Junior doctors and the full shift rota – psychological and hormonal changes: a comparative cross-sectional study

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ABSTRACT – We studied the hormonal and psychological effect of the full shift rota on junior doctors after implementation of the European Working Time Directive, using a comparative, cross-sectional study design of male doctors in South Yorkshire. Cortisol and testosterone levels were measured and subjects completed the general health questionnaire (GHQ-12) and the androgen deficiency in the aging male screening questionnaire (ADAM), after a week of holiday (baseline), a week of nights, and a normal working week. The results showed that cortisol levels decreased from 480.6±33.1 nmol/l at baseline (after a week of holiday), to 355.7±29.1 nmol/l post normal working week (p=0.003); to 396.7±32.5 nmol/l post nights (p=0.03). GHQ-12 scores increased from 0.5±0.3 at baseline, to 1.8±0.5 post normal working week (p=0.02) and to 2.3±0.5 post nights (p=0.005). These results suggest that there are still appreciable physiological consequences with new work patterns.

KEY WORDS: hormones, junior physician, psychology

Objectives

Historically junior doctors' training involved long working hours with little sleep overnight[1] and was recognized to be hazardous to both the doctor's and patient's health.[1–3] The association between long working hours and illness occurs largely as a result of stress, as doctors try to maintain performance levels with increasing fatigue.[4] Stress results in emotional, behavioral and psychological reactions,[5] such as anxiety, depression, increased consumption of alcohol, increased blood pressure and, in extreme cases, death, through suicide or cardiovascular disease. There is evidence that shift work is associated with an increased risk of cardiovascular disease[6] and gastrointestinal disorders,[7] which are thought to be due to alterations in the circadian rhythm, following changes to the sleep–wake cycle.[8] Circadian adjustment takes time, being most rapid in the first 1–3 days[9] and during this period the subject experiences jet lag or desynchronosis. The most important consequence is reduced quantity and quality of sleep,[8,9] which has been linked to declines in both cognitive and psychomotor performance in junior doctors.[1] Human error is also more common during the night, as shown in the increase in single vehicle car crashes, due to drivers falling asleep at the wheel and driving off the road, which peak between 1 and 4am.[10]

The effect of stress and shift work in doctors was first measured in 1971,[1] in a study of reporting errors on electrocardiographs. More recent studies have shown increased attentional failures[2] and an increase in serious medical errors[3] when doctors work frequent 24-hour shifts, as compared with shifts of a maximum 16 hours and reduced total hours worked per week.

The evidence on the adverse effects of stress, long working hours and sleep deprivation in doctors led to the Government, doctor's representatives and NHS managers to agree the 'New Deal' in 1991. This improved junior doctors working conditions, by ensuring that the maximum contracted hours for a full shift rota should be 56 per week by 1996. However, by March 2000, 36% of junior doctor posts did not comply.[6] More recently the European Working Time Directive has been implemented and by August 2009 the maximum working week should be 48 hours. This means that junior doctors' working hours are limited to a maximum 13-hour shift, followed by a minimum break of 11 hours.[11] Shift work is now commonplace with NHS trusts employing doctors working blocks of seven nights. In December 2004, three quarters of medical senior house officers and up to half of specialist registrars were working this shift pattern.[12] It has recently been reported that today's doctors are exhausted[13] with 70% of specialist registrars reporting problems sleeping in the daytime.[14]

This study was carried out to assess the biochemical and psychological effect of the full shift rota on male junior doctors, focusing on testosterone and cortisol levels as markers of stress.

Study design

This was a comparative, cross sectional study of male doctors in two hospitals in South Yorkshire working a full shift rota and was approved by the local Research Ethics Committee. Informed, written consent was obtained from all participants. Baseline data including age, drug and past medical history were recorded. Blood samples were taken between 8.00am and 9.30am. Levels of cortisol, C-reactive protein (CRP), sex hormone binding globulin (SHBG), and total and bio-available testosterone were measured. Subjects were asked to fill out a general health questionnaire (GHQ-12) and the androgen deficiency in the aging male (ADAM) screening questionnaire after three different shift patterns: after a week of holiday (baseline), a week of nights and a normal working week (9am–5pm). There was no consistent relationship between these three periods.

Participants

32 doctors, age range 24–38 years, were recruited between January 2002 and December 2002. Subjects were excluded if they were taking hormone-manipulating therapy or had a chronic inflammatory illness as this could influence the biochemical parameters independent of the work pattern (as indicating an underlying inflammatory condition). Four subjects did not complete the study and two were excluded from further analysis due to raised CRP levels.

Outcome measures

The GHQ-12 questionnaire was used to detect non-psychotic psychological symptoms, such as anxiety and depression. It consists of 12 questions, each having four responses. The participants' answers were scored, as 0-0-1-1 based on their responses and a total score out of 12 was determined. A score greater than three was used as the threshold for high levels of psychological symptoms.[15] Increasing scores on the GHQ-12 questionnaire represent deteriorating mental health. The ADAM questionnaire has been validated in older men,[16] to assess for androgen deficiency, but there is no available questionnaire to use in this age group. It comprises 10 questions, with 'yes' or 'no' answers. Each 'yes' answer was given a score of one and a total score out of 10 was determined. A positive score is defined as a score of three or more, or a single positive response to any one of two highly specific questions: 'Do you have reduced libido?' or 'Do you have reduced ability to maintain erections?' Cortisol and CRP were measured by standard hospital assays (Centaur, Bayer and Synchron, Beckman) and serum total testosterone and SHBG were measured by enzyme immunoassay (DRG Instruments GmbH, Germany). Percentage bio-available testosterone was assayed using an adaptation of the method described by Tremblay and Dube,[17] where 3H-labelled testosterone radioactive tracer was measured in the supernatant fraction following ammonium sulphate precipitation of SHBG. The concentration of bioavailable testosterone was then calculated from the percentage of the total testosterone.

Baseline measurements were taken after a holiday and the two subjects with a high CRP result were excluded from further participation as inflammation may influence the hormone response. Analysis was undertaken to confirm the data were parametric using Kolmogorov–Smirnov test. Intra-variable comparisons were made using single factor ANOVA with post-hoc t-tests, where appropriate. Unless otherwise stated, data are expressed as mean ± standard error of the mean (SEM). Statistical significance was accepted at $p<0.05$.

Key Points

Junior doctors' training has been associated with long hours and little overnight sleep which are known to reduce psychomotor performance and increase medical errors

Recent legislation, namely the 'New Deal' and the European Working Time Directive, have reduced the number of hours that doctors are allowed to work

Although junior doctors' hours have been reduced, significant falls in cortisol levels and general well being, as measured by GHQ-12, are found following a normal working week and a week of nights, compared to after a holiday. This suggests that junior doctors are still under considerable stress during these shift patterns

Results

General health

Scores on the GHQ-12 showed significant increases both after a normal working week and after nights when compared to baseline, representing a decline in mental health (0.5±0.3 baseline, 1.8±0.5 after a normal working week ($p=0.02$), 2.3±0.5 after nights ($p=0.005$)). The ADAM scores significantly increased from baseline following a normal working week and after nights (0.4±0.2 at baseline to 2±0.4 ($p=0.0007$) normal working and 2.0±0.4 ($p=0.0006$) after nights (Table 1)), with 8.3% of participants having positive ADAM scores at baseline, compared to 28% during a normal working week and 40% post nights.

Hormones

Cortisol levels significantly decreased from baseline values following a normal working week and after nights (480.6±33.1 nmol/l at baseline to 355.7 ±29.1 nmol/l after a normal working week ($p=0.003$), to 396.7±32.5 nmol/l after nights ($p=0.03$) (Table 1)).

There were no significant differences in the levels of bio-available and total testosterone during the study period. Levels of SHBG increased from baseline following a normal working week (25.8±2.2 nmol/l to 28.6±2.2 nmol/l ($p=0.03$)) before returning to near baseline values post nights (25.1±2.6 nmol/l ($p=0.54$)) (Table 1).

Discussion

Effect on psychological well-being

The GHQ-12 questionnaire is widely used to detect non-psychotic psychiatric disorders, such as depression and anxiety, with a high sensitivity and specificity.[18] Previous studies using the GHQ in doctors have shown 22% to 46% have features of depression and anxiety,[19,20] compared to 18% of the general working population.[21] In this study we have shown that well-being was best after a holiday and that it deteriorated after a normal working week – especially after a week of nights. A GHQ-12 score of >3 is the threshold for high levels of psychological symptoms. In this study 4% of doctors had a score >3 after a holiday (n=1) compared with 24% after a normal working week (n=6) and 33% after a week of nights (n=10). A positive score on the GHQ-12 questionnaire (>3), also indicates high levels of stress, which are associated with increased rates of medical errors and reduced quality of patient care.[20,22,23] We have therefore shown that compared to baseline, following a normal working week and a week of nights there are appreciable decreases in the mental health of doctors, which may have long term consequences not only for the doctors themselves, but for the patients under their care.

Effect on cortisol

This study shows that a full shift rota is associated with significant biochemical and psychological effects on junior doctors. Significant biochemical changes included a decrease in cortisol levels from baseline. Cortisol production is stimulated by adrenocorticotrophin hormone (ACTH), which is controlled by corticotrophin-releasing hormone (CRH) from the hypothalamus (hypothalamus–pituitary–adrenal (HPA) axis). Increased cortisol output is induced by acute stress such as infection, trauma, surgery and hypoglycaemia as well as by various neurotransmitters.[24] There is increasing evidence, however, that chronic stress is associated with reduction in cortisol levels,[25] although the mechanism has not been fully elucidated. Four hypotheses have been proposed[26] including reduced biosynthesis or depletion of the HPA axis; down-regulation of CRH receptors in the pituitary; increased feedback sensitivity of the HPA axis and morphological changes. These mechanisms can also be affected by other factors, such as coping mechanisms.[26] Subjects in demanding situations who are able to exert control over their environment, are found to be able to sustain their work level with a positive outlook and low cortisol levels. Situations with strain, characterised by striving to maintain work goals with variable success, are associated with high cortisol levels.[27] Our results are limited by the fact that we did single-point measurements of cortisol and at the same time of day even after a week of nights, rather than a 24-hour urinary collection. This was to reduce the study's impact on the working life of the doctors involved. The lower cortisol after nights may be influenced by circadian adjustment whereby doctors biochemically adjust to alert periods at night.

Effect on testosterone

In this study bioavailable and total testosterone was measured, with no significant changes over the three periods found. The bioavailable portion comprises free testosterone, which constitutes 2 to 3% of the total testosterone plus the portion bound to albumin (20–40%).[17] The remainder is tightly bound to SHBG (60–80%), making it not readily available to the tissues. This result is in contrast to initial work done by Singer *et al*, which showed a significant reduction in total testosterone in male internal medicine residents, when compared with other hospital staff.[28]

Studies of the effect of stress on testosterone levels have used differing methodologies including both acute and chronic stress, and produced conflicting results. Acute stress was associated with either an increase[29] or decrease[30] in total testosterone. With chronic stress, testosterone levels have been shown to be unaffected,[31] or to fall.[32] These studies used different assays of total testosterone, different times of collection, different stressors, and demonstrated inter-personal variations in response to stress. Although we have not found a significant change in testosterone levels we did find a significant rise in the proportion of doctors with positive ADAM scores. This questionnaire

Table 1. Results of questionnaire on hormone levels after a week of holiday (baseline), a normal working week and a week of nights.

	Baseline (after holiday)	After normal working week	T Test p value	After nights	T Test p value	ANOVA
Bioavailable testosterone	7.2±0.5	6.90±0.5	0.6	6.8±0.5	0.5	0.85
Total testosterone (nmol/l)	17.1±1.4	16.7±1.1	0.97	15.0±1.1	0.1	0.43
SHBG (nmol/l)	25.8±2.2	28.6±2.2	0.03	25.1±2.6	0.8	0.54
Cortisol (nmol/l)	480.6±33.1	355.7±29.1	0.003	396.7±32.5	0.03	0.02
GHQ-12	0.54±0.3	1.8±0.5	0.02	2.3±0.5	0.005	<0.0001
ADAM	0.4±0.2	2±0.4	0.0007	2.0±0.4	0.0006	0.002

Results are shown as mean ± SEM. ADAM = androgen deficiency in aging males questionnaire, GHQ-12 = general health questionnaire-12, SHBG = sex hormone binding globulin.

is used to detect androgen deficiency in older patients, with 88% sensitivity and 60% specificity,[16] although symptoms of anxiety and depression, and androgen deficiency are similar.

These results show that although changes may have occurred in the number of hours junior doctors work, there are still appreciable biochemical and psychological changes with new work patterns.

References

1 Friedman RC, Bigger JT, Kornfeld DS. The intern and sleep loss. *N Engl J Med* 1971;**285**:201–3.

2 Lockley SW, Cronin JW, Evans EE, Cade BE *et al*. Effect of reducing interns' weekly work hours on sleep and attentional failures. *N Engl J Med* 2004;**351**:1829–37.

3 Landrigan CP, Rothschild JM, Cronin JW, Kaushal R *et al*. Effect of reducing interns' work hours on serious medical errors in intensive care units. *N Engl J Med* 2004;**351**:1838–48.

4 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.

5 Levi A. A model for assessing the costs of stressors at national level. In: *European foundation for the improvement of living and working conditions*. Dublin, 1996.

6 JDC Report. *Implications for health and safety of junior doctors' working arrangements*. London: BMA, 2000.

7 Tuchsen F, Jeppesen HJ, Bach E. Employment status, non-daytime work and gastric-ulcer in men. *Int J Epidemiol* 1994;**23**:365–70.

8 Winget CM, Deroshia CW, Markley CL, Holley DC. A review of human physiological and performance changes associated with desynchronosis of biological rhythms. *Aviat Space Environ Med* 1984;**55**:1085–96.

9 Akerstedt T. Psychological and psychophysiological effects of shift work. *Scand J Work Environ Health* 1990;**16**:67–73.

10 Dawson D, Armstrong SM. Chronobiotics – drugs that shift rhythms. *Aliment Pharmacol Ther* 1996;**69**:15–36.

11 Council Directive 93/104/EC. *Official Journal of the European Community*. 1993.

12 Mather H, Pounder RE. *Coping with problems in acute medicine in the post-WTD era – a survey of RCP college tutors in December 2004*. London: RCP, 2005.

13 Murray A, Pounder R. Junior doctors' shifts and sleep deprivation. *BMJ* 2005;**330**:1404.

14 Horrocks N, Pounder RE. Working the night shift: an audit of the experiences and views of SPRs. www.rcplondon.ac.uk/news/EWTD_nightshift.pdf

15 Firth-Cozens J. Emotional distress in junior house officers. *BMJ* 1987;**295**:533–36.

16 Morley JE, Charlton E, Patrick P, Kaiser FE *et al*. Validation of a screening questionnaire for androgen deficiency in aging males. *Metabolism* 2000;**49**:1239–42.

17 Tremblay RR, Dube JY. Plasma concentrations of free and non-TeBG bound testosterone in women on oral contraceptives. *Contraception* 1974;**10**:599–605.

18 Boardman AP. The General Health Questionnaire and the detection of emotional disorder by general-practitioners – a replicated study. *Brit J Psychiatry* 1987;**151**:373–81.

19 Kapur N, Borrill C, Stride C. Psychological morbidity and job satisfaction in hospital consultants and junior house officers: multicentre, cross sectional survey. *BMJ* 1998;**317**:511–2.

20 Caplan RP. Stress, anxiety, and depression in-hospital consultants, general-practitioners, and senior health-service managers. *BMJ* 1994; **309**:1261–3.

21 Wall TD, Bolden RI, Borrill CS, Carter AJ *et al*. Minor psychiatric disorder in NHS trust staff: occupational and gender differences. *Brit J Psychiatry* 1997;**171**:519–23.

22 Jones JW, Barge BN, Steffy BD, Fay LM *et al*. Stress and medical malpractice – organizational risk assessment and intervention. *J Appl Psychol* 1998;**73**:727–35.

23 Firth-Cozens J. Interventions to improve physicians' well-being and patient care. *Soc Sci Med* 2001;**52**:215-22.

24 Genuth SM. Adrenal Cortex. In: Berne RM, Levy MN. *Principles of Physiology*. St Louis: Mosby, 2000.

25 Pruessner JC, Hellhammer DH, Kirschbaum C. Burnout, perceived stress, and cortisol responses to awakening. *Psychosom Med* 1999;**61**: 197–204.

26 Heim C, Ehlert U, Hellhammer DH. The potential role of hypocortisolism in the pathophysiology of stress-related bodily disorders. *Psychoneuroendocrinology* 2000;**25**:1–35.

27 Hockey GRJ, Payne RL, Rick JT. Intra-individual patterns of hormonal and affective adaptation to work demands: an n=2 study of junior doctors. *Bio Psychol* 1996;**42**:393–411.

28 Singer F, Zumoff B. Subnormal serum testosterone levels in male internal-medicine residents. *Steroids* 1992;**57**:86–9.

29 Tigranian RA, Orloff LL, Kalita NF, Davydova NA *et al*. Changes in blood levels of several hormones, catecholamines, prostaglandins, electrolytes and cAMP in man during emotional stress. *Endocrinol Exp* 1980;**14**:101–12.

30 Schulz P, Walker JP, Peyrin L, Soulier V *et al*. Lower sex hormones in men during anticipatory stress. *Neuroreport* 1996;**7**:3101–4.

31 Allen PIM, Batty KA, Dodd CAS, Herbert J *et al*. Dissociation between emotional and endocrine responses preceding an academic examination in male medical-students. *J Endocrinol* 1985;**107**:163–70.

32 Francis KT. The relationship between high and low trait psychological stress, serum testosterone, and serum cortisol. *Experientia* 1981;**37**: 1296–7.