Elaborating on the work of Kleitman and Doktorsky (1933), Van Dongen et al., 1996 examined the differences between the effects of lying down and of falling asleep on body temperature after going to bed at the habitual time. By subtracting constant routine temperature data from the measurements in the corresponding experimental conditions, the circadian modulation of body temperature was removed from the data. Figure 1 (taken from Van Dongen et al., 1996) shows the remaining temperature drop attributed to lying down while staying awake (solid curve, labeled PASSIVE). The figure also shows the temperature decrease attributed to the combination of lying down and falling asleep (dotted curve, labeled ASLEEP).

In the present study, we further examined the differential effect of lying down on body temperature. Five male students (18 to 19 years old, no extreme morning- or evening-types) maintained their regular lifestyles, but went to bed two hours before their habitual bed-time (which was assessed by means of a two-week sleep log). They were instructed to stay awake for four hours (the observation window), while monitored by their parents. The subjects' passive wakefulness was verified with a wrist activity monitor. Body temperature was measured by means of a calibrated rectal probe (Yellow Springs 401) and a portable, digital recorder (SmartReader 8-N). Average body temperature values of 2 min epochs were stored on a personal computer afterwards.

To determine the circadian component of body temperature regulation, the subjects came to the sleep laboratory of our department several days later. They participated in a constant routine study, during which body temperature was measured with the previously used equipment. Average body temperature values of
2 min epochs, in the interval corresponding to the observation window of the recording at home, were stored on a personal computer afterwards. The constant routine data were subtracted from the data of the recordings at home, for each subject individually, to remove the circadian component of body temperature.

We used the subjects' habitual bed-times as a common reference (time zero) for the resulting time-series. Figure 2 shows the average of these time-series, i.e. the average effect of lying down on body temperature. Notice the difference in scale compared with figure 1; the dashed box in figure 2 indicates the equivalent area of the other figure. In figure 1, the levels of both curves were adjusted to start at a temperature effect of 0°C. This adjustment has not been applied in figure 2.

![Temperature effect of lying down (°C)](image)

Figure 2: Time relative to habitual bed-time (min)

In a statistical analysis of the raw data per hour, we find a significant trend in the body temperature data only in the first hour after lying down (t-test after linear regression, \( P < 0.01 \)). The average differential temperature decrease in the first hour is \( 0.25°C \pm 0.09°C \). This is about twice as much as the differential effect of lying down in figure 1 (solid curve). No statistically significant effect on body temperature remained at habitual bed-time (time zero), nor at the average habitual time of sleep-onset (20 min \( \pm \) 14 min after bed-time, as assessed by means of the sleep logs).

The present results show that the temperature drop associated with lying down, compensated for the circadian modulation of body temperature, persists when subjects lie down two hours earlier than their habitual bed-time. Gillberg and Åkerstedt (1982) reported a circadian modulation of the combined effect of lying down and falling asleep on body temperature. The difference in amplitude of the temperature drop in figure 2 with respect to figure 1 (solid curve) may indicate that their findings should be attributed to a circadian modulation of the differential effect of lying down only.
REFERENCES