Original article

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Weekday and weekend patterns of diurnal cortisol, activation and fatigue among people scoring high for burnout

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Objectives The present pilot study attempted to investigate the diurnal pattern of cortisol, subjective activation, and mental fatigue among workers scoring high for burnout. The purpose was also to relate the cortisol data to objective sleep data.
Methods One group with high (N=9) burnout scores and one with low (N=11) such scores were compared during a workday and a day off.
Results The high-burnout group showed higher awakening cortisol during the workday than during the weekend. They also showed higher ratings for activation and mental fatigue during the weekend than the low-burnout group. A higher frequency of arousals during the prior sleep was associated with a higher diurnal amplitude and an earlier diurnal peak of cortisol during the workday.
Conclusions The present results, which, due to the small sample size, should be interpreted with caution, may indicate that stress-induced frequency of arousal during sleep could contribute to the diurnal amplitude of cortisol. Furthermore, increased activation and mental fatigue during the weekend may reflect impaired recovery, which is of possible importance in the burnout process.

Key terms burnout; cortisol; fatigue; recovery; sleep; stress.

Burnout is a growing health problem in many western countries (1). The characteristic clinical symptoms of the condition are excessive and persistent fatigue, emotional distress, and cognitive dysfunction (2–4). Burnout is related to long-term work stress, and sustained strain in daily life (2, 5). The symptomatology is shared, to some extent, with disorders such as depression (6), chronic fatigue syndrome (7), and vital exhaustion (8).

The physiological mechanism behind burnout is unknown, but it has been suggested to include long-term allostatic up-regulation of the hypothalamic-pituitary-adrenal (HPA) axis, leading to subsequent down-regulation with decreased responsiveness to challenges (9). However, the cortisol data available are inconclusive. Elevated morning cortisol has been found in some studies (10–12), but the opposite has also been found (13, 14), and diurnal data regarding cortisol in persons suffering from burnout is lacking.

As persistent fatigue or exhaustion is the main feature of burnout, recovery (sleep and relaxation) may play an important role in the process of developing burnout. Sleep disturbance has been reported in persons with burnout in questionnaire studies (10, 11) and in one recent study using polysomnography (15). The latter used the same sample of people as our present study, and the results showed an increased frequency of arousals in the burnout group both during the workweek and during the weekend (15). Furthermore, results from other studies have shown a connection between sleep disturbance and cortisol levels (16–19), and our own study showed a relation between the frequency of arousals and cortisol on awakening (20). However, cortisol has a pronounced circadian rhythm, and it is possible that also the diurnal pattern may be changed during burnout. The aim of the present study was to investigate the diurnal pattern of salivary cortisol, subjective activation, and mental

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fatigue during a workday and a day off among people scoring high versus low with respect to burnout. In addition, the purpose was to relate objective sleep parameters to the cortisol data.

Study population and methods

Study population

The study was carried out in an information technology company subjected to high production pressure. A questionnaire focusing on stress at work, health, sleep, and lifestyle was distributed to all of the employees. A total of 414 of 676 employees completed the questionnaire. To locate the participants with burnout symptoms, a modified version of the Shirom-Melamed Burnout Questionnaire (SMBQ) (3, 10, 21), graded 1–4=almost always, was used. The 4-grade scale correlated highly ($r=0.78$, $P<0.001$) with the original 7-grade scale administrated 2 months later to the selected sample. The respondents from the initial questionnaire were allocated to two groups on the basis of scores on the modified SMBQ. Inclusion criteria for the high-burnout group was set at ≥ 2.75 (overall mean, representing 6% of the original sample), on the basis of clinical data from our stress clinic (22), and at a mean of ≤ 1.5 (overall mean, representing 14% of the original sample) for the low-burnout group. The groups were labeled "high-burnout group" and "low-burnout group, in order to reflect their high versus low scores on the SMBQ. Twelve participants in the high-burnout group were randomly selected, and all of them agreed to participate in the study. Twelve control participants were thereafter selected from the low-burnout group, matched for gender, age, and experience in the company. If more than one person in the low-burnout group met the matching criteria, selection between these persons was made randomly. Two selected persons in the control group declined participation and were replaced by two others, selected from the low-burnout group as already described. The properties of the selected sample are presented in table 1. After recruitment, the participants were given verbal information about the procedures. All of them gave their written informed consent to participate. There was no monetary incentive involved. The study was approved by the ethics committee of the Karolinska Institutet.

Procedure

Saliva samples were collected over 2 days (a workday and a day off) to measure free cortisol concentrations. Ambulatory sleep recordings were carried out in the participants' homes (the nights prior to the saliva sampling). The data on sleep and sleepiness can be found in the report of Söderström et al (15). Daytime ratings included sleepiness, activation, and mental fatigue every 2 hours from awakening to bedtime.

Measurements

The participants were instructed to sample saliva (Salivette®, Sarstedt, Rommelsdorf, Germany) at the time of awakening, and at 15, 30, and 60 minutes thereafter in order to identify the postawakening peak. The morning saliva was sampled between 0530 and 0730 (before breakfast). The participants continued to sample saliva at 1100, 1500, 1900, 2100, 2300, and/or at bedtime in order to evaluate the diurnal cortisol pattern. The participants were instructed not to eat or to brush their teeth for at least 30 minutes before giving a saliva sample to avoid contamination of the saliva by food or blood. Salivary cortisol was determined by radioimmunoassay techniques (Orion Diagnostica, Espoo, Finland). The lower limit of detection was 1 nmol/l in the saliva and the average inter- and intraassay coefficient of variation never exceeded 10%.

The diary consisted of one sleep diary, the Karolinska Sleep Diary (KSD) (23), and one daytime diary. For more details on the KSD and for the results of these measurements, see Söderström et al (15). The daytime diary included questions concerning the workday, rest and recovery, and health complaints. Perceived activation was rated every second hour throughout the diary period. The scale ranged from 1 to 9 (very relaxed–very activated). In the same way, mental fatigue was measured every second hour on a scale ranging from 1 to 9 (very fresh–exhausted).

Table 1. Sociodemographic and lifestyle variables for the participants with high and low burnout scores.

Group	Age (years)		Gender		Menstrual cycle phase		Use of hormonal contraceptives		Sick leave during previous 3 months		Married or cohabiting (N)	Number of children		Number of managers or project leaders	Amount of excercise (moderate to hard) (N)		Present smokers (N)	Alcohol intake (once per week) (N)
	Mean	SD	Male (N)	Female (N)	Follicle	Luteal	Yes	No	Yes	No		<7 years of age	>7 years of age		<twice per week	>twice per week		
High burnout	30	2	5	7	3	4	5	2	4	8	6	2	1	2	9	3	0	9
Low burnout	31	2	5	7	3	3	4	3	4	7	5	1	2	6	7	5	0	11

The SMBQ consists of a list of 22 symptom sentences measuring different facets of the burnout syndrome, like "My batteries are empty", "I am tense", "I am fed up", "I feel restless", "I feel full of vitality" (reverse scored), "My head is not clear" (3, 24). Each item was scored on a 7-point scale graded from 1 to 7 (almost never–almost always). An overall burnout index was calculated for each participant, with a reliability coefficient (Chronbach's alpha) of 0.90. This index correlates highly with the emotional exhaustion subscale of the Maslach Burnout Inventory and with Pine's Burnout measure (11).

Statistical analyses

The differences between the groups were analyzed using a two-factor repeated-measures analysis of variance (ANOVA) (with Greenhouse-Geisser correction for sphericity) (25). All of the values in the analyses are expressed as means and the standard error of the means. All of the calculations were carried out using Statview software (version 5.0.1) (SAS Institute Inc, Cary, NC, USA) and SPSS 10.0 (SPSS Inc, Chicago, Il, USA) for Macintosh.

To obtain similar intersample intervals in the analysis of the diurnal cortisol pattern, we included the awakening value and the value at 1100, 1500, 1900, and 2300 in the analysis. The diurnal amplitude of cortisol was calculated as the difference between the postawakening peak value and the bedtime value. This method was used since the cortisol levels at these two points in time were expected to show the largest difference between each other throughout the day. Three participants in the high-burnout group and one in the low-burnout group were omitted from the analysis due to missing data.

Results

Cortisol in saliva

Figure 1 shows the diurnal pattern of cortisol in saliva on a workday and on a day off for the two burnout groups. The results showed no main effect of group or day, but there was, however, a significant main effect for time of day ($F_{4,72}$=54,20, P=0.0001). In addition, there was a significant three-way interaction effect for group by day by time of day ($F_{1,72}$=3,65; P=0.050). No other significant interaction was found. No significant differences were found between the groups at any point in time in the posthoc t-tests. Nor were there any differences within the groups when each time point workday–weekend was compared using the paired t-test, except for the high-burnout group showing higher cortisol at awakening during the workday as opposed to the weekend ($t_{1,8}$=2.37, P=0.045). The postawakening peak of cortisol is plotted in figure 1 for both groups. There was no significant difference in the absolute peak level between the groups during either day (workday: $t_{1,18}$=0.66, P=0.516; weekend: $t_{1,19}$= –0.49, P=0.632). Nor were there any differences between the groups regarding the diurnal amplitude of cortisol (calculated as the difference between the peak value and the bedtime value) during either day (workday: $t_{1,18}$=1.11, P=0.280; weekend: $t_{1,19}$=0.50, P=0.626).

To further investigate possible associations between cortisol and sleep (data from polysomnography), we carried out a set of univariate linear regression analyses (see table 2). The results showed, for the workday

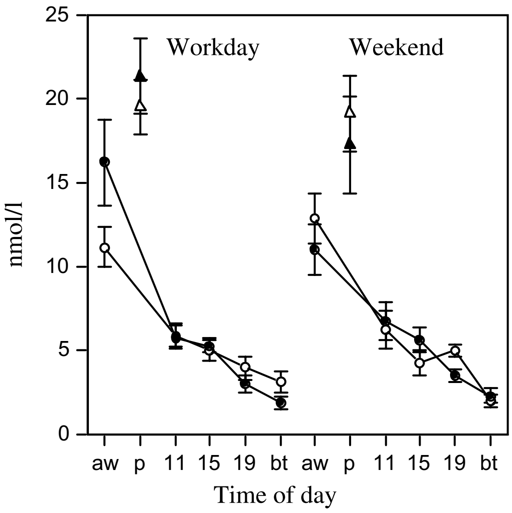

Figure 1. Diurnal pattern of salivary cortisol during a workday and a day off (mean and standard error of the mean) for the groups with high versus low-burnout scores (high burnout = closed circles, low burnout = open circles). The diurnal maximum (postawakening peak) of cortisol is plotted with triangles (mean and standard error of the mean) (high burnout = closed triangles, low burnout = open triangles).

Table 2. Univariate regressions testing polysomnographic data against the diurnalamplitude of cortisol (workday) and the time since awakwning for the cortisol peak (workday). [a] (NS = not significant, WASO = wake after sleep onset, SWS = slow-wave sleep, TST = total sleep time)

Indipendent variables	N	β	Adj R^2	F	P-value
Diurnal amplitude of cortisol (workday)					
Arousals/hour	20	0.513	0.223	6.44	0.021
Sleep efficiency	20		0.01	NS	
WASO	20			0.81	NS
SWS	20			1.82	NS
TST	20			0.00	NS
Time since awakewning for the cortisol peak (workday)					
Arousals/hour	20	–0.492	0.199	5.73	.028
Sleep efficiency	20			0.83	NS
WASO	20			0.23	NS
SWS	20			0.30	NS
TST	20			0.08	NS

[a] Number of participants with peak morning cortisol: 3 at awakening; 4 15 minutes after awakening; 9 30 minutes after awakening, and 4 60 minutes after awakening.

condition, that the frequency of arousals during sleep significantly predicted the diurnal amplitude of cortisol and the time (minutes after awakening) for the diurnal cortisol maximum. Hence a higher frequency of arousals during sleep was associated with a higher diurnal amplitude of cortisol and an earlier postawakening peak for cortisol. The same analyses were conducted regarding weekend data, but they yielded no significant results. Slow wave sleep (%), time awake after sleep onset (%), sleep efficiency, and total sleep time were also tested as independent variables against diurnal amplitude and postawakening peak time (for the workday and the day off), but no significant results were found.

Activation and mental fatigue during a workday and a day off

Figure 2 shows the subjective ratings of activation during a workday and a day off for the two groups. The results of the repeated measures ANOVA showed significant main effects for group ($F_{1,20}$=7,77, P=0.011), day ($F_{1,20}$=7,06, P=0.015), and time of day ($F_{6,120}$=12,49, P=0.0001). The values were higher for the high-burnout group for the workday and for the time around mid-afternoon. There was also a significant interaction effect for day by group ($F_{1,20}$=6,54, P=0.019) (ie, subjective activation was lower for the low-burnout group during the day off, but not for the high-burnout group. With regard to mental fatigue (see figure 2), the repeated measures ANOVA showed significant main effects for group ($F_{1,20}$=5,62, P=0.028), day ($F_{1,20}$=12,02, P=0.002), and time of day ($F_{6,120}$=8,47, P=0.0001). The high-burnout group showed higher mental fatigue in general. Both groups showed higher mental fatigue during the workday, and the ratings showed, for both groups, an increase in fatigue in the afternoon or evening. There was no significant interaction effect.

Discussion

Diurnal cortisol showed a different pattern between the groups for the workday and the weekend. The high-burnout group showed higher awakening cortisol during the workday than on the weekend, but no difference was found in the cortisol levels for the low-burnout group between the days. The diurnal amplitude of cortisol (awakening peak–bedtime difference) did not differ between the groups during either day. Regression analyses showed, however, that a higher frequency of arousals during the prior sleep was associated with a higher diurnal amplitude of cortisol and an earlier postawakening peak during the workday. In addition, higher subjective activation was shown for the high-burnout group during the weekend, but no difference was found between the groups during the workday.

Previous studies on cortisol in burnout groups have shown elevated morning cortisol (10–12), but the opposite has also been found (13, 14). The reason for this discrepancy is not clear, but there are obvious methodological differences between the studies. For example, different scales have been used for selecting the participants. In our study, the Shirom-Melamed Burnout Questionnaire was used to obtain burnout scores, as was done by Melamed et al (10) and Grossi et al (26). Pruessner and his colleagues (13) made use of the Maslach Burnout Inventory, however (27). Further research is needed to investigate whether or not the scales possibly emphasize different aspects of burnout that could be associated with a different cortisol pattern. Another reason for inconclusive results could be the duration of exposure. One limitation of our study was our lack of information on the duration of the burnout symptoms. It is possible that a longer duration of burnout may have yielded different results. On the other hand, results from previous studies have indicated hypercortisolism

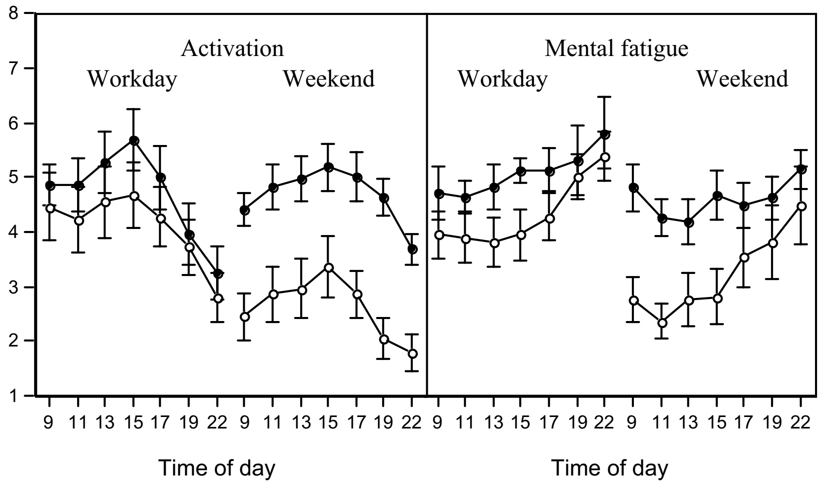

Figure 2. Ratings for activation and mental fatigue (mean and standard error of the mean) during a workday and a day off for the groups with high versus low burnout scores (high burnout = closed circles, low burnout = open circles).

(10, 12, 26), as well as hypocortisolism (13), in chronic burnout participants. Taken together, the results from available studies on the cortisol levels of people with burnout do not seem to form a coherent pattern. Prospective studies would be needed to investigate further the role of cortisol in burnout.

Even if the results of our study did not show any difference regarding the awakening cortisol or the diurnal amplitude of cortisol between the groups, interesting results emerged when the cortisol data were related to the objective sleep data. A higher frequency of arousals during sleep during the workweek was associated with a higher diurnal amplitude of cortisol and an earlier postawakening peak during the workday. No other sleep parameter yielded any significant results in these regression analyses. Our findings indicate that sleep disturbance—subtle fragmentation due to repeated arousals—may influence the cortisol rhythm to show an earlier rise, possibly starting in the late night. Born and his colleagues (28) have demonstrated significantly higher adrenocorticotropin (ACTH) plasma levels within the last hour before waking in persons expecting to be awakened, compared with participants awakened by surprise. The authors interpreted this finding as an anticipation effect. The same mechanism may lie behind the results of our study. In the paper by Ekstedt et al (20), using the same sample of participants as in our present study, we showed that the higher frequency of arousals during the workweek was predicted by tension and a higher degree of bringing work home. One possibility is that stress and tension (or anticipation) associated with work may contribute to the sleep fragmentation, which, in turn, activates the HPA system.

According to previous observations (29, 30), the time of awakening could affect morning cortisol levels. However, in our study, there were no differences between the groups regarding time of awakening during the workday or during the day off [data presented in Söderström et al (15)]. The high-burnout group showed differences in awakening cortisol between the days, which could have been due to the different awakening times on the different days. On the other hand, the low-burnout group did not show any difference in awakening cortisol between the workday and the weekend, despite the same awakening times as the high-burnout group. Even if the cause of the different patterns is impossible to identify, the results in fact showed that the groups differed with respect to the cortisol pattern.

The diurnal ratings of activation and mental fatigue showed that the high-burnout group did not recover, or relax, during the weekend. This issue has not been studied before, but the observations seem logical when the role of long-term stress exposure and the inability to recuperate from burnout are considered (4). Whether this sustained "wound-up" pattern was due to work stress, family strain, or other off-work stress (or combinations) was not investigated in this study. However, it is plausible that the lack of relaxation reflects an important component of the burnout process. Presumably, preoccupation with work and a lack of relaxation during leisure time may contribute to the development of burnout.

Our study had a pilot character, and its main limitation is the small sample size. The results should therefore be interpreted with caution. When the results from small samples are analyzed, one should expect it to be more difficult to find significant results. One should also bear in mind that a person with extreme values could have a great impact on the results in a small sample. With regard to the cortisol analyses in our present study, the variation was indeed larger within the high-burnout group for the values at awakening during the workday (high burnout: SD 7.36, range 8.4–30.9 nmol/l; low burnout: SD 4.0, range 5.6–18.2 nmol/l). However, three participants in the high-burnout group showed awakening cortisol values above 20 nmol/l, whereas none of the participants in the low-burnout group did. This result supports the notion that the finding of elevated cortisol at awakening on a workday in the high-burnout group mirrors the actual pattern within the two groups rather than it being due to a single outlier value. In addition, the differences in the diurnal patterns of activation or mental fatigue seem to be robust, as they rely upon repeated measures during the days. The same can be argued for subjective recovery across the week, as the pattern differed consistently between the groups across repeated measures.

Despite the limitations already discussed, the study also has several advantages. First, investigating burnout in relation to cortisol and sleep is, to our knowledge, unique. It was a field study, carried out in a work environment in which many employees experienced high levels of work stress and, possibly, could have been at risk of developing burnout symptoms. This feature gives the study a certain external, or ecological, validity. Furthermore, the design included repeated measures of cortisol, polysomnography, and diary ratings, and this aspect gives the study high internal validity. The participants were also highly motivated to participate in the study and followed the protocol very well. The latter was concluded as the researchers were in contact with the participants repeatedly throughout the study period and could answer their questions regarding the protocol, remind the participants of the different measurements, and the like. Third, even if our study has its limitations regarding the small sample size, its results may inspire further important research concerning the relationship between cortisol, burnout, and sleep.

Even if further research is needed to confirm such a hypothesis, the results of our study indicate that stress-induced sleep fragmentation (ie, frequency of arousals) may have a mediating effect on the diurnal cortisol rhythm. As burnout participants often suffer from sleep disturbances, it is possible that the lack of consensus in the research literature regarding burnout and cortisol can be connected to whether sleep disturbances have been taken into account when cortisol data from burnout groups are analyzed. Another interesting result from our study was that the high-burnout group showed higher ratings of activation and mental fatigue during the weekend than the controls did. This lack of recovery during the weekend may possibly be a part of the burnout process.

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