14967

ISRAEL
JOURNAL
OF
MEDICAL
SCIENCES

EFFECTS OF WORKLOAD ON RESIDENTS' SLEEP DURATION: OBJECTIVE DOCUMENTATION

NAVE TOV, AMI-HAI RUBIN and PERETZ LAVIE

VOL. 31, NO. 7, JULY 1995, JERUSALEM, ISRAEL.

EFFECTS OF WORKLOAD ON RESIDENTS' SLEEP DURATION: OBJECTIVE DOCUMENTATION

NAVE TOV, AMI-HAI RUBIN and PERETZ LAVIE

Sleep Laboratory, B. Rappaport Faculty of Medicine, Technion–Israel Institute of Technology, Haifa, Israel

ABSTRACT. Sleep–wake cycles of 27 residents from the 800-bed Rambam hospital, which serves the northern part of Israel, were investigated by wrist-worn actigraphs. Fifteen subjects (aged 30.6±4.6) worked in wards with a "heavy" workload, and 12 (aged 35±2.6) in wards with a "light" load. There were significant differences among the residents in sleep duration. Residents working in the emergency room had the shortest sleep periods, and those working in "light" wards had the longest. There was no significant increase in sleep duration the day after the night "on call." Sleep duration was significantly negatively correlated with the number of new admissions, and with the subjective daily assessment of work load. It is concluded that residents working in wards with a heavy load suffer from chronic partial sleep deprivation, which should be taken into consideration in residents' work regulation.

Isr J Med Sci 1995;**31**:417–423

Keywords: workload; actigraph; physicians/residents; sleep deprivation

Recent years have seen a growing awareness and concern regarding physicians' long working hours. Physicians' work schedules have been sharply criticized because of inadequate consideration of sleep and rest periods (1–5). In 1987, the New York grand jury investigating the Libby Zion death case placed part of the blame on the exhaustion of a resident who had been on call for 18 hours (6). This highly publicized case led to a new legislation that has been adopted in several states. It established limited hours for residents working in the Emergency Ward as well as in other loaded wards, to no more than 12 and 24 consecutive hours, respectively (3,4).

In addition, the professional literature has often cited prolonged working hours and the consequent accumulated sleep loss as the main reasons for deterioration in mood (7–11) and decreased performance (10–16). However, previous data on performance measures have been inconsistent. Although many studies using cognitive tasks have convincingly shown deterioration of residents' performance after a night 'on call' (10–16), others have shown no change (8,9,17–20). One of the main reasons for these inconsistencies is the lack of an operational definition regarding the meaning of "sleep loss." All of the above-mentioned studies were based on subjective reports of sleep duration. To date, only a single study (21) has objectively documented sleep loss in six hospital house-officers during night-call duty.

In spite of growing public interest and increased concern in the professional literature, there is still very little information on how much residents actually suffer from sleep deprivation, and how this interacts with workload in terms of new admissions, patients cared for, etc. Recently, Sadeh et al. (22) showed that ambulatory measurements of body motility by miniature wrist actigraphs provide an objective, reliable, and valid assessment of sleep quantity. It has also proved to be a tool for valid clinical assessment in children and adult patient groups with a variety of sleep disorders (23,24).

This study was undertaken to investigate sleep-wake cycles in hospital residents by actigraphic means, and to determine if sleep duration interacts with workload.

Materials and Methods

Twenty-seven residents from the 800-bed Rambam hospital, which serves the northern part of Israel, participated. Informed consent was obtained from all residents following a full explanation of our procedure. Most of them had up to 3 years experience in night shifts. All volunteered to participate after permission was obtained from the director of the hospital and the chairmen of the respective wards. Two groups of residents were recruited, from wards with "heavy" and "light" workloads. These will be referred to as groups HWL and LWL. The distinction between them was based on the number of hospitalized patients, the number of new admissions, the number of patients cared for, and the number discharged (per day).

Group HWL comprised 15 residents (3 women and 12 men, mean age 30.6±4.6 years, range 29–38 y) who worked in Internal Medicine and General Surgery wards; most of them worked night shifts in the Emergency Room (ER) as well.

Group LWL comprised 12 residents (3 women and 9 men, mean age 35±2.6 years, range 30–39 y) who worked in the following wards: oncology, dermatology, ophthalmology, neurology, urology, otolaryngology, and radiology.

Actigraphic Recordings

Sleep–wake cycles were monitored for at least 9 consecutive days by a wrist-worn actigraph (AMI Ltd., Ardsley, NY, USA), attached to the nondominant hand. The actigraph consists of a sensitive piezoelectric accelerometer whose lower limit of sensitivity is about 0.1 g. Movements are sampled at a constant rate of 10 Hz, and any suprathreshold movement is registered in the actigraph's 16 k memory. The number of registrations was accumulated in 1 min bins continuously. Actigraphic data were analyzed by an algorithm developed previously in our laboratory (22). The following three variables were automatically derived for each resident for every major bedtime: a) sleep duration — the length of sleep period as determined by the automatic algorithm; b) time of sleep onset, and c) sleep efficiency — the percentage of minutes defined as sleep out of total bedtime.

In addition, the residents kept a diary of their daily schedule and activities. Each day they registered sleep hours, the time they removed the actigraph (for bathing, swimming, etc.), and the type of working day (Normal day — a 24 h period that did not include or precede a night shift; Shift — a 24 h period that included on-call night duty; After shift — a 24 h period following a night shift).

Work Load Variables

We measured three workload variables: a) the number of hospitalized patients; b) the number of new admissions, and c) the number of patients cared for and discharged. These variables were divided by the number of residents on duty to account for the different number of residents in the different wards. In addition, at the end of each working period, residents were asked to rate their on-call workload on a 10-point scale. This ranged from "very light" to "very heavy."

Statistical Data

All variables were averaged for each resident by day

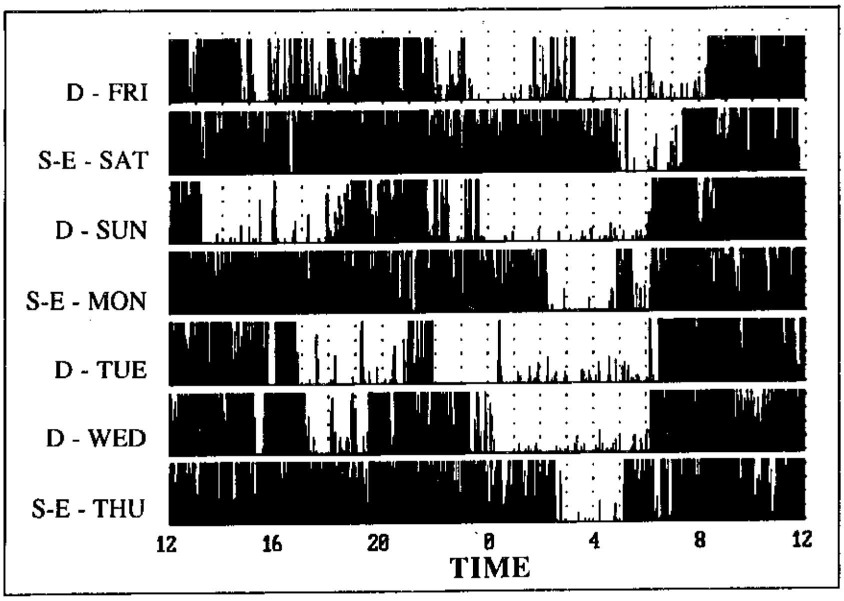
Address for correspondence: Dr. P. Lavie, Sleep Laboratory, Gutwirth Building, Technion–Israel Institute of Technology, 32000 Haifa, Israel

type. Residents from group HWL were divided into two subgroups: those who worked shifts in wards, and those who worked in the ER. We used one-way analysis of variance (ANOVA) with Duncan's post hoc tests, to compare these variables between and within groups according to day type. Correlation between sleep duration and the workload variables was made by Pearson correlation coefficients. Stepwise regression analysis was used to determine the most important predictors of work load scores.

RESULTS

Residents had at least two on-call nights per week. Analysis of sleep durations revealed large differences between groups HWL and LWL, particularly during nightshifts. Fig. 1 presents a representative week of actigraphic data of two residents from each group. Fig. 1a clearly shows a considerable decrease in the amount of sleep during night shifts in a resident from the HWL group, while Fig. 1b shows an almost unchanged sleep-wake cycle in a resident from the

A



B

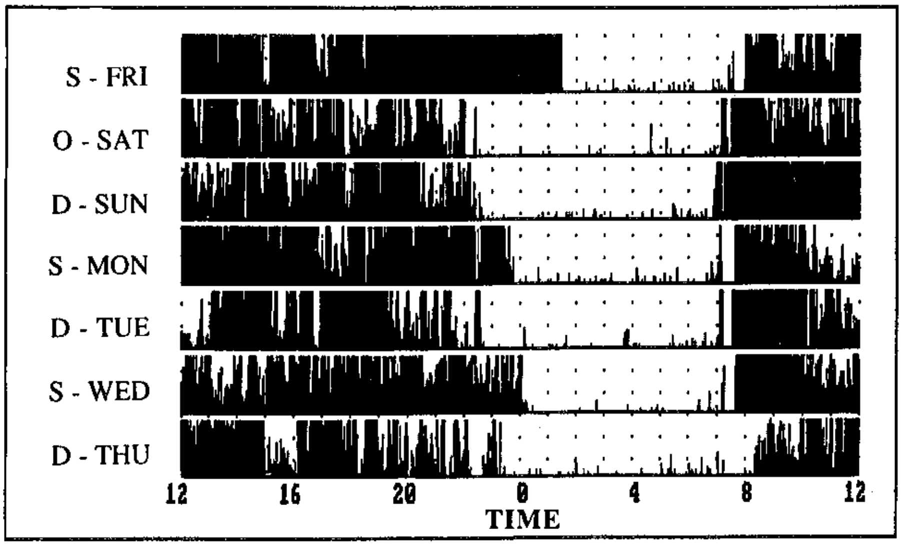


Fig. 1. One representative week of actigraphic data:
A) resident from the HWL group. B) resident from the LWL group. S = Night shift; SE = night shift in the Emergency Room; D = day without night shift. Black peaks represent the activity period.

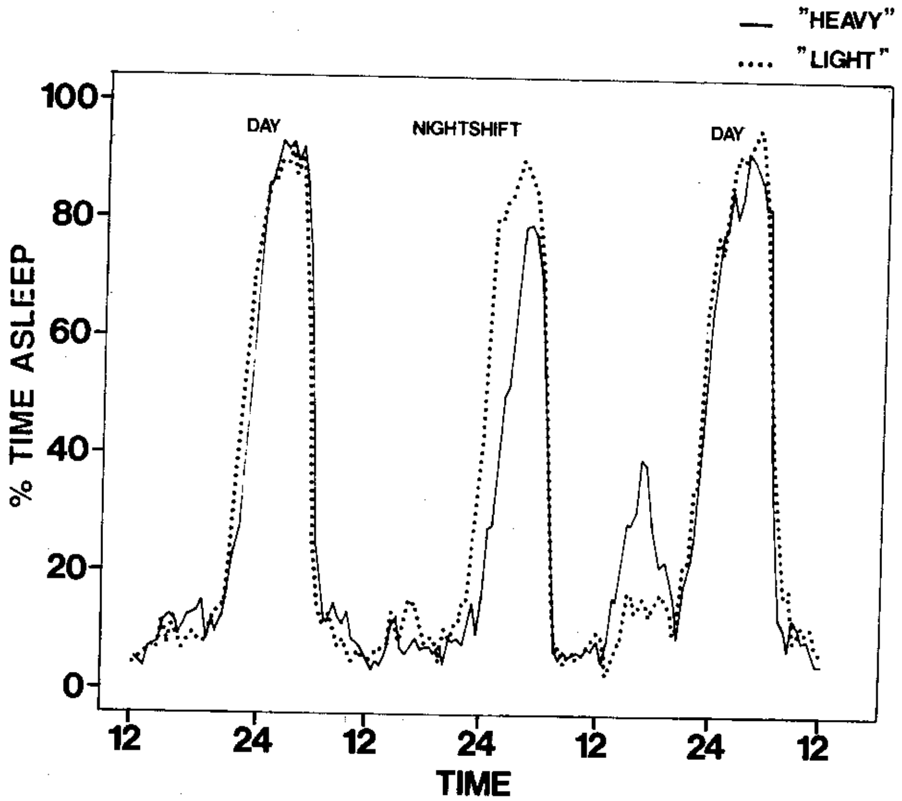


Fig. 2. Sleep-wake cycles shown by percentages of residents' sleep epochs during a 24-h period for each day type. —— heavy workload, ... light workload

LWL group. Fig. 2 summarizes the percentages of residents' sleep epochs based on 24 h actigraphic recordings for each day type. During night shifts, although both groups had a single episode of sleep, HWL residents retired to sleep 2 h later than LWL residents (02:40±1:30 vs. 00:30±1:25; P <0.0001), and almost 3 h later than their usual bedtime (00:00±1:25, P <0.0001). During the day after night shifts, both groups retired to sleep at approximately the same time (23:30±1:30). However, some of the residents from the HWL group also took a nap during the afternoon (15:50±1). Napping was unrelated to sleep duration during the night and occurred only in 50% of the residents.

Table 1 summarizes the means (± SD) of the actigraphically derived sleep durations for the two groups. During night shifts both groups slept less than usual. The decrease was significant, however only for group HWL. In addition, the amount of sleep during night shifts in HWL wards was significantly shorter than that in LWL wards (4:49±1:34 vs. 6:03±1:07 h P<0.0005). The shortest duration of sleep was found in ER residents who slept only 3:06±1 h. No significant increase in total amount of sleep was found during the 24 h after a night shift. However, albeit not significantly so, residents in the ER subgroup had higher total amount of sleep than usual during the 24 h after a night shift (8:49±1:43 h). It is notable that although residents slept less during night shifts, sleep efficiency remained unchanged (90%) for both groups.

As expected (Table 2), overall the workload in the HWL wards was significantly higher than in the LWL wards. They had more hospitalized patients (31±11 vs. 16±6; P <0.0001), and their subjective workload 'score' was higher (6.3±2.5 vs. 5.3±2.3; P <0.02). The mean number of new admissions per resident in the ER was significantly higher than in either HWL or LWL wards: 18±10 vs. 3±3 and 1±0.6 (P <0.0001). The ER residents also had the highest subjective workload 'score' (7.6±2.2).

Significant correlations between sleep duration and workload variables were found only for the night shifts (Table 3). The workload variable with the highest (negative) correlation with sleep duration was the number of new admissions per doctor (–0.48, P<0.009). Subjective workload score and the number of hospitalized patients were less significantly correlated (–0.38, P <0.03 and –0.36, P <0.05, respectively).

Stepwise regression analysis was used to determine which was the most important variable that pre-

Table 1. Comparison of sleep duration (hour:min) during different types of days between groups

	Normal day (D)	Night shift (S)	After shift (A)	Significant difference
Heavy workload				
Night sleep duration	7:11±2:08 (15)	4:49±1:34 (12)	7:41±2:48 (9)	NS
Total sleep duration	7:42±1:59 (15)	5:00±1:48 (12)	7:49±0:56 (9)	S < D,A[a]
Emergency room				
Night sleep duration		3:06±1:00 (8)	7:15±1:05 (7)	S < A[a]
Total sleep duration		3:17±1:09 (8)	8:49±1:36 (7)	S < A[b]
Light workload				
Night sleep duration	7:06±1:15 (11)	6:03±1:07 (12)	6:37±1:29 (11)	NS
Total sleep duration	7:24±1:26 (11)	6:34±1:23 (12)	7:01±1:32 (11)	NS

[a] $P<0.002$; [b] $P<0.0001$

Table 2. Comparison of number of new patients per doctor and workload scores between groups during night shifts

	No. of observations	No. of new patients per doctor	Subjective workload score
HWL ward	11	3±3 (6–1)	6.3±2.5 (9.1–3.0)
ER	8	18±10 (45–10)	7.6±2.2 (10.0–4.0)
LWL ward	12	1±0.6 (4–0)	5.3±2.3 (9.0–1.5)
Significant differences		$P<0.0001$ ER>>HWL,LWL	NS

HWL = heavy workload; LWL = light workload; ER = emergency room.

Table 3. Pearsonian correlation coefficients between sleep duration and workload variables during night shifts

Workload variables	N	*r*	*P*
No. of new admissions per doctor	29	–0.48	$P<0.009$
Subjective workload score	31	–0.38	$P<0.03$
No. of hospitalized patients	29	–0.36	$P<0.05$

dicted subjective workload during nights on call. Only the number of new admissions entered the predicting equation, accounting for 24.1% of the variance ($P<0.006$). Adding sleep duration to the model had a minimal effect ($R^2 = 30\%$).

DISCUSSION

Our results showed that during night shifts, residents from loaded wards slept significantly less than usual, especially when on duty in the emergency room. The amount of recovery sleep during the day after night shifts was higher than usual, though not significantly so. Therefore, there appeared to be no complete compensation for the amount of sleep lost during night shifts. Consequently, having two to three on-call nights per week resulted in a chronic partial sleep loss. Although residents in HWL are somewhat younger than those in LWL (mean age 30.6 vs. 35.2 yr), this 5 year difference is too small to have any effect on sleep duration. It is known that age is a risk factor for coping with shiftwork, and this increases after the age of 50 (25).

Previously, little has been documented on the sleep–wake cycles of residents. Most studies have relied on subjective reports. The only study where sleep of house officers was documented objectively was reported by Akerstedt et al. (21). They showed a significant decrease in total sleep during night shift (4 hour/sleep) of six house officers. However, contrary to our results, in that study most of the sleep lost was recovered within the subsequent 24 h. These incongruent results may be explained by different work routines and workload in Israel and Sweden, as well as by the small number of participants in the Swedish study. Other reports based on subjective evaluation of sleep duration revealed variable amounts of decreases in sleep during night shift (sleep durations of 1.8–5.0 h) (7–20).

Although we did not aim to study the influence of sleep deprivation on residents' mood and performance, such deterioration in mood and performance has been documented previously. However, these studies mostly examined the influence of acute sleep deprivation, while the influence of chronic sleep loss is less known. Studies of other groups of volunteers, particularly in the military, showed that chronic sleep loss caused deterioration in mood, increased hostility and aggression, and a tendency toward depression. These changes may be accompanied by a decrease in performance depending on the type of the specific task (for an extensive review see Johnson, ref. 26).

Although it is difficult to generalize these observations to the hospital environment, there is evidence that sleep duration may be the most important variable determining subjective assessment of workload in residents (27). Pediatric residents who reported short sleep periods also perceived their workload as heavier, and were also perceived by others to work much harder. In contrast to the present results, in that study sleep duration was the most important variable predicting subjective workload. But the number of admissions in that study was considerably lower than in the HWL group in our study (only two per shift). In our study, the mean number of new admissions in the ER was ninefold higher (18±10). Thus, the lack of sleep in the pediatric wards possibly reflected individual differences in work style rather than new admissions, which also influence the perception of others regarding the resident's workload.

Recently, legislative action has been taken, and changes have been made in residents' training programs. The fact that residents sleeping approximately 2–3 h per night are required to continue their daily activities as if they had had a normal sleep raises the question of patients' safety and well-being. More studies are needed to determine what the accumulated effects of partial chronic sleep loss on residents' performance are, and how they interact with workload. It seems imperative, however, that residents working in emergency rooms, who sleep very little during their night duty, will be prohibited to continue working the following day without first having an appropriate rest period. Such a change in residents' working conditions should not wait for a repetition of the tragic case of Libby Zion before being implemented.

This study was carried out in partial fulfillment of requirements towards the M.D degree of Nave Tov, and supported by a grant from The Committee for Research and Prevention in Occupational Safety and Health.

References

1. McCall TB. The impact of long working hours on resident physicians. *N Engl J Med* 1988;**318**:775–778.
2. McCall TB. No turning back. A blueprint for residency reform. *JAMA* 1989;**261**:909–910.
3. Colford JM, McPhee SJ. The raveled sleeve of care: Managing the stresses of residency training. *JAMA* 1989;**261**: 890–894.
4. Samkoff JS, Jacques CHM. A review of studies concerning effects of sleep deprivation and fatigue on residents' performance. *Acad Med* 1991;**66**:687–693.
5. Butterfield P. The stress of residency — A review of the literature. *Arch Intern Med* 1988;**148**:1428–1435.
6. Asch DA, Parker RM. The Libby Zion case: one step forward or two steps backward? *N Engl J Med* 1988;**318**:771–778.
7. Friedman RC, Kornfeld DS, Bigger TJ. Psychological problems associated with sleep deprivation in interns. *J Med Educ* 1973;**48**:436–441.
8. Ford CV, Wentz DK. The internship year: a study of sleep, mood state, and psychophysiological parameters. *South Med J* 1984;**77**:1435–1442.
9. Engel W, Seime R, Powell V, D'Allesandri RD. Clinical performance of interns after being on call. *South Med J* 1987;**80**:761–763.
10. Hart RP, Buchsbaum DG, Wade JB, et al. Effect of sleep deprivation on first year residents' response times, memory and mood. *J Med Educ* 1987;**62**:940–942.
11. Deary IJ, Tait R. Effects of sleep disruption on cognitive performance and mood in medical house officers. *Br Med J* 1987;**295**:1513–1516.
12. Friedman RC, Bigger TJ, Kornfeld DS. The intern and sleep loss. *N Engl J Med* 1971;**85**:201–203.
13. Hawkins MR, Vichick DA, Silsby HD, et al. Sleep deprivation and performance of house officers. *J Med Educ* 1985;**60**:530–535.
14. Densico RA, Drummond JN, Gravenstein JS. The effect of fatigue on the performance of a simulated anesthetic monitoring task. *J Clin Monit* 1987;**3**:22–24.
15. Jacques CHM, Lynch JC, Samkoff JS. The effects of sleep loss on cognitive performance of resident physicians. *Fam Pract* 1990;**30**:223–229.
16. Robbins J, Gottlieb F. Sleep deprivation and cognitive testing in internal medicine house staff. *West J Med* 1990; **152**:82–86.
17. Deaconson TF, O'Hair DP, Levy MF, et al. Sleep deprivation and resident performance. *JAMA* 1988;**260**:1721–1727.
18. Resnick Rk, Folse JR. Effect of sleep deprivation on the performance of surgical residents. *Am J Surg* 1987;**154**: 520–525.
19. Bartle EJ, Sun JH, Thompson L, et al. The effects of acute sleep deprivation during residency training. *Surgery* 1988; **104**:311–316.
20. Storer JS, Floyd HH, Gill Wl, et al. Effects of sleep deprivation on cognitive ability and skills of pediatric residents. *Acad Med* 1989;**64**:29–32.
21. Akerstedt T, Arnetz BB, Anderzen I. Physicians during and following night call duty — 41 hour ambulatory recording of sleep. *EEG Clin Neurophysiol* 1990;**76**:193–196.
22. Sadeh A, Alster J, Urbach D, Lavie P. Actigraphically based automatic bedtime sleep-wake scoring: validity and clinical applications. *J Ambul Monit* 1989;**2**:209–216.
23. Lavie P, Lorber M, Tzischinsky O, Epstein R, Sharf Y. Wrist actigraphic measurements in patients with rheumatoid arthritis. *Drug Invest* 1990;**2**:15–21.
24. Sadeh A, Lavie P, Sher A, Tirosh E, Epstein R. Actigraphic home-monitoring of sleep-disturbed and normal infants: Establishing the clinical validity of actigraphic monitoring in infancy. *Pediatrics* 1991;**87**:494–499.

25. Monk TH. Shift work. In: Kryger MH, Roth T, Dement WC, eds. Principles and practice of sleep medicine. Philadelphia: WB Saunders, 1989:332–337.
26. Johnson LC. Sleep deprivation and performance. In: Webb WB, ed. Biological rhythms, sleep and performance. Chichester: Wiley 1982:111–141.
27. Tanz RR, Charrow J. Black clouds. Work load, sleep, and resident reputation. *Am J Dis Child* 1993;**147**:579–584.