

All-night EEG sleep measurements in young adults¹

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The EEG sleep characteristics of normal, young adults were measured for three consecutive nights. The mean percentage of Stages 1-REM, 3 and 4 showed an increase with each consecutive night. Within a night's sleep, Stages 3 and 4 decreased markedly and Stage 1-REM increased considerably from the first to the second half of the night. The mean duration of REMPs increased from the first to third REMP and then leveled off. The mean interval between REMPs range from 90 to 110 min. with some indication that the cycle shortens late in the morning.

Since the discovery that rapid eye movement periods (REMPs)² occur cyclically throughout the night, (Aserinsky & Kleitman, 1955; Dement & Kleitman, 1957), other studies have provided an overall picture of the sleep of normal young adults and have shown that the Ss spend a characteristic percentage of time in each sleep stage (Agnew, Webb, & Williams, 1966; Dement & Kleitman, 1957; Rechtschaffen & Verdone, 1964; Williams, Agnew, & Webb, 1964, 1966). In the present experiment, we proposed to determine if the sleep stage measurements were consistent in another group of Ss as well as to study other sleep parameters.

Method

Ten Ss, five male and five female, ages 20-29 (mean 24.7) years were studied. The Ss were screened to eliminate those with any medical or psychiatric disorders as well as those taking medications or drugs. They were instructed to abstain from any caffeine or alcohol and to maintain their usual day time habits.

Two Ss were studied each night, sleeping in separate air conditioned, sound attenuated rooms. The Ss were continuously monitored throughout the night with electroencephalogram (EEG), electromyogram (EMG), and electrooculogram (EOG) on sixteen channel Grass model IV-C electroencephalographs (Jacobson, Kales, Zweizig, & Kales, 1965).

The records were scored according to a modified version of the criteria of Dement & Kleitman (1957). Stage 1 consists of low voltage fast EEG activity without spindles, and Stage 2, low voltage fast activity with spindles of 14 to 16 cps. In Stage 3, high voltage, slow waves (50 microvolts or greater and 1-3 cps) are present with some spindling superimposed whereas in Stage 4 at least half of the record is dominated by these high voltage slow waves. REMPs are characterized by a Stage 1 EEG and rapid eye movements. The onset is determined by the presence of eye movements and a decrease in the muscle tonus in the submental area (Berger, 1961; Jacobson, Kales, Lehmann, & Hoedemaker, 1964). The REMP is terminated

Table 1. General Mean Sleep Measurements¹

	Sleep Latency ²	No. of Wakes ³	Ave. Length of Wakes ³	Sleep Onset to First REMP	Interval Between REMPs ⁴	No. of REMPs
Night 1	22.3	7.1	6.4	134.8	108.0	3.3
Night 2	20.8	6.0	5.0	102.7	100.2	4.0
Night 3	25.7	4.0	2.5	85.3	93.3	4.4

1. All figures except number of wakes and REMP's are expressed in minutes.

2. Time from lights out until sleep onset.

3. Number and average length of wakes do not include final awakening of the night.

4. Time from the beginning of a REMP to the onset of the next REMP. (does not include time from sleep onset to first REMP).

following the cessation of REMs when the EEG indicates either a waking state or Stage 2 sleep.

Results

The sleep time ranged from 313 to 500 min. with an average of 441 min. In Table 1, various sleep parameters are compared for the three nights of study. The total number and average length of awakenings following sleep onset decreased with each consecutive night. In addition, the time from sleep onset to the first REMP, as well as the interval between consecutive REMPs decreased from the first to the third nights. With each night of the study, the total number of REMPs for the night increased.

Table 2 lists the changes in the mean sleep stage times for the three nights. The percentage of Stages 1-REM, 3 and 4 increased while Stages 1 and 2 decreased with each consecutive night.

In order to compare the sleep of different portions of the night, the time from sleep onset to the final awakening was divided into halves and each part analyzed. The results are listed in Table 3. The most marked changes are in REM and Stage 4 sleep and to a lesser extent Stage 3. Whereas Stage 4 sleep comprises approximately 20 percent of the total time of the first half of the night, it is practically non-existent in the last half. At the same time, Stage 3 sleep decreases by about 50 percent in the last half

Table 2. Sleep Stage Percentages: Means and Standard Deviations

	1-REM	1	2	3	4
Night 1	\bar{x} 19.4	7.1	57.5	7.8	8.2
	σ 4.8	3.9	6.7	3.2	4.4
Night 2	\bar{x} 21.9	4.0	52.9	10.0	11.2
	σ 3.6	2.4	5.9	3.9	5.8
Night 3	\bar{x} 24.0	4.9	49.6	10.3	11.2
	σ 3.4	3.2	4.1	3.0	3.4

Table 3. Sleep Stage and Awake Time by Halves of Night

Sleep Stage	First Half		Second Half	
	Absolute	%	Absolute	%
1-REM	29.8 mins.	13.0	78.2 mins.	34.1
1	10.3	4.5	11.9	5.2
2	105.0	45.8	117.0	51.0
3	30.6	13.8	15.1	6.6
4	50.4	21.9	0.7	0.3
Awake	3.4	1.0	6.6	2.8

of the night so that there is a marked reduction of high voltage, slow wave sleep (Stages 3 and 4) in the latter half of the night. REM sleep on the other hand, shows a marked increase in the latter half of the night, almost three fold. It can also be seen that the total time spent awake in either half of the night is quite low.

As mentioned previously, the number of REMPs for each night increased, while the time interval between consecutive REMPs of a night decreased, with each successive night in the lab. On night three, all of the Ss had at least three REMPs and six had as many as five. The mean intervals between the first five REMPs of night three were 99.2, 95.6, 104.1, and 64.1 min., respectively.

The mean durations of the first three REMPs for all three nights showed a steady increase (11.3, 22.5, and 31.5 min.). The results were more variable for the fourth and fifth REMPs of the night (25.4, 32.6 min.).

These data are in general agreement with previous studies of adaptation (Agnew, Webb, & Williams, 1966) and baseline sleep measurements in normal young adults (Dement & Kleitman, 1957; Rechtschaffen & Verdone, 1964; Williams, Agnew, & Webb, 1964, 1966). The findings of a marked decrease in Stages 3 and 4 and increase in Stage 1-REM from the first to the

second half of the night, parallel the results reported by Williams et al (1964) by thirds of the night. Whereas Agnew (1966) reported approximately similar figures for the mean REMP interval for each night, our data show a decrease in this parameter for each successive night. Our results also suggest that there is a leveling off of REMP durations and a decrease in REMP intervals late in the sleep period. The former finding has also been noted by Feinberg (1966).

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Notes

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2. REMPs and Stage 1-REM are used interchangeably throughout the paper.