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The Effects of Presleep Activity on All-Night Sleep

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ABSTRACT

The effects of different presleep activities on all-night sleep were assessed. Nine young adult males engaged in brief periods of progressive relaxation (Relaxation), light dynamic exercise (Exercise), or a boring monotonous vigilance task (Vigilance) immediately before bed on consecutive nights. Standard electrophysiological data were recorded during the 7.5 hrs of sleep. The latency of sleep onset was shortest after Relaxation and longest after Exercise. Presleep heart rate and electromyograph levels were not related to sleep onset. Sleep stages were not differentiated by condition and no sleep parameter differed from normative data. The results suggest that it is possible to alter sleep latency by manipulating presleep behavior without disrupting the normal sleep pattern.

DESCRIPTORS: Sleep, EEG, Presleep activity, Progressive relaxation, Vigilance, Exercise.

A number of investigations have examined the effects of different waking activities on sleep. Typically these studies have focused on daytime or early-evening behavior (e.g., Baekeland & Lasky, 1966; Desjardins, Healey, & Broughton, 1974). There has been only limited research on the effects of distinct activities *immediately* before bed on all-night sleep. Specifically, there is little research addressed to the problem of what a person could do in the late evening to facilitate the onset of sleep. While some behaviors before bed may not alter sleep latency (Baekeland, Koulack, & Lasky, 1968; Castaldo, Krynicki, & Goldstein, 1974), such an effect has been reported. Hauri (1969) obtained shorter sleep onset times for both presleep exercising and relaxing when compared with studying. Freedman and Papsdorf (1976) found that progressive relaxation or biofeedback before bed reduced the time to sleep onset for insomniacs. Goodenough, Witkin, Koulack, and Cohen (1975) reported that sleep latency was longer after viewing a "stressful" film just before bed than following a boring film.

The results of this research suggest that presleep exercise, relaxation, or boring activity may facilitate sleep onset. The inferences that could be drawn about the effects on the normal sleep pattern, however, are somewhat limited, since some of these studies have involved multiple awakenings during sleep (Goodenough et al., 1975; Hauri, 1969) whereas others have not used normal subjects (Freedman & Papsdorf, 1976). In the present investigation, the relative effects of brief periods of presleep exercise, relaxation, and boring, monotonous task on the uninterrupted sleep of normals is evaluated.

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Method

Subjects

Nine male undergraduates with a mean age of 18.89 yrs served as unpaid volunteers. All were of average physical fitness. A sleep-habit questionnaire, the MMPI, and the Cornell Medical Index were administered individually to screen out any subject with obvious problems.

Procedure

The subjects reported to the laboratory 2.5 hrs prior to their normal bedtime. Upon arrival at the laboratory, the subject was asked questions about the day's events and electrodes were attached. Electroencephalogram (EEG), electro-oculogram, and submental electromyogram (EMG) electrodes were placed according to the Rechtschaffen and Kales (1968) criteria. The presleep treatment was started approximately 50 min before the subject's bedtime. All subjects were in bed for the night within 5 min of completing each experimental task and remained undisturbed for 7.5 hrs.

Each subject slept four consecutive nights in the laboratory. The first night was used for adaptation to the procedure; the subject participated in a different presleep activity on each of the three subsequent nights. The subjects were instructed to abstain from all drugs, daytime naps and evening caffeine sources, to refrain from unusual daytime exercise, and to keep their meals constant during participation in the experiment.

Presleep Activities

The three presleep activities were progressive relaxation (Relaxation), an auditory vigilance task (Vigilance), and light dynamic exercise (Exercise). Each activity was 45 min in length and the order of conditions was counterbalanced. The subjects practiced a complete duration of each of these activities once on separate days prior to sleeping in the laboratory.

Relaxation. The subject was seated on a comfortable chair in a darkened room during the Relaxation. The progressive relaxation procedure was similar to that reported by Paul (1969), with the exception that each muscle group was tensed and then relaxed twice before moving on to the next muscle group. The progressive relaxation lasted from 26 to 30 min, with a mean of 28.76 min. For the duration of the 45 min, the subject was instructed to engage in self-directed visual imagery of a personally relaxing scene. EEGs monitored during the visual imagery indicated that no subject was asleep during the activity.

Vigilance. The auditory vigilance task has previously been described in detail by Wilkinson (1970). Briefly, the subject listened through matched headphones to tones of 0.5 sec duration presented every 2 sec over white noise; occasionally one of the tones was shorter. The subject was instructed to depress a microswitch every time a short tone was detected. To keep the task monotonous rather than one of performance, no knowledge of results were given the subject. EEGs were monitored throughout the task and indicated that no subject was asleep.

Exercise. The subject rode a Monark bicycle ergometer with a 0.5 kg weight factor loaded on the friction wheel. The subjects were instructed to pedal at a constant rate and on the average rode the equivalent of 19.60 km, with a range of 19.00 to 21.56 km. The subjects alternated between 5 min of riding and 3 min of non-exercise.

Presleep Physiology

To assess the physiological effects of the presleep activities, muscle tension and heart rate were measured. A 1 min recording of each on a Grass Model 7 polygraph was made every 7.5 min during the Exercise breaks and Vigilance, and at four equal intervals during the visual imagery portion of Relaxation. Forearm muscle tension was measured as described by Paul (1969), except that the recording was from Beckman 16 mm biopotential electrodes placed on the left arm. Muscle tension was determined by the average peak unintegrated EMG amplitude per sec for 60 sec. Movement artifacts were excluded from the analysis. Heart rate was counted from recordings made with a Grass photoelectric transducer placed on the index finger of the left hand. The number of beats during the 60 sec period determined heart rate.

Sleep Electrophysiology

All-night electrophysiological data were recorded on a Grass Model 7 polygraph. The sleep records were scored visually in 20 sec epochs according to standardized criteria (Rechtschaffen & Kales, 1968) for awake after sleep onset, stage 1, stage 2, slow wave sleep (SWS), rapid eye movement (REM) sleep, and movement time (MT). The 7.5 hr recording period minus time awake defined total sleep time (TST). Sleep latency data were determined by the first epoch of stage 1 and stage 2. REM periods (REMPs) were divided into 4 sec intervals, with REM density the ratio of the number of 4 sec intervals with at least one REM to the total number of these intervals. The number of body movements was assessed by the artifact method described by Rechtschaffen and Maron (1964).

Questionnaire Data

Subjects completed presleep and postsleep questionnaires every night and morning, respectively. The questions used were adapted from Baekeland and Hoy (1971). Each subject was given a copy of the questionnaires the week prior to sleeping in the laboratory to become familiarized with the questions. The evening questionnaire was filled out within 1 min of lights out. The subject was instructed to drink a glass of orange juice in the morning before completing the postsleep questionnaire, which was filled out 5 to 10 min after awakening.

Statistical Analysis

Each variable was tested in a repeated measures analysis of variance design unless otherwise indicated. When the overall F was significant, individual means were compared with the Newman-Keuls test. Reported correlations are product-moment coefficients. Alpha was set at .05 for all statistical tests.

Results

Presleep Variables

The changes in muscle tension and heart rate from basal levels during the presleep activities are presented in Fig. 1. All analyses concerning these variables are in terms of post-activity levels. Muscle tension differences were not significant. Heart rate level under conditions of Relaxation and Vigilance did not differ, but heart rate level of both was significantly lower than that for the Exercise condition, $F(2/16)=21.38$. For the three presleep subjective questions, differences were significant for one F. Subjects felt more awake after Exercise than after either Relaxation or Vigilance, $F(2/16)=4.13$.

Sleep Latency

The means and sample variability (standard deviation) of stage 1 latency and stage 2 latency estimates of sleep onset are presented in Table 1. For all latency measures, the average value for the Relaxation condition was shortest and that for the Exercise condition was longest. Individual comparisons of stage 2 latency indicated that Relaxation was significantly lower than Exercise. The relative stage 1 latency for each subject revealed similar significant results: 6 subjects fell asleep fastest after Relaxation, 3 after Vigilance, and none after Exercise, $\chi^2(2)=6.00$. In addition, the sample variability of sleep onset was significantly lower for Relaxation than for the other conditions. Tests for the difference between variances of dependent samples (Glass & Stanley, 1970) indicated that the variability of stage 1 latency of Relaxation was

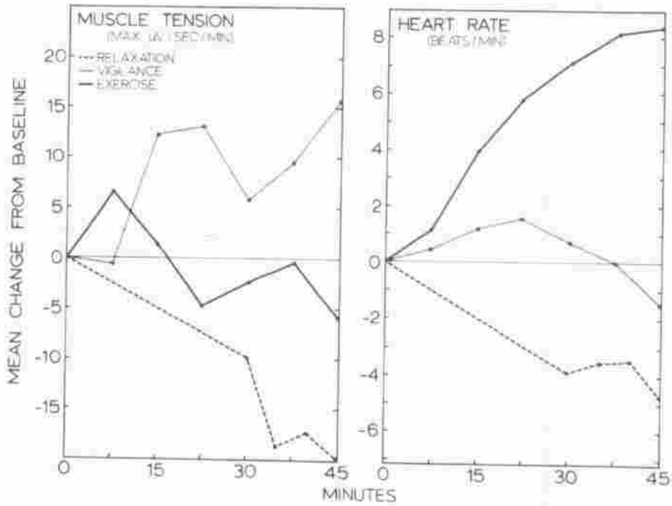

Fig. 1. Mean changes in muscle tension and heart rate from baseline levels during the three presleep activities.

TABLE 1

Estimates of sleep latency following three presleep conditions

Parameters	Sleep Latency Means (SDs in Parentheses) in Min			*F*
	Exercise	Relaxation	Vigilance	
Stage 1 Latency	12.37(6.57)	7.26(3.86)	11.63(10.54)	3.17
Stage 2 Latency	17.22(6.30)	10.92(3.92)	15.48(10.59)	3.93*
Subjective Estimate	12.94(6.46)	8.44(5.42)	12.72(9.77)	1.92

*Statistically significant.

lower than that of Exercise, $t(7)=2.51$, and Vigilance, $t(7)=5.77$, and stage 2 latency variance of Relaxation was less than that of Vigilance, $t(7)=5.22$. The difference between latency variance of Exercise and Vigilance for stage 1 or stage 2 was not significant.

Correlations by condition and overall between either stage 1 or stage 2 latency and the level of each of the presleep physiological variables were not significant. Likewise, changes in these presleep variables from basal levels were not correlated with either estimate of sleep onset. Multiple correlations of EMG level and heart rate with sleep latency by condition and overall were insignificant.

Sleep Variables

The sleep stages were analyzed as percentages of total sleep and the remaining variables were also analyzed relative to total sleep. The means and sample variability (standard deviation) for each of these parameters are presented in Table 2. Of these analyses, only REM latency yielded significant differences. The data were also analyzed by thirds of night (0 to 2.5 hrs, 2.5 to 5.0 hrs, and 5.0 to 7.5 hrs). None of these analyses yielded any significant differences.

The all-night sleep parameters for each condition were compared against the normative data reported by Coble, McPartland, Silva, and Kupfer (1974). Tests for the difference between means of independent samples (Glass & Stanley, 1970) were all insignificant.

Postsleep Variables

Consistent with no differences in the electrophysiological parameters during sleep, none of the means on the seven postsleep subjective questions were differentiated by condition. Subjective estimates of sleep latency did not differ across conditions, but the means and variability were in the same direction as the electrophysiological estimates. This data is also presented in Table 1. Correlations between the overall subjective estimates of min to sleep onset and both the first EEG stage 1, $r(25)=.915$, and first EEG stage 2, $r(25)=.883$, were significant. Subjective estimates of

TABLE 2

Selected sleep parameters following three presleep conditions

Sleep Parameters	Means (SDs in Parentheses)			F
	Exercise	Relaxation	Vigilance	
Awake(%)	0.24 (0.25)	0.30 (0.49)	0.10 (0.11)	0.99
Stage 1 (%)	6.40 (3.90)	5.88 (3.19)	5.60 (1.78)	0.21
Stage 2 (%)	58.60 (4.14)	57.75 (6.15)	59.61 (4.40)	0.46
SWS (%)	13.07 (3.91)	12.22 (3.78)	12.51 (3.91)	0.75
REM (%)	20.45 (5.05)	22.91 (3.81)	21.04 (3.47)	2.09
MT (%)	1.25 (0.66)	0.95 (0.52)	1.15 (0.47)	2.43
Awakenings (no)	1.33 (1.12)	0.89 (0.93)	0.78 (0.97)	1.93
Body Movements (no)	37.78 (10.29)	32.00 (10.10)	34.89 (9.25)	2.44
REM Density	.236(.078)	.241(.093)	.263(.109)	1.66
REMPs (no)	3.67 (0.50)	4.11 (0.78)	4.22 (0.67)	2.43
REM Latency (min)	106.07 (25.90)	87.26 (21.86)	80.41 (14.34)	7.07*
TST (hr)	7.28 (0.10)	7.36 (0.08)	7.31 (0.17)	2.82

*Statistically significant.

sleep latency, awakenings during the night, and TST were not significantly different from the electrophysiological estimates of these parameters, as determined by two-tailed *t*-tests for dependent samples.

Discussion

The conditions used in this study suggest that activity immediately before bed may effect changes in sleep latency without any substantial disturbance to the normal sleep pattern. The only relative difference in the sleep cycle, an increase in REM latency after Exercise, occurred with no corresponding statistical increase in any prior sleep stage. The tendency for an increase in REM latency following afternoon or evening exercise is a rather consistent but generally nonsignificant finding (e.g., Adamson, Hunter, Ogunremi, Oswald, & Percy-Robb, 1974; Horne & Porter, 1975). A stress effect of exercise (Baekeland & Lasky, 1966) appears not to be an appropriate explanation for the present data, due to the light level of the exercise regime (see Horne & Porter, 1976). A full explanation of this REM latency effect, if reliable, seems premature.

Presumably the differences in sleep latency would have been statistically greater if Exercise and Vigilance had produced as consistent an effect as Relaxation. It is entirely possible that other types and levels of relaxation, exercise, and monotonous task than those used in the present study can produce different sleep latency results. For example, a boring task without the repetitive auditory stimulation or more strenuous exercise than used here may have different effects. It does seem unlikely, however, that alternative forms of these activities would substantially reduce the mean latency or variability to that obtained with progressive relaxation.

It is tempting to extend the results of this study directly to the clinical situation in which progressive relaxation has been suggested as a therapy to ameliorate sleep onset difficulties. The present data encourage additional research directed at the further evaluation of this possibility. In no real sense do the results of this study provide definitive evidence that progressive relaxation is the therapy of choice for insomniacs in general.

An attempt was made to account for the differences in sleep latency with the level of physiological arousal. Based on the suggestion by Kahn, Baker, and Weiss (1968) that a high level of muscle tension is related to the inability to fall asleep, correlations between sleep latency and EMG activity level were calculated. Neither the absolute level nor the change in muscle tension correlated with the latency of sleep onset. The failure to demonstrate a relationship between EMG level and sleep latency has previously been reported for slightly older subjects (Good, 1975) and insomniacs (Freedman & Papsdorf, 1976). Likewise, the heart rate level or change in the heart rate level were not related to sleep onset. Similar findings have been noted by Hauri (1969) and others. Multiple correlations of EMG and heart rate levels with sleep onset were also insignificant. Apparently these measures of physiological arousal level per se are not accurate predictors of sleep onset.

A final point concerns the accuracy with which the subjects were able to estimate sleep latency, awakenings during the night, and TST. There was a tendency for reports to underestimate TST and to overestimate sleep latency and awakenings, but subjective estimates of these parameters did not differ statistically from EEG estimates. The data confirm previous reports (e.g., Baekeland & Hoy, 1971; Karacan, Thornby, Booth, Okawa, Salis, Anch, & Williams, 1975) that normal subjects can estimate certain parameters of sleep.

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Announcement

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