## Restricted Sleep Regime: Effects on the Occurrence of Different Sleep Phases and Spiking Activity in the Lateral Geniculate Nucleus

In the cat, marked spiking activity (ponto-geniculate-occipital-PGO spikes) is found in the electroencephalogram (EEG) obtained from the pons, lateral geniculate nucleus (LGN) and occipital cortex during and shortly preceeding rapid eye movement (REM) sleep[1]. The nature of the regulatory mechanism which consistently limits PGO spikes to periods of REM sleep is uncertain. However, it has been shown in several studies that the administration of serotonin antagonists such as *p*-chloro-phenylalanine (PCPA), *p*-chloromethamphetamine, reserpine and lysergic acid diethylamide (LSD) to cats produces a marked increase in spike activity during waking and slow-wave sleep[2-5].

These are the only drugs known to elevate the amount of spiking outside of the REM sleep period. These results are taken as highly suggestive that monoaminergic neurons (serotonin) exert a tonic inhibitory influence at the brain-stem level which serves to confine PGO waves to REM sleep. Recently, KARADŽIĆ[6] reported that, in the cat, reduced total sleep time affects the distribution of PGO spikes increasing the percentage of slow-wave sleep (SWS) occupied by spikes.

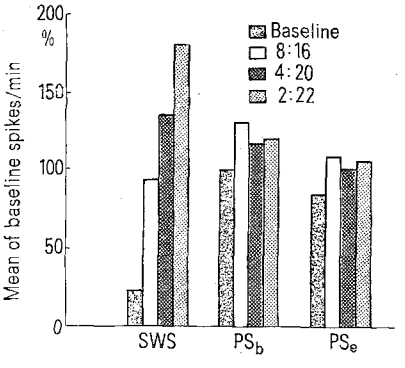
The present study was undertaken to examine the effects of reduced total sleep time upon the occurrence of PGO spikes during and shortly preceding REM sleep.

*Materials and methods.* Four adult cats were prepared for chronic recording of sleep using the technique described elsewhere[6]. After recovery from surgery, the animals were allowed to adapt to the experimental conditions in the course of several days during which no recordings were taken. The cats were studied under 'a human sleep-wakefulness schedule' by being placed on a treadmill (1 m/min) for 16, 20 and 22 h with the balance of any 24 h period spent in recording chamber and EEG, electro-oculogram (EOG) and electromyogram (EMG) recordings were taken. Tracings obtained from continuous recordings during 8, 4 and 2 h period have been analyzed and three categories of behaviour were quantitatively evaluated using the already available criteria[7,8].

A minimum of 5 consecutive recordings were conducted in each cat, and recordings always begin at 08.00 h. A polygraph recorded the data continuously throughout each session at a paper speed of 15 mm/sec. In addition to calculated percentages of each state in every sleep-waking schedule, the number of LGN spikes per minute of slow-wave sleep and REM sleep were determined. LGN spikes were visually identified by their characteristic waveform and high amplitude (only those spikes exceeding 50 μv were counted). The spike rates were counted in the following minutes: 1. In the 2 min of slow-wave sleep just preceeding the onset of REM sleep. 2. In the 2nd min of a clearly developed REM sleep period. 3. In the last but 1 min of REM sleep period.

*Results.* It is obvious that partial sleep deprivation caused the reorganization of sleep states, leading to much less decrease of REM sleep than of other behavioral states. The proportional increase of REM sleep is higher when the sleep deprivation is longer, which is specially evident when sleep was restricted to only 2 h out of 24 h (Table). The LGN spike densities, i.e., the number of spikes per min in slow-wave sleep and REM sleep is shown in the Figure. It is obvious that, in the cat, LGN spikes herald the REM period, build to an early crescendo and diminish in frequency before the end of the REM period.

Restricted sleep regime increased the spike density in slow-wave sleep and REM sleep. However, REM spike density showed little increase, even though total REM time was reduced. On the other hand, spike density was markedly increased in SWS overshooting the rate occurring in the REM sleep beginning. The change in spike rate of SWS during the reduced total sleep time is not




Mean LGN spike rates during 24, 8, 4 and 2 h of sleep recordings. The mean of LGN spike rates at the beginning of paradoxical sleep ($PS^b$) was taken as 100%, while LGN spike rates for SWS and paradoxical sleep end ($PS^e$) are expressed as mean percent of $PS^b$ spikes per min (baselines). The mean LGN spike rates during 8, 4 and 2 h recordings are expressed as percent of baseline spikes per min.

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The sleep-waking pattern of the laboratory cat during different schedules of sleep and wakefulness (Means ± S.D.)

| | 24 h | 8:16 | 4:20 | 2:22 |
|---|---|---|---|---|
| Waking | 35.19 ± 2.03 | 14.88 ± 7.35 | 11.31 ± 4.67 | 11.30 ± 3.62 |
| SWS | 78.57 ± 0.65 | 71.46 ± 1.79 | 66.96 ± 0.56 | 59.96 ± 1.84 |
| REM sleep | 21.61 ± 1.18 | 28.53 ± 4.48 | 33.01 ± 1.00 | 40.15 ± 3.96 |

Waking is expressed as percent from recording time. Slow-wave and REM sleep are expressed as percents from total sleep time.

simply due to a general increase of spike densities across the sleep states, since REM spike rate did not change significantly.

*Discussion.* The reorganization of sleep-waking profile with reduced total sleep time was in favor of REM sleep, thus confirming the data reported by KARADŽIĆ[6] and by FERGUSON[9]. The effects of reduced sleep time on the occurrence of LGN spiking appear to be similar to the effects of PCPA, reserpine and LSD. In cat, those drugs increase the number of LGN spikes which occur outside of REM sleep as well as reduce the time spent in SWS and REM sleep.

The build-up of the endogenous electrical activity of LGN brought about by partial sleep deprivation, was also shown as a consequence of selective REM sleep deprivation[10]. It was shown by quantitative analysis of LGN spikes that REM deprivation leads to higher density of LGN spikes during REM sleep and also during SWS which preceded it.

The increase in LGN spike rate in SWS and the reduction in the total amount of REM sleep time supports the view of DEMENT et al.[11] that the number of spikes to be discharged importantly determines the amount of REM sleep that occurs. The results of their 'spike deprivation' experiment suggest that the postdeprivation increase in REM time might be regarded as a response to the loss of spiking activity along the visual system rather than to the loss of REM time per se. Conversely, the occurrence of spikes outside of REM sleep periods could reduce the time spent in REM sleep and reduce or eliminate a REM sleep rebound. Moreover, in the instances of reduced opportunity to sleep, the loss of REM sleep is compensated for not only by maintaining the higher proportion of REM sleep state, but also by increasing the discharge of spiking activity in other sleep state, thus subserving the homeostatic regulatory function, the role of which is still unknown.

*Résumé.* Chez le rat adulte on a étudié l'effet de la réduction de la durée du sommeil sur la succession de ses différents stades. On a trouvé que la réduction de la durée totale du sommeil avait provoqué la réorganisation du profil veille-sommeil et de même l'augmentation des pointes au niveau des noyaux géniculés latéraux au cours du sommeil paradoxal aussi bien qu'en dehors de ce stade.

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## Interpretation Problems of Intestinal Iron Absorption from Isotopically Labelled Meat*

Retention measurements of $^{59}$Fe or $^{55}$Fe labelled meat can be performed routinely by whole body or blood counting techniques[1,2]. However, it is less certain whether these data will reflect true iron uptake, since knowledge on intestinal absorption and specific radioactivity ($^{59}$Fe or $^{55}$Fe/Fe) of the single iron-containing meat compounds is still insufficient.

Neglecting potential, as yet unknown, interfering factors, the total radioiron retention R and the total food iron retention F of a meat sample can be described by the equations

$$\sum a_i r_i/\mathrm{A} = \mathrm{R} \qquad \text{and} \qquad \sum m_i r_i/\mathrm{M} = \mathrm{F},$$

where $a_i$ stands for the partial and A for the total radioiron activity, $m_i$ for the partial and M for the total iron mass, and $r_i$ for the partial retention coefficient of a single iron-containing compound $i = 1, 2, \ldots . n$. It can be shown that the total iron retention coefficients R and F get equalized (R = F) if all the partial retention coefficients become identical: $r_1 = r_2 = \ldots . = r_n$, or if all the iron-containing compounds indicate the same specific radioactivity: $a_1/m_1 = a_2/m_2 = \ldots . = a_n/m_n$, which also means: $a_1/\mathrm{A} = m_1/M$; $a_2/A = m_2/\mathrm{M}$; $\ldots . a_n/\mathrm{A} = m/_n\mathrm{M}$, i.e. that the relative distributions of active and inactive iron within the meat are the same.

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Iron and radioiron in various fractions of fillet from a 85 kg pig injected i.v. 5 mCi $^{59}$Fe 4 weeks prior to slaughter

| | Total | Insoluble | Column chromatography | | | | Total groups |
|---|---|---|---|---|---|---|---|
| | | | I | II | III | IV | |
| Fe (μg/g) | 13.7 | 2.8 | 1.5 | 0.9 | 2.7 | 5.6 | 13.5 |
| $^{59}$Fe (nCi/g) | 20.7 | 2.7 | 2.7 | 0.9 | 2.7 | 9.4 | 18.4 |
| $^{59}$Fe/Fe (nCi/μg) | 1.5 | 1.0 | 1.8 | 1.0 | 1.0 | 1.7 | 1.4 |
| Fe (%) | 100 | 20.2 | 11.2 | 6.7 | 19.3 | 40.5 | 97.9 |
| $^{59}$Fe (%) | 100 | 12.9 | 13.1 | 4.5 | 13.3 | 45.2 | 89.0 |

Pork radioactivity refers to time of dosing.