density by eating a larger quantity of the food with the lower energy density, while dietary restraint prevented compensation in the same experiment (Westerterp-Plantenga *et al.* 1998).

As correctly stated in the paper of Goldberg *et al.* (1998), up-regulation of energy intake in response to deficits will have been subjected to stronger evolutionary selection than the down-regulation after excess intake. The increasing incidence of obesity is indeed likely to be a consequence of the evolutionary disadvantage to down-regulate intake in a situation with an ample food supply and a low energy requirement. The majority of studies on intake compensation focused on the effect of an increase in energy intake, often as a pre-load, on subsequent food intake. Part of the

energy compensation after intake reduction is a reduction in energy expenditure, i.e. a reduction in diet-induced energy expenditure and a reduction in basal metabolic rate. However, the increase in energy expenditure after an equivalent increase in energy intake is smaller, i.e. just an increase in diet-induced energy expenditure of the same magnitude. Therefore, the intended manipulation was not reduced by an 'unexpectedly' large amount, but by an expected reduction of basal metabolic rate next to a reduced diet-induced energy expenditure (Westerterp *et al.* 1995).

The choice for reduction of energy intake with a fixed activity protocol is one option to create a negative energy balance. A negative energy balance in real life often occurs on days with a high energy expenditure because of physical exercise. A short-term response to physical exercise is a negative energy balance on the exercise day, because of an unchanged energy intake. Compensation takes place on a subsequent quieter day. Military cadets showed a 'matching' increase in intake for the high expenditure during a drill competition about 2 days afterwards (Edholm *et al.* 1955). Endurance athletes have to learn how to maintain energy balance when exercise days are not alternated with quieter days by consuming food during exercise.

In conclusion, a mild negative energy balance under sedentary conditions offers optimal conditions for immediate compensation in lean unrestrained subjects.

Klaas R. Westerterp  
 Department of Human Biology  
 Maastricht University  
 6200 MD Maastricht  
 The Netherlands

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