Elevated salivary cortisol levels as a result of sleep deprivation in a shift worker

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**Introduction**

Cortisol levels show a well-known circadian rhythm, with highest levels after waking and a fall over the day until going to bed. This is also found for permanent night workers [1]. The cortisol circadian rhythm is therefore linked to sleep rhythm and may be altered when sleep is disturbed, for example in shift-workers on rotating shift pattern. When there is a change from day to night work, the circadian rhythm of cortisol may take 5 days to adapt and the ability to do this may constitute a marker of an individual's adaptability to shift-work [1].

This study looked at a group of 63 petrol industry shift-workers (G. Lac and A. Chamoux, unpublished work), who worked a rapidly rotating three-shift schedule. For each subject, salivary cortisol levels were measured at intervals of 2 h during each period when the person was awake. Measurements were taken over the three shift patterns of mornings, evenings and nights.

**Methods**

All 63 subjects entering this study gave informed consent to be involved and ethical approval was obtained for this work before the study commenced. The volunteers were process supervisors in the petrol industry, whose job involves tasks requiring a high level of concentration throughout the shift. All were regular shift-workers for at least 1 year. The shift-work schedule was as follows: MMM/RR EEE/RR NNN/RR, with M = morning (4−12 a.m.), E = evening (12 a.m.–8 p.m.), N = night (8 p.m.–4 a.m.) and R = rest day. This corresponds to a total of nine working days and six rest days over a 15 day period. The bold type indicates the shifts when salivary cortisol sampling was undertaken. Each volunteer had a medical examination by the company occupational physician. The following measurements were recorded: continuous heart rate recording over a 24 h period including the shift period using a Polar Sport Tester 4000.
and salivary cortisol levels by non-invasive sampling at intervals of 2 h when the subject was awake. The subjects also completed a lifestyle questionnaire covering smoking, alcohol intake and leisure activity. Cortisol levels were measured using methods described previously [2].

Results

One subject among the 63 was found to have much higher levels of salivary cortisol from samples taken during morning shifts: a mean value of 48.4 nmol/l and peak value of 67.8 nmol/l, compared with group values of 8.9 and 11.0 nmol/l, respectively, over the same shift (Figure 1). These results were not artefactual, as all samples were assayed in the same batch and this was repeated using three series and compared with reference samples. The results for this individual taken between 3 a.m. and 11 a.m. (Figure 1) over the 8 h working session rose steadily. However, values for the night and evening periods (from days –6 and +28) for the same subject were similar to the mean values for the whole group [3].

For this individual, the average heart rate during the morning shift corresponding to findings of high levels of cortisol was the same as that recorded during another

sequence for the same subject (71 versus 71 b.p.m.). No particular factor emerged from the lifestyle questionnaires to account for the salivary cortisol findings; the volunteer was 38 years old, practised sport (4 h/week), had a good level of fitness (with a BMI of 19.4), was a smoker, but had no ongoing illness or current medical treatment.

The occupational physician was asked to examine this subject and compare the time spent at work as declared by the subject with the company’s work-time recording. The result showed that this employee had, over a 40 h period, worked the following sequence of hours: 8 p.m.–4 a.m./12 p.m.–8 p.m./4 a.m.–12 p.m. (Figure 1). In addition, taking into account travelling between home and work (30 min) and allowing for meals and other daily activities, it was estimated that he could not have slept >11 h out of the 40 h period. It should be noted that this particular sequence of shifts was carried out in exceptional circumstances following personal agreement between the employee and manager.

Discussion

Since the subject declared that he had not been subjected to any kind of stressor (somatic or psychological), this cortisol response is likely to have resulted from fatigue caused by the lack of sleep [4] and from the rapid

Figure 1. Salivary cortisol profile during three work-shift periods. The x-coordinates represent the 40 h worked by the individual, with associated salivary cortisol results (shaded bars). The mean group salivary cortisols are shown as light bars with standard error from 7 a.m. to 11 p.m.
work-shift rotation opposed to the natural biorhythm [5]. This break in homeostasis may have induced increased activity in the corticotrophic axis (alarm reaction), although corresponding changes in average or maximal heart rate were not recorded. The effects of elevated cortisol levels were not perceived by the individual and not apparent from responses to the questionnaire. The cortisol response to this stress was gradual and proportional to the intensity of the stressor, since cortisol rose with increasing sleep deprivation. In the case reported, this increase in cortisol occurred during professional activity and when carrying out tasks requiring vigilance, which could have implications for health and safety at work.

References


