SK Mak 麥肇嘉
P Spurgeon

The effects of acute sleep deprivation on performance of medical residents in a regional hospital: prospective study

短暫的睡眠缺乏對地區醫院駐院醫生表現的影響：預期性研究

Objective. To evaluate the effects of acute sleep deprivation on the level of perceived occupational stress and cognitive functioning in a group of medical residents.
Design. Prospective study.
Setting. Regional hospital, Hong Kong.
Participants. Twenty-one residents who had regular in-hospital on-call duties.
Main outcome measures. From January to April 2002, participants were asked to complete the Raven Advanced Progressive Matrices (sets I and II) and Occupational Stress Inventory–Revised tests at the beginning of an on-call day. They then repeated the tests towards the end of their on-call duties on their next on-call day, at a mean (standard deviation) interval of 8.9 (2.3) days. Occupational Stress Inventory–Revised test scores were transformed into T-scores to provide information about an individual's scores relative to the scores of participants in a normative sample.
Results. The group slept for a mean (standard deviation) of 2.9 (1.0) hours during 29.3 (3.8) hours of on-call duties. Before the on-call duties, participants' mean T-scores for the Occupational Stress Inventory–Revised test ranged from 50.6 to 54.5 for the Occupational Role Questionnaire, 52.0 to 57.0 for the Personal Strain Questionnaire, and 37.3 to 52.3 for the Personal Resources Questionnaire. After on-call duties, apart from a slight increase in Role Insufficiency T-scores (50.6 [5.9] versus 52.1 [6.0]; P=0.044), there was no significant change in all other scales of the Occupational Stress Inventory–Revised test. The scores of the Raven Advanced Progressive Matrices test remained stable after the on-call duties (11.3 [1.2] versus 11.5 [0.8], P=0.129 for set I; 29.9 [5.5] versus 30.2 [6.3], P=0.2 for set II).
Conclusion. Acute sleep deprivation among medical residents was not associated with any significant changes in both cognitive functioning and level of stress perceived.

目的：從意識到的工作壓力及認知功能兩個層面，評估短暫的睡眠缺乏對一班駐院醫生的影響。
設計：預期性研究
安排：地區醫院，香港。
參與者：21 名定期值班的駐院醫生。
主要結果測量：21 名駐院醫生於 2002 年 1 月至 4 月期間，於當值日開始時進行高級雷芬氏漸進圖形測驗（卷一及卷二）及職業壓力資料庫（修訂）測驗。他們並於下一個當值日快將完結時，再進行同一測驗；平均（標準差）時間差距為 8.9（2.3）日。職業壓力資料庫（修訂）測驗得分被轉化為T值，作為提供個別參與者相對於其他參與者的得分資料。
結果：在平均（標準差）為 29.3（3.8）小時的值班期間，這一組駐院醫生平均睡了 2.9（1.0）小時。值班前，他們的職業壓力資料庫（修訂）測驗的平均T值為：「職業責任調查」50.6 至 54.5 ，「個人壓力調查」52.0 至 57.0 ，「個人資源調查」37.3 至 52.3 。值班後，除了「未能勝任職責」的T值（50.6 [5.9] 對比 52.1 [6.0]；P=0.044）略為上升外，職業壓力資料庫（修訂）測驗的其他分數並無顯著改變。高級雷芬氏漸進圖形測驗的得分，在值班後保持穩定（卷一：11.3 [1.2] 對比 11.5 [0.8]， P=0.129；卷二：29.9 [5.5] 對比 30.2 [6.3]， P=0.2）。
結論：對駐院醫生來說，短暫的睡眠缺乏與認知功能及意識到的壓力水平上的明顯改變並無關係。

Key words:
Cognition;
Internship and residency;
Sleep deprivation;
Stress

關鍵詞：
認知；
實習及駐院實習；
睡眠缺乏；
壓力

Hong Kong Med J 2004;10:14-20

Department of Medicine and Geriatrics, Kwong Wah Hospital, 25 Waterloo Road, Kowloon, Hong Kong
SK Mak, MB, BS, FRCP
Health Services Management Centre, The University of Birmingham, Park House, 40 Edgbaston Park Road, Birmingham, United Kingdom
P Spurgeon, PhD

Correspondence to: Dr SK Mak (e-mail: maksk@ha.org.hk)

Introduction

Modern society depends on the continuous operation of a diverse array of services, including health care services. Many workforces have a rotating work schedule, in which people are engaged in night-shift or on-call work[1]; but after 8 hours of work, an individual's performance declines, the ability to concentrate decreases, and the risk of motor and cognitive errors increases.[2] Working at night and working hours that restrict sleep opportunity have been implicated in compromised safety at work.[3]

Long hours of work have always been regarded as an integral part of the medical profession, including training.[4] Many hospitals' schedules are structured in such a way that residents need to be on-call at nights and sometimes need to work very long hours. Sleepiness is common among house staff: 10% of residents perceive sleepiness as an almost daily occurrence.[5] However, physicians have to perform complex problem-solving, which includes obtaining relevant clinical information, generating a differential diagnosis, and formulating a treatment plan. Thus, whether physicians are affected by sleep deprivation after on-call duties is of utmost importance to the quality of health care. It has been suggested that coping mechanisms could play a role in the ability of caregivers to resist sleepiness, especially during night shifts.[6] It is also apparent that tolerance of disturbances in circadian and social rhythm varies a lot between individuals.

Storer et al[7] evaluated residents' procedural skills, such as endotracheal intubation and vein and artery catheterization, as well as their performance in a written test consisting of 30 board examination questions. Compared with rested residents, sleep-deprived residents required slightly longer to catheterize umbilical arteries; however, no differences in the other measures were found. Beatty et al[8] used a 50-minute simulated monitoring task and Denisco et al[9] used a 30-minute simulated videotape to evaluate the vigilance of anaesthesiologists under rested and sleep-deprived conditions. Both studies showed decreases in performance after a night on-call.

Because of difficulties in trying to measure how clinical performance is affected by sleep deprivation, researchers have used psychomotor and neuropsychological tests as proxy measures, although the validity of these approaches is not known.[10,11] The majority of these tests last only several minutes and assess manual dexterity, reaction times, and recall tasks; consequently, most studies do not show a deterioration in test results after one night's sleep loss.[10] It remains uncertain whether tests that require sustained concentration and attention would be able to reveal any detrimental effects of acute sleep deprivation on the functioning of doctors.

Although long working hours and sleep deprivation tend to occur together, high levels of stress and depression (leading to decrements in mood and performance) seem to be related to loss of sleep rather than to long hours of work.[12] When deprived of sleep, interns may feel significantly more fatigue and sadness and perceive themselves to develop numerous psychophysiological abnormalities.[13] It is apparent from the literature that data on the sources of stress in a physician's work environment, the psychological strains experienced by physicians as a result of work stressors, and the coping resources available to combat the effects of stressors are scarce.

In our department, normal office hours apply on Monday to Friday. We have five on-call residents working in two levels (ie first- and second-call levels) every day and, on average, they are on-call within the hospital once every 6 to 7 days. In this study, we examine whether internal medicine residents' performance in tasks requiring higher-level thinking skills declines after working on-call overnight. We also assess how levels of perceived occupational stress, experienced psychological strain, and coping skills differ between rested and sleep-deprived doctors. Because residents in our department were not expected to be chronically deprived of sleep, only the effects of acute sleep deprivation were evaluated.

Methods

Participants

Medical residents at first- and second-call levels in the Department of Medicine and Geriatrics at the Kwong Wah Hospital were considered eligible for evaluation and invited to participate in the study. The typical in-hospital on-call period begins at 9:00 am and finishes by 1:00 pm the next day, followed by a half-day off. However, if residents have scheduled duties on the afternoon post-call, they will have to work until about 6:00 pm to 7:00 pm and will have their half-day off some other day. The total number of working hours for an on-call day could thus be as many as 34. Of the residents invited, 21 agreed to participate.

Participants were asked to complete two tests—the Raven Advanced Progressive Matrices (APM I & II)[14] and the Occupational Stress Inventory–Revised (OSI-R)[15]—at the beginning of one of the on-call days. The APM test assesses eductive mental activity, which involves making meaning out of confusion; developing new insights; going beyond the given to perceive that which is not immediately obvious; and forming largely non-verbal constructs to facilitate the handling of complex problems involving many mutually dependent variables.[16] Accurate perception and attention to detail are important.[16] The test requires problem identification, reconceptualisation of a situation, and monitoring of tentative solutions to achieve consistency with all the available information.[16] It is apparent that these factors represent the higher levels of functioning that a clinician requires in clinical practice. The OSI-R provides measures for an integrated theoretical model that links sources of stress in the work environment, the psychological strains

experienced by individuals as a result of work stressors, and the coping resources available to combat the effects of stressors and to alleviate strain.[15] For each of these domains, questionnaire scales measure specific attributes of the environment or individual that represent important characteristics of occupational adjustment.

Participants repeated the tests towards the end of their on-call duties on the next on-call day. The interval between tests was at least 7 days (mean, 8.9 days; standard deviation [SD], 2.3 days). On the day of the repeated test, participants were asked post-call to record the time they started work and the time they finished their work. The total sleep time during the entire on-call period was also obtained. The total number of working hours was then calculated by subtracting the total sleep time during call from the total time on call.

Study protocol

All participants gave informed consent. When the tests were administered, the importance of answering all items and the need for choosing only one response per item was emphasised. Participants were told they needed to concentrate and try to ensure that there were no interruptions, including telephones and pagers, during the tests.

The APM is composed of two sets of questions. Set I consists of 12 problems,[16] and is generally used to establish a field of thought for respondents and to provide them with training in the method of working. Set I is normally followed immediately by set II.[16] The 36 items in set II are identical in presentation and argument with those in set I, but they steadily become more difficult and complex. We used both sets in this study. Participants were told that the upper diagram in each question was a shape with a piece cut out of it, and only one of the lower diagrams represented the cut-out piece. They were told that the test was untimed and that accurate work counted.[14]

The OSI-R uses a Likert-type scale, in which some items are reverse-scored—that is, a rating of "never" scores 1 on some items and 5 on others.[15] The item scores for each of the 14 scales (the raw scores) were transferred to a generic profile form (for professionals) to facilitate calculation of T-scores.[15] T-scores are linear transformations of raw scores, derived to have a mean of 50 and an SD of 10. T-scores provide information about the individual's scores relative to the scores of participants in the normative sample.[15]

Statistical analysis

The values of parameters are given as mean (SD) where appropriate. Differences between groups were assessed by the Mann-Whitney *U* test, and differences in scores between pre-call and post-call tests were compared using the paired Wilcoxon's test. Correlations between parameters were assessed by Spearman's rank correlation. The cut-off level for statistical significance was taken as P=0.05 (two-tailed).

Results

All 21 residents completed the study. It took them, on average, half an hour to finish the OSI-R and 50 minutes to finish both sets of the APM. Some participants commented that the tests were lengthy, especially at a time when they could have left the office post-call. There were, however, no dropouts. They all chose only one response per item.

The group consisted of five women and 16 men; seven were on first call and 14 were on second call. The mean (SD) age of the group was 28.7 (2.6) years. The second-call doctors were on average older than those on first call (29.8 [2.5] versus 26.6 [1.3]; P=0.002). The average length of service among the first-call doctors was 2.6 (1.3) years (range, 1-4 years) and that of the second-call doctors was 5.8 (2.5) years (range, 2-10 years). Nevertheless, the two groups had comparable durations of on-call duty, sleep times, and durations of work on the day of test (Table 1). Thus, the two groups were exposed to similar levels of sleep deprivation and could be treated as a homogeneous group for the analysis of the effects of acute sleep loss.

Baseline data

On the day of the repeated test, the residents had slept 2.9 (1.0) hours during 29.3 (3.8) hours of on-call duty. Before the on-call duties, the average T-scores of the OSI-R ranged from 50.6 to 54.5 (Occupational Role Questionnaire scales), 52.0 to 57.0 (Personal Strain Questionnaire scales), and 37.3 to 52.3 (Personal Resources Questionnaire scales). The scores of sets I and II of the APM were 11.3 (1.2) and 29.9 (5.5), respectively (Table 2).

Change in test parameters pre- and post-call

After the on-call duties, there was no significant change in most of the scales of the OSI-R, except for a slight increase in role insufficiency T-scores (from 50.6 [5.9] to 52.1 [6.0], P=0.044) [Table 2]. The scores of the APM

Table 1. Participants' baseline characteristics, and duration of on-call duty, sleep, and work on the day of the post-call test

	First-call residents, n=7 Mean (SD)	Second-call residents, n=14 Mean (SD)	P value*
Sex (M:F)	16:5		
Age (years)	26.6 (1.3)	29.8 (2.5)	0.002
Length of service (years)	2.6 (1.3)	5.8 (2.5)	0.002
Total duration of on-call duty (hours)	27.3 (3.3)	30.3 (3.7)	0.091
Total duration of sleep (hours)	2.9 (0.9)	2.93 (1.1)	0.938
Total duration of work (hours)	24.4 (3.4)	27.4 (4.4)	0.166
Interval between baseline and repeated tests (days)	8.9 (2.3)		

* Mann-Whitney *U* test

Table 2. Comparison of test parameters at the end of on-call duties with those pre-call

	Pre-call, n=21 Mean (SD)	Post-call, n=21 Mean (SD)	P value*
Occupational Stress Inventory–Revised†			
Occupational Role Questionnaire			
Role overload	54.4 (7.2)	55.4 (6.3)	0.229
Role insufficiency	50.6 (5.9)	52.1 (6.0)	0.044
Role ambiguity	54.1 (5.5)	54.6 (6.1)	0.599
Role boundary	52.6 (5.6)	52.9 (5.6)	0.642
Responsibility	54.5 (6.8)	54.4 (6.3)	1.0
Physical environment	54.1 (9.5)	53.0 (8.0)	0.154
Personal Strain Questionnaire			
Vocational strain	57.0 (10.0)	58.6 (10.0)	0.21
Psychological strain	56.1 (11.2)	56.2 (11.4)	0.669
Interpersonal strain	55.5 (10.7)	54.1 (8.7)	0.677
Physical strain	52.0 (8.0)	52.3 (8.4)	0.656
Personal Resources Questionnaire			
Recreation	52.3 (9.0)	50.7 (7.7)	0.14
Self-care	44.2 (5.9)	45.7 (6.8)	0.086
Social support	49.0 (7.9)	47.8 (8.4)	0.123
Rational/cognitive coping	37.3 (13.4)	38.1 (12.6)	0.797
Raven APM‡ I	11.3 (1.2)	11.5 (0.8)	0.129
Raven APM II	29.9 (5.5)	30.2 (6.3)	0.2

* Paired Wilcoxon's test
† T-score
‡ APM Advanced Progressive Matrices

remained stable after the on-call duties (11.3 [1.2] versus 11.5 [0.8], P=0.129 for set I; 29.9 [5.5] versus 30.2 [6.3], P=0.2 for set II) [Table 2].

Comparison of changes in test parameters between first- and second-call residents

With a comparable level of sleep deprivation, the two groups of residents had no significant differences with regard to the changes of APM scores, and most of the scales of the OSI-R. The only exceptions were the role insufficiency (+3.43 [1.72] versus +0.50 [3.20]; P=0.026) and the interpersonal strain scales (+3.14 [2.91] versus -3.64 [6.21]; P=0.005) [Table 3].

Correlations between total duration of work and changes in test parameters

The total number of working hours on the on-call day (without sleep) was negatively correlated with the role overload scale (r= –0.6675, P=0.0009) and all four scales of the Personal Strain Questionnaire (vocational strain, r= –0.4918, P=0.023; psychological strain, r= –0.4828, P=0.026; interpersonal strain, r= –0.4391, P=0.046; physical strain, r= –0.5107, P=0.018). There were no correlations between the total number of working hours and changes in results of either set of the APM (Table 4).

Discussion

Previous studies that assess the functioning of physicians have not adequately addressed the higher levels of functioning, such as clear thinking and problem identification. Physicians with little sleep may be able to react quickly and to perform tasks previously mastered, but may have difficulties making key decisions and solving complex problems often presented in clinical practice.[17] In addition, studies investigating the effects of sleep deprivation on the psychological and functional performance of on-call medical staff have shown conflicting results.[7,13,18] Differences in participants' specialties, definitions of sleep deprivation, psychological tests used, timing of tests, and different shift patterns may explain this variability.[19,20]

This study aimed at assessing how sleep deprivation affects a resident's ability to perform his or her job. Clinical performance is very difficult to measure, especially when there is no standard means of doing it.[10,11] The APM test assesses eductive mental activity, which is the higher-level functioning that a clinician requires in clinical practice.[16] Timed testing penalises those who work more slowly and carefully; untimed testing tends to yield more useful results in terms of intellectual capacity.[14] Occupational stress has been defined as job characteristics that pose a threat to the individual, and occupational strain as a deviation from a normal response that an individual would experience in a given situation.[15] Furthermore, coping skills[21,22] are critical in the definition of occupational stress and are included in the occupational stress inventory development.[15]

In this study, we have prospectively studied the effects of acute sleep deprivation on the level of stress and cognitive functioning of medical residents using two tests. To maximise the effects of acute sleep deprivation, repeated tests were performed towards the end of the on-call period. We considered the amount of time required to take the series of tests (70-90 minutes) to be sufficient to evaluate parameters, such as sustained concentration,[11,23] which has been regarded by Asken and Raham[24] to be vulnerable to sleep deprivation. The standard error of measurement (SEM) of a test is based on a test's reliability and SD, both of which vary with the population tested.[14] Although it can be expected that the APM is a test with relatively high discriminative power and reliability, with an SD of 8.8 and a

Table 3. Comparison of score changes (from pre- to post-call) in test parameters between first- and second-call residents

	First call, n=7 Mean (SD)	Second call, n=14 Mean (SD)	P value*
Occupational Stress Inventory–Revised†			
Occupational Role Questionnaire			
Role overload	+1.14 (2.67)	+1.00 (6.35)	0.4
Role insufficiency	+3.43 (1.72)	+0.50 (3.20)	0.026
Role ambiguity	+0.71 (2.75)	+0.43 (3.34)	0.881
Role boundary	+1.43 (5.35)	-0.21 (4.63)	0.653
Responsibility	-3.14 (4.88)	+1.36 (3.69)	0.059
Physical environment	-3.14 (2.54)	-0.14 (5.13)	0.187
Personal Strain Questionnaire			
Vocational strain	+17.1 (2.69)	+1.50 (6.26)	0.85
Psychological strain	+2.00 (2.71)	-0.86 (5.64)	0.078
Interpersonal strain	+3.14 (2.91)	-3.64 (6.21)	0.005
Physical strain	+0.57 (2.51)	+0.21 (3.81)	0.625
Personal Resources Questionnaire			
Recreation	-4.00 (4.90)	-0.50 (3.03)	0.09
Self-care	+0.57 (3.31)	+1.86 (3.74)	0.366
Social support	-3.14 (3.18)	-0.35 (3.71)	0.124
Rational/cognitive coping	+1.43 (5.62)	+0.43 (7.21)	0.82
Raven APM‡ I	+0.29 (0.95)	+0.21 (0.58)	0.92
Raven APM II	+0.43 (3.95)	+0.36 (1.86)	0.341

* Mann-Whitney *U* test
† T-score
‡ APM Advanced Progressive Matrices

commonly reported reliability of 0.9, the SEM of the APM set II according to British standardisation is about 2.5. Hence, about one in three of a random sample of people who are retested would get a score that differs from their first score by more than 2.5.[14] If the tests are repeated, the overall set II scores would increase by an average of 3 points.[14] Thus, we retested the residents after an interval of 8.9 [SD, 2.3] days, trying to diminish any impact of practice effect on retesting. We admit that there is no evidence to show that we completely eliminated such an effect in the study.

Compared with the data from the 1992 British Standardisation and the 1993 Standardisation in Des Moines, Iowa,[14] residents' baseline scores in our study correspond to the 90th percentile in both contexts for sets I and II. The average results of the residents compare favourably with those of Zhang's series of adults in the People's Republic of China and college undergraduates from other countries.[14]

It might be expected that high scores on occupational stress and personal strain scales (Occupational Role Questionnaire and Personal Strain Questionnaire) are not surprising given the nature of medical residents' work. The average profile from the baseline study did not present the picture of a group under considerable burden of responsibility and undesirable physical work conditions. None of the Occupational Role Questionnaire and Personal Strain Questionnaire scales exceeded the normal range (40-59 T-score).[15] It is also true that the levels of the group's coping resources (Personal Resources Questionnaire scales) were generally adequate (40-59 T-score). The rational/cognitive coping scale had a mean T-score of 37.3 and thus suggested mild deficits in these skills.[15] With reference to the nature of doctors' work, it is not surprising that doctors might not be able to put their jobs completely out of mind after a day's work. Such a deficiency in cognitive skills might also indicate that residents had not set and followed priorities, or re-examined and re-organised their work schedule optimally.

Table 4. Correlations between total duration of work and changes in test parameters from pre- to post-call

	Correlation coefficient	P value*
Occupational Stress Inventory–Revised		
Occupational Role Questionnaire		
Role overload	-0.6675	0.0009
Role insufficiency	-0.2236	0.308
Role ambiguity	-0.3686	0.1
Role boundary	-0.3043	0.18
Responsibility	0.3573	0.112
Physical environment	0.1587	0.492
Personal Strain Questionnaire		
Vocational strain	-0.4918	0.023
Psychological strain	-0.4828	0.026
Interpersonal strain	-0.4391	0.046
Physical strain	-0.5107	0.018
Personal Resources Questionnaire		
Recreation	0.2285	0.319
Self-care	0.1209	0.602
Social support	-0.0492	0.832
Rational/cognitive coping	0.1182	0.61
Raven APM† I	-0.0341	0.883
Raven APM II	-0.0535	0.818

* Spearman's rank correlation
† APM Advanced Progressive Matrices

Whereas the total duration of work correlated with changes in some scales of the OSI-R (role overload scale and scales in the Personal Strain Questionnaire—Table 4), the performance in both the APM set II and OSI-R did not change significantly with acute sleep loss among residents who had slept 2.9 hours only during 29.3 [SD, 3.8] hours of on-call duties. This observation echoes the findings of Bartle et al,[25] who had also used the APM, and is reassuring in that cognitive function is an integral part of a physician's job.

There are possible explanations for our apparently negative results. Validation studies have shown that the APM test can predict about 10% of the variance in performance within a wide range of occupations, including professionals.[14] However, we understand the limited discriminative power of psychological tests.[14] In fact, the real-life performance of people with marginally different scores would be indistinguishable, and there could be enormous variation between performances of people with the same score.[14] Thus, it is possible that the tests used were not sufficiently sensitive to discriminate between rested and sleep-deprived residents.

Another possibility is that residents may perform as well in acute sleep-deprived condition as they do when well rested. Webb and Agnew[26] have shown that adaptation to reduced sleep is possible. Moderate fatigue could be associated with a state of high, rather than low, arousal,[27] and the tests used in this study may have stimulated an arousal state.

Previous studies of sleep loss in residents have shown that the severity of neurobehavioural impairment may be similar in both short-term sleep loss (recent 24-hour complete sleep loss) and chronic partial sleep restriction (<6 hours of sleep per night for at least 1 week).[11] One study found that performance testing of vigilance (responsiveness to simple repeated tasks) and serial mathematical calculations were equally affected by 24 hours of total sleep loss and 1 week of sleep restriction to 5 hours of sleep per night.[28,29] Because we did not include an assessment of sleep both before the study or in between the pre- and post-call tests, there is no way that we could have excluded the possibility that the residents studied were indeed chronically deprived of sleep.

Yet another possible explanation for the findings is that the level of sleep deprivation in this study (<3 hours of sleep in a 29.3-hour period) was not severe enough to induce changes in performance. However, although sleep was possible during on-call duty, it would have been fragmented. A longer duration of acute sleep deprivation might have produced different results.

Other variables that may affect performance after sleep loss include intake of caffeine or other stimulants, physical exertion,[30-32] ambient temperature,[33] body temperature,[34] and recent food intake.[35] Thus, studies evaluating the effects of sleep loss on neurobehavioural performance should ideally be carefully controlled for such factors.

Although the results of this study suggest that acute moderate sleep deprivation may not adversely affect residents' performance, Wilkinson et al[36] asked British house officers in a survey: "Do you think your hours of duty are so long as to impair your ability to work with adequate efficiency?" Of the 2452 respondents, about 3% answered "always", 34% answered "often", 48% answered "occasionally", 12% answered "rarely", and 3% answered "never".

The baseline data from the OSI-R test showed that the residents were working under a normal dose of occupational stress and psychological strain. At the same time, they had an average level of coping resources. These results, and the fact that there was no significant deterioration with acute sleep deprivation, are encouraging. The relationship between loss of sleep, long hours of work, and psychological stress is a complex one. Night-shift work resulting in loss of sleep certainly produces stress reactions. But the anxiety resulting from the stress could lead to insomnia. To some extent, the relationship between these variables depends on the experience and personality of the individual doctor.[37]

We expected and found no correlations between changes in the two sets of test parameters when they were used to assess different areas of functioning. In terms of changes in test parameters in the first- and second-call residents, the two groups tended to behave similarly. After the on-call work, there was no significant change in the role insufficiency score for the second-call residents, but there was an increase of 3.43 among those on first call. Similarly, there was a discrepancy in the changes of interpersonal strain score of the two groups (Table 3). Thus, the feeling of a poor fit between their skills and the job they were performing, and the level of interpersonal strain might have been affected by a resident's experience.

Conclusion

This is a small study that attempted to answer a complex question with a simple experimental design. It cannot, however, definitively answer the critical questions regarding the relationship between work hours, sleep deprivation, and work performance. With this in mind, we have used a reasonable "real-life" design with standardised tests that measure cognitive performance and stress. The results of this study did not support the hypothesis that acute sleep deprivation negatively affects a medical resident's performance in the domains of eductive ability and psychological stress and strain. We understand that circadian timing of the testing, practice effects, differences in accumulated sleep debt, and previous training experiences would have been potential confounders in the study. Further evaluation should be undertaken to determine the effects of sleep deprivation on more subtle levels of performance, especially those specifically related to residency duties.

Acknowledgement

The authors acknowledge the help of Ms Tracy Ma, Clinical Psychologist of Kwong Wah Hospital, on the choice and use of psychological tests.

References

1. Gordon NP, Cleary PD, Parker CE, Czeisler CA. The prevalence and health impact of shiftwork. Am J Public Health 1986;76:1225-8.
2. Poissonnet CM, Veron M. Health effects of work schedules in healthcare professions. J Clin Nurs 2000;9:13-23.
3. Spurgeon A, Harrington JM, Cooper CL. Health and safety problems associated with long working hours: a review of the current position. Occup Environ Med 1997;54:367-75.
4. Holzman IR, Barnett SH. The Bell Commission: ethical implications for the training of physicians. Mt Sinai J Med 2000;67:136-9.
5. Daugherty SR, Baldwin DC Jr, Rowley BD. Learning, satisfaction, and mistreatment during medical internship: a national survey of working conditions. JAMA 1998;279:1194-9.
6. Van Deursen CGL, Mul CAM, Smulders PGW, DeWinter CR. Health and working situation of day nurses compared with a matched group of nurses on rotating shift work. Occupational health for health care workers. In: Hagberg M, Hofmann F, St bel U, Westlander G, editors. Occupational Health for Health Care Workers. Congress on Occupational Health. Ecomed; 1993:83-7.
7. Storer JS, Floyd HH, Gill WL, Giusti CW, Ginsberg H. Effects of sleep deprivation on cognitive ability and skills of pediatrics residents. Acad Med 1989;64:29-32.
8. Beatty J, Ahern BK, Katz R. Sleep deprivation and the vigilance of anesthesiologists during simulated surgery. In: Mackie RR, editor. Vigilance: theory, operational performance, and physiological correlates. New York: Plenum Press; 1977:511-27.
9. Denisco RA, Drummond JN, Gravenstein JS. The effect of fatigue on the performance of a simulated anesthetic monitoring task. J Clin Monit 1987;3:22-4.
10. Samkoff JS, Jacques CH. A review of studies concerning the effects of sleep deprivation and fatigue on residents' performance. Acad Med 1991;66:687-93.
11. Veasey S, Rosen R, Barzansky B, Rosen I, Owens J. Sleep loss and fatigue in residency training: a reappraisal. JAMA 2002;288:1116-24.
12. Firth-Cozens J, Moss F. Hours, sleep, teamwork, and stress. Sleep and teamwork matter as much as hours in reducing doctors' stress. BMJ 1998;317:1335-6.
13. Friedman RC, Kornfeld DS, Bigger TJ. Psychological problems associated with sleep deprivation in interns. J Med Educ 1973;48:436-41.
14. Raven J, Raven JC, Court JH. Manual for Raven's progressive matrices and vocabulary scales: section 4, advanced progressive matrices. Oxford: Oxford Psychologists Press; 1998.
15. Osipow SH. Occupational stress inventory. Revised edition. Florida: Psychological Assessment Resources, Inc; 1998.
16. Raven J, Raven JC, Court JH. Manual for Raven's progressive matrices and vocabulary scales: section 1, general overview. Oxford: Oxford Psychologists Press; 1998.
17. Alexander D, Bushell IW. Coping with night call: part 1: understanding the benefits and challenges of traditional call. Hosp Physician 1999; 35:53-69.
18. Lewis KE, Blagrove M, Ebden P. Sleep deprivation and junior doctors' performance and confidence. Postgrad Med J 2002;78:85-7.
19. Blagrove M, Akehurst L. Effects of sleep loss on confidence-accuracy relationships for reasoning and eyewitness memory. J Exp Psychol Appl 2000;6:59-73.
20. Dorrian J, Lamond N, Dawson D. The ability to self-monitor performance when fatigued. J Sleep Res 2000;9:137-44.
21. Lazarus RB, Averill JR, Opton EM Jr. The psychology of coping: issues of research and assessment. In: Coehlo GV, Hamburg DA, Adams JE, editors. Coping and adaptation. New York: Basic Books; 1974: 249-315.
22. Roskies E, Lazarus RS. Coping theory and the teaching of coping skills. In: Davidson PO, Davidson SM, editors. Behavioral medicine: Changing health lifestyles. New York: Bruner Mazel; 1980:38-69.
23. Kleitman N. The effects of prolonged sleeplessness on man. Am J Physiol 1923;66:67-92.
24. Asken MJ, Raham DC. Resident performance and sleep deprivation: a review. J Med Educ 1983;58:382-8.
25. Bartle EJ, Sun JH, Thompson L, Light AI, McCool C, Heaton S. The effects of acute sleep deprivation during residency training. Surgery 1988;104:311-6.
26. Webb WB, Agnew HW Jr. The effects of a chronic limitation of sleep length. Psychophysiology 1974;11:265-74.
27. Cameron C. Fatigue problems in modern industry. Ergonomics 1971; 14:713-20.
28. Linde L, Bergstrom M. The effect of one night without sleep on problem-solving and immediate recall. Psychol Res 1992;54: 127-36.
29. Polzella DJ. Effects of sleep deprivation on short-term recognition memory. J Exp Psychol [Hum Learn] 1975;104:194-200.
30. De Valck E, Cluydts R. Slow-release caffeine as a countermeasure to driver sleepiness induced by partial sleep deprivation. J Sleep Res 2001; 10:203-9.
31. Kingshott RN, Vennelle M, Coleman EL, Engleman HM, Mackay TW, Douglas NJ. Randomized, double-blind, placebo-controlled crossover trial of modafinil in the treatment of residual excessive daytime sleepiness in the sleep apnea/hypopnea syndrome. Am J Respir Crit Care Med 2001;163:918-23.
32. Wiegmann DA, Stanny RR, McKay DL, Neri DF, McCardie AH. Methamphetamine effects on cognitive processing during extended wakefulness. Int J Aviat Psychol 1996;6:379-97.
33. Franco P, Szliwowski H, Dramaix M, Kahn A. Influence of ambient temperature on sleep characteristics and autonomic nervous control in healthy infants. Sleep 2000;23:401-7.
34. Cajochen C, Knoblauch V, Krauchi K, Renz C, Wirz-Justice A. Dynamics of frontal EEG activity, sleepiness and body temperature under high and low sleep pressure. Neuroreport 2001;12:2277-81.
35. Edwards SJ, Montgomery IM, Colquhoun EQ, Jordan JE, Clark MG. Spicy meal disturbs sleep: an effect of thermoregulation? Int J Psychophysiol 1992;13:97-100.
36. Wilkinson RT, Tyler PD, Varey CA. Duty hours of young hospital doctors: effects on the quality of work. J Occup Psychol 1975;48: 219-29.
37. Poulton EC, Hunt GM, Carpenter A, Edwards RS. The performance of junior hospital doctors following reduced sleep and long hours of work. Ergonomics 1978;21:279-95.