Free-Running Human Circadian Rhythms in Svalbard

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The body temperature, activity-rest time, electrolytes of urine samples and mood was measured in two persons during a 19 day period under continuous light conditions in the arctic (vicinity of Ny Ålesund, Svalbard-Spitsbergen). For temperature recording a new thermoprobe and a portable printer was used. Possible week Zeitgeber of the 24 hour day did not synchronize the circadian system, since circadian rhythms of about 26 hours were found. These results open up the possibility to study effects of drugs on the circadian system of humans under Svalbard conditions.

Introduction

Absence of time cues in the arctic regions during the summer provides an interesting possibility to study human circadian rhythms under free-running conditions. People working in Svalbard have reported that they easily change working habits or even free run during the summer months. We were interested in finding out whether Svalbard-Spitzbergen-conditions could provide an alternative to bunker and cave experiments by allowing more natural life conditions (hiking, natural light conditions, etc.). If successful, such an experiment could offer important opportunities for later tests of the influence of drugs (*e. g.* lithium) on free running human circadian rhythms. Finally, we were also interested in testing a field equipment for continuous body temperature recording.

We report here briefly results of such an experiment in Svalbard during the summer of 1978. A more detailed report will follow elsewhere.

Methods

Two graduate students, H. E and F. M., volunteered to participate in this experiment. Both were healthy males and 30 years of age. They were transported to the "London hut" about 5 km north of Ny Ålesund. They stayed here from the 9th of July to the 27th of July and recorded automatically the rectal body temperature with a portable unit developed by one of us (W. K.). It uses a special temperature sensor of high accuracy and a thermoprinter (a description will be given elsewhere). The temperature sampling interval was 512 sec. A numerator was used as a coded time reference for numbering daily events in the diary (rising and fall asleep, meals, subjective mood, etc.) and for urine samples (the volume and pH of which were determined on the spot, using a pH-glass electrode and a light weight digital pH-meter developed by one of us (W. K.)). Urine samples were collected in small polyethylene vials, labelled with the numerator and used later for electroyte analyses (flame spectrophotometry). No alcoholic beverages except beer were available to the subjects. Both were smokers (about 20 cigarettes per day).

Data were analysed according to procedures described by Pflug, Eriksson and Johnsson [1].

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Results

Temperature recordings

The temperature curve of the two subjects are shown in Fig. 1. Sleep periods are indicated by black bars beneath each curve. Subject F. M. had two periods with printout failures (paper feed problems) as indicated. The time span analysed is indicated above the figure.

The analyses of the temperature data were simple in the case of H. E.: frequency analyses and autocorrelation function (acf) analyses yielded periods of 25.7 and 26.3 hours for the rhythm, respectively. The acf of the signal is shown in Fig. 2 A.

F. M. made two longer hiking tours, dotted lines in Fig. 1, and this might have influenced the temperature pattern. His data were therefore analyzed over the whole period as well as over three intervals I, II, and III as indicated in the figure.

Frequency analyses and acf analyses yield an overall period of the rhythm of about 30.2 and 29.3 hours respectively. The periods were 24.8 (26.8), 29.2 (27.7), and 24.8 (25.2) hours respectively in the three intervals I, II, and III (frequency analyses data in parentheses).

Fig. 2 B – 2 E show the overall acf of the F. M. data as well as the acf for the three intervals separately. There is a clear difference in the position of the maxima, indicating different period lengths during the intervals, although the peaks in the acf's are fairly broad. (An analysis of data for H. E. in intervals I, II, and III does not reveal a difference of the period lengths and therefore only curve 2 A, valid for the whole period is presented.)

Whether F. M.'s temperature rhythm did indeed show two or more frequency components or whether this rhythm is distinctly shifted and different in the three intervals has to be clarified. However, it is safe to conclude that both subjects had a free running temperature rhythm with $\tau > 24$ hours.

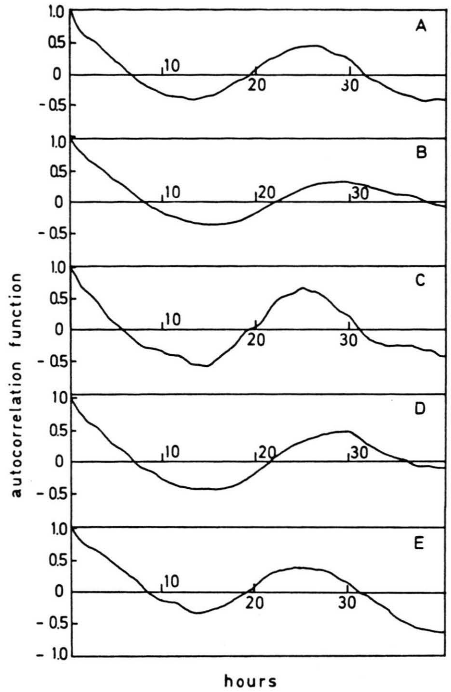

Fig. 2. Autocorrelation functions calculated from temperature recordings in Fig. 1. A. Subject H. E.; analysis of recordings from the whole time interval 12. 7. 78 – 26. 7. 78. B. Subject F. M.; analysis of recordings from the whole time interval 12. 7. 78 – 26. 7. 78. C. Subject F. M.; analysis of recordings in interval I (*cf.* Fig. 1). D. Subject F. M.; interval II. E. Subject F. M.; interval III.

Activity recordings

The sleep intervals coincided by and large with the low temperature intervals. Sleep intervals as determined from the numerator values in the diaries

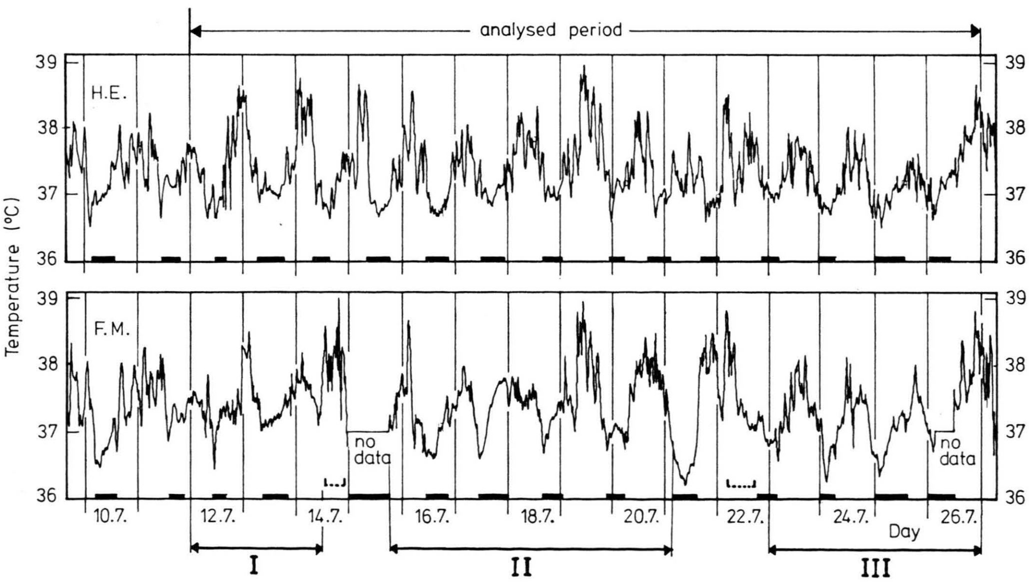

Fig. 1. Temperature recordings from the two subjects H. E. and F. M. Rectal temperature is given as a function of time, date is indicated at bottom. Black bars below the curves indicate sleeping periods of subjects. Time interval which was analysed for period content is indicated at top of figure. For subject F. M. shorter with respect to period content. Dotted lines in the F. M. figure denote times for extended hiking tours.

are indicated by the bars below the temperature recordings in Fig. 1. They are replotted in a conventional manner in Fig. 3 to emphasize that the free running activity period is, again, well above 24 hours.

It can be observed that the two subjects seem to entrain mutually in respect to the sleep periods: sleep intervals coincide more or less throughout the analysed period. Two exceptions are found around the 14th to 15th of July and 20th to 22th of July, *i. e.*, when F. M. made his two hiking tours. Then the sleep periods are out of phase (which seems to be partly true also for the temperature curves).

Urine data

Urination times were determined by the two subjects themselves. Urine data were sparse and scattered and did not allow precise determinations of the free running periods. This was especially true for the urine volume and the electrolyte determinations. The pH-variations seemed to be more regular. Some τ-values of the urine rhythms are given below, as determined from the acf or the frequency analyses. The values are fairly uncertain (maxima in the acf are very broad), but taken together they clearly indicate the presence of rhythms with periods >24 hours.

H. E.: urine pH 25 h (frequency analyses), 25 h (acf, very uncertain); urine volume 24, 30, 33 h (acf); K^+ 29 h (acf); Ca^{2+} 29 h (acf); Cl^- 27 h (acf); Na^+ 27 h (acf).

F. M. (analyses of data for the whole period 12th to 26th of July): urine pH 25 h (frequency analyses); urine volume 26 h (acf), 25 h (frequency analyses); Ca^{2+} 27 h (acf); Cl^- 27 h (acf); Na^+ 26 h (acf); K^+ no clear maximum.

Determinations of mood etc. were very irregular and did not allow period determinations.

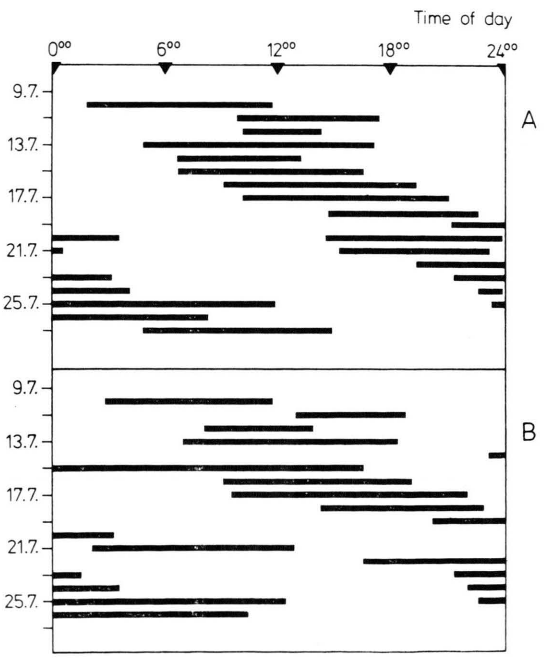

Fig. 3. Sleeping pattern of the two subjects. Sleeping periods for succesive days are denoted by the black bars. Date is shown to the left, time of day at the top of the figure. A. Subject H. E.; B. Subject F. M.

Conclusions

The results of the experiment is interesting from several points of view. It was shown that under Svalbard conditions human beings do indeed show free running rhythms. The period of the temperature rhythms was clearly longer than 24 hours: subject H. E. as well as subject F. M. – under intervals I and III – showed a period close to the 25.0 ± 0.5 hour periods recorded in bunker experiments [2]. The agreement on this point between the Svalbard results and the bunker recordings is satisfactory and indicated that, *e. g.*, physical exercise in itself does not influence the period substantially (as already found by Wever [3] in bunker experiments).

One should keep in mind that weather conditions might have influenced the results. The cloudy weather during most of the time of the experiment favoured of course conditions for free running. Clear weather could provide time cues (and subjects should, therefore, be told to disregard such cues).

Lobban [4] reports on experiments, in which 21-, 22- and 27-hour "days" were inforced by special watches on experimental subjects living as an isolated community in Spitsbergen during the summer. Under these conditions a 24 h rhythm component was observed in addition to the enforced rhythm. However, in later studies carried out 1960 in Spitsbergen and 1969 in Devon Island using 21 hour time schedules a rhythm slightly but significantly longer than 24 hours (24.4 and 24.6 hours) was analysed in addition to a 21 hour rhythm [5]. Daan (cited ref. [6]) recorded the daily routines of a couple during a 4 month stay in Svalbard and found a free run period of 25.6 hours inspite of their knowledge of real time.

The results of the present experiment show that it is possible to measure continously circadian rhythms of humans under Svalbard conditions and check for drug induced period-changes. Such an experiment on the action of lithium is planned for the summer of 1979.

First of all we would like to thank H. E. and F. M. for their interest and the essential part they played in this experiment.

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