SESSION III

Chairman: DR J. J. MISIEWICZ

Duration of EEG sleep stages in different types of disturbed night sleep

VLASTA BŘEZINOVÁ
M.D., Ph.D.

Sleep Laboratory, Department of Psychiatry, University of Edinburgh

Summary

The duration of each episode of any one electro-physiological sleep stage or any episode of intervening wakefulness was determined in three kinds of disturbed sleep, namely, in naturally impaired sleep of late middle-aged, normal people, in sleep after caffeine administration, and in sleep after hypnotic drug withdrawal.

When compared with the sleep of young people, the sleep of late middle-aged subjects was characterized by an increase in longer episodes of intervening wakefulness plus drowsiness, and by a decrease in longer episodes of sleep stages 3 + 4 and REM. The sleep after caffeine, compared with the baseline sleep, contained an increased proportion of longer episodes of intervening wakefulness plus drowsiness but no significant change in the episode duration of any of the sleep stages. In the case of the drug withdrawal sleep, compared with the sleep on hypnotic drug, there was no change in the episode duration of intervening wakefulness plus drowsiness but there was a significant shortening of episode duration for sleep stages 2 and 3 + 4, with a similar trend for REM sleep episodes.

Thus a sleep disturbance might be characterized by increased stability of wakefulness, by decreased stability of sleep or both. Different types of sleep disturbance might require different types of treatment.

Introduction

In sleep there is a continuously unfolding sequence of EEG patterns known as sleep stages. Single episodes of any particular sleep stage and of intervening wakefulness vary widely in their duration, short ones being most frequent (Williams, Agnew and Webb, 1964; Agnew, Webb and Williams, 1967). The present study examines the length of the period

for which any one EEG pattern is continuously maintained. It is a variable that might demonstrate the stability of sleep and wakefulness in a more fundamental way than the commonly used whole night measures.

Three types of impaired sleep were studied, namely, the naturally impaired sleep of late middle-aged, normal people (Březinová, 1975), the sleep disturbed by caffeine and the sleep disturbed by withdrawal from a hypnotic (Březinová, Oswald and Loudon, 1975).

Method

Ten young, normal volunteers aged 20–30 years (mean 22 years), six males and four females, were compared with fourteen older normal subjects aged 42–66 years (mean 55 years), five men and nine women. In each subject four normal nights were used for analysis.

In six normal subjects aged 50–63 years (mean 56 years), two males and four females, baseline sleep was compared with sleep after caffeine 300 mg taken in decaffeinated coffee 15 min before lights out. Four nights on each condition were recorded in a balanced order.

Six hospital in-patients with neurotic disorders, aged 44–68 (mean 58 years), one male and five females, were accustomed to sleeping pills. Their sleep while taking their usual hypnotic was recorded on two nights and was compared with sleep on the first and fourth nights of withdrawal from the drug. The hypnotics concerned were nitrazepam 10 mg (three patients), quinalbarbitone 100 mg + amylobarbitone 100 mg, quinalbarbitone 100 mg, or glutethimide 250 mg. In all subjects two or three adaptation nights preceded the recording.

Recording and scoring

On each night silver electrodes placed above and below each outer canthus provided two channels of bipolar eye movement recording, a pair of centroparietal electrodes (C_Z-P_Z) provided one channel of EEG, and a pair of submental electrodes monitored muscle tone. The paper speed was 15 mm/sec, lights out was at 11.00 p.m., recording until 7.30 a.m.

The records were scored according to international criteria (Rechtschaffen and Kales, 1968) in epochs of 20 sec. The following stages were scored: wakefulness (stage 0), drowsiness (stage 1), non-rapid eye movement (NREM) sleep stage 2, slow wave NREM sleep (stage 3+4), and rapid eye movement sleep (stage REM).

The duration of every episode of each sleep stage was calculated and categorized in the range between 1 and 45 min in steps of 1 min. For each night and each stage the numbers of episodes lasting up to 3 min, those lasting between 4 and 9 min, and those over 9 min, were computed and expressed as percentages of the total number of episodes of the given stage on each night. Individual means of those percentages on the four or two nights, and under each condition, were then calculated, correcting for unequal total numbers of episodes on different nights (Guilford, 1956). Individual mean percentages for episodes lasting up to 3 min were then contrasted with mean percentages for all episodes over 3 min. Further, individual mean percentages for all episodes up to 9 min were contrasted with those for episodes which exceeded 9 min.

In addition, the usual whole night characteristics of sleep were computed for each night in each subject.

Non-parametric tests were used for statistical evaluation, namely, Wilcoxon's composite rank method for comparison of the young and older group, Friedman's two-way analysis of variance for comparison of the undisturbed and disturbed sleep in the caffeine and hypnotic withdrawal groups (Siegel, 1956).

Results

Whole night characteristics

In all three comparisons the sleep with the disturbing factor was significantly shorter than the sleep without the disturbing factor. The total sleep time of the older people averaged 455 min and that of the young subjects 484 min. The mean total sleep time after caffeine was 350 min, 2 hr less than on baseline condition, 475 min. Sleep on withdrawal averaged 289 min, 89 min shorter than it was on hypnotic, 378 min. The impaired sleep of all three kinds also contained significantly more minutes of intervening wakefulness and drowsiness and significantly increased number of awakenings.

The duration of the episodes of each stage

The main results are shown in Table 1.

Ageing

When a comparison was made of the proportions of episodes lasting up to 3 min and those of over 3 min, significantly higher proportions of the longer episodes of stage 0+1 were found with the older people. When the proportions of episodes lasting up to 9 min and over 9 min also were compared, significantly higher proportions of the longer episodes of stage 0+1 were found again in the older group. In addition, the older subjects showed significantly lower proportions of the longer episodes of stage 3+4 and stage REM. A tendency to higher proportions of longer episodes of stage 2 in the older subjects did not reach significance.

Caffeine

When a comparison was made of the proportions of episodes lasting up to 3 min and those of over 3 min, all six subjects had higher proportions of the longer episodes of stage 0+1 on caffeine. No significant differences were found for stage 2, 3+4, combined stages 2+3+4, or stage REM. A similar result was obtained when the proportions of episodes lasting up to 9 min and over 9 min were

TABLE 1. Episodes in excess of 9 min duration

Condition	Stage of sleep				
	0+1	2	3+4	2+3+4	REM
Young	1 ± 1*	12 ± 5	22 ± 4	16 ± 4	33 ± 14
Older	3 ± 2	17 ± 8	15 ± 9	16 ± 7	20 ± 9
diff.	<i>P</i> < 0.01	n.s.	<i>P</i> < 0.02	n.s.	<i>P</i> < 0.02
Baseline	2 ± 1	17 ± 7	9 ± 4	14 ± 5	22 ± 11
Caffeine	7 ± 3	16 ± 10	8 ± 6	14 ± 9	22 ± 11
diff.	<i>P</i> < 0.02	n.s.	n.s.	n.s.	n.s.
Hypnotic	5 ± 3	29 ± 13	22 ± 17	29 ± 12	23 ± 13
Withdrawal	6 ± 4	14 ± 11	5 ± 6	13 ± 10	13 ± 11
diff.	n.s.	<i>P</i> < 0.02	few data	<i>P</i> < 0.02	n.s.

*Mean percentage of the total number of episodes of the stage ± s.d.

compared. All six subjects had higher proportions of longer episodes of stage 0+1 on caffeine but no significant changes in the proportions for NREM stages or REM stage.

Hypnotic withdrawal

When the proportions of episodes lasting up to 3 min and those over 3 min were compared, there was no significant difference in the proportion of longer episodes of state 0+1 during withdrawal sleep compared with the drug sleep condition. All six subjects, however, showed decreased proportions of longer episodes of stage 3+4 and of combined stages 2+3+4 after withdrawal. When proportions of episodes lasting up to 9 min and over 9 min were also compared, there was no significant change in the duration of episodes of stage 0+1. In all subjects there were, however, decreased proportions of longer episodes of stage 2 and of combined stages 2+3+4 in withdrawal sleep. Five of six subjects also showed smaller proportions of longer episodes of stage REM on withdrawal. The comparison for stage 3+4 alone was uncertain because some subjects had no longer episodes.

Discussion

All three kinds of disturbed sleep were similar in their whole night characteristics, showing a decreased total sleep time, an increased amount of intervening wakefulness and drowsiness and an increased number of awakening. Nevertheless there were differences in the duration of episodes. In the case of caffeine, the impairment took the form especially of longer episodes of intervening wakefulness, while the duration of the sleep stage episodes was not changed. By contrast, in the withdrawal 'insomnia' the duration of episodes of intervening wakefulness was not changed, while the duration of the sleep stage episodes was decreased, especially in the case of the NREM stages. In the impaired sleep of older people both types of change were present. If the duration of the episodes tells us something about the stability of sleep and wakefulness, then the caffeine sleep dis-

turbance seems to be characterized by increased stability of wakefulness, the withdrawal sleep disturbance by decreased stability of sleep, the age related sleep disturbance by both increased stability of wakefulness and decreased stability of sleep.

The three groups of subjects in this study differed from each other in the amount of sleep accumulated when without the disturbing factor, and also in the amount of sleep decrement induced by the disturbing factor. Nevertheless the differences in the durations of episodes probably do not reflect different degrees of a sleep disturbance: a shortening of episodes of sleep stages was found not only in the most curtailed sleep on withdrawal but also in the much less affected sleep of older people.

It might not seem surprising that disturbed sleep should contain fewer lengthy episodes of sleep stages, yet the fact that the disturbance of sleep induced by caffeine was without any such significant change suggests that episode duration change is not just a secondary corollary of sleep disturbance. It might be of both theoretical and practical interest to consider this in the investigation of spontaneous insomnias: different types of sleep impairment might require different types of treatment.

References

- AGNEW, H.W., WEBB, W.B. & WILLIAMS, R.L. (1967) Sleep patterns in late middle age males; an EEG study. *Electroencephalography and Clinical Neurophysiology*, **23**, 168.
- BŘEZINOVÁ, V. (1975) The number and duration of the episodes of the various EEG stages or sleep in young and older people. *Electroencephalography and Clinical Neurophysiology*, **39**, 273.
- BŘEZINOVÁ, V., OSWALD, I. & LOUDON, J. (1975) Two types of insomnia: too much waking or not enough sleep. *British Journal of Psychiatry*, **126**, 439.
- GUILFORD, J.P. (1956) *Fundamental Statistics in Psychology and Education*, p. 565. McGraw-Hill, New York.
- RECHTSCHAFFEN, A. & KALES, A. (1968) *A Manual of Standardized Terminology, Techniques and Scoring System for Sleep Stages of Human Subjects*, p. 13. N.I.H. Publication No. 204, U.S. Govt Printing Office, Washington, D.C.
- SIEGEL, S. (1956) *Nonparametric Statistics for the Behavioral Sciences*, p. 312. McGraw-Hill, New York.
- WILLIAMS, R.L., AGNEW, H.W. & WEBB, W.B. (1964) Sleep patterns in young adults: an EEG study. *Electroencephalography and Clinical Neurophysiology*, **17**, 376.