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The importance of sleep: Relationships between sleep quality and work demands, the prioritization of sleep and pre-sleep arousal in day-time employees

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Sleep deprivation is an often hidden problem in working adults. In this study, we evaluated self-regulation processes contributing to poor sleep patterns of full-time office employees. We investigated whether work-related demands and prioritizing sleep (in relation to other activities) predicted sleep behaviours over an 11-day period. Seventy-three adults in New Zealand completed online measures, including the Copenhagen Psychosocial Questionnaire, a measure of sleep prioritization, and the Pittsburgh Sleep Quality Index. Mixed-model analyses of daily data revealed that higher sleep prioritization and positive work-related emotions during a workday predicted better sleep quality that night. Cognitive demands on a workday predicted a later bedtime that night, whereas emotional demands predicted an earlier bedtime (but also an earlier waking time). Regression analyses revealed that when controlling for baseline levels of each dependent measure, pre-sleep arousal predicted fewer hours of sleep and greater sleep difficulty whereas sleep prioritization predicted a faster time getting to sleep, longer sleep and less sleep difficulty. High priority for sleep and positive emotions at work may promote sleep quality, whereas cognitive and emotional demands, or pre-sleep arousal may disrupt sleep patterns. These findings point to sleep prioritization and cognitive-emotional self-regulation skills as potential targets for work-based interventions aimed at promoting sleep.

Keywords: sleep prioritization; work demands; pre-sleep arousal; sleep; day-time employees; self-regulation

Introduction

Sleep deprivation is a significant problem for many working adults, especially since it can have detrimental effects on health and well-being (Barber, Munz, Bagsby, & Powell, 2010; Norra et al., 2011). Sleep deprivation can impair immune function (Taylor, Lichstein, & Durrence, 2003), appetite regulation (Copinschi, 2005) and other physiological processes influencing health (Brindle & Conklin, 2012). It can also increase disease risk by undermining physical activity, healthy diet choices and other health

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behaviours requiring motivation and self-control (Hagger, 2010a). Although some research has evaluated a range of psychosocial factors influencing sleep behaviour (LeBlanc et al., 2009), more research is needed to better understand the sleep decisions of working adults and how their workplace experiences and sleep priorities may contribute to sleep deprivation.

The workplace can be a primary source of experiences responsible for poor sleep (Basner et al., 2007). Working adults typically experience job-related demands and emotions that can undermine the relaxation and sleep initiation processes required for a good night's sleep (Jones, Burke, & Westman, 2006). Moreover, work-related demands and conflicts can motivate decisions to prioritize work goals over sleep-related goals. Sleep self-regulation, which typically requires effortful goal-setting, planning and behavioural control, can be difficult to achieve when confronted with the cognitive and emotional demands of work (Hagger, 2010b). Prioritizing the need for sleep could be one strategy for achieving sleep self-regulation in the face of work demands. Individuals who give sleep high priority may be better able to maintain healthy sleep patterns despite work-related demands. Giving priority to sleep involves highlighting its general importance in terms of need, as well as its relative importance with regard to other life domain activities. In this study, we examined whether work-related demands and sleep prioritization predict sleep behaviour and quality among office employees.

To date, only a few studies have evaluated associations between daily work demands and sleep quality, and nearly all have utilized a cross-sectional design (Åkerstedt, 2006). A more recent longitudinal study (de Lange et al., 2009) provides initial evidence that work-related demands predict poor sleep quality over a one-year time lag, but the study did not explore the daily dynamics of work demands on sleep. The relationships between work demands and sleep deprivation in the non-clinical population thus remain unclear. Moreover, research demonstrating that prioritizing sleep predicts beneficial adaptive sleep behaviours and better sleep quality is lacking. Further prospective theory-guided research is needed to examine how work demands, work goal conflicts and sleep prioritization predict sleep behaviours and quality on a daily basis.

Psychological theory on the self-regulation of behaviour can offer new insights into the cognitive, emotional and decision-making factors influencing sleep behaviour. Self-regulation theory (Cameron & Leventhal, 2003; Scheier & Carver, 2003) provides such a framework for advancing our understanding of work and sleep dynamics, goals and behaviours. According to self-regulation theory, individuals set priorities and goals in multiple life domains, including work and sleep. Individuals strive to achieve these goals, and their appraisals of progress influence both cognitive and emotional experiences and subsequent decisions. Appraisals that one's progress towards achieving a goal is hampered can elicit experiences of cognitive demands and increased efforts to meet that goal, as well as emotional reactions of anxiety, worry, frustration, depression or anger. Appraisals that one's progress is appropriate or faster than expected can elicit positive experiences of challenge and emotions such as contentment, happiness and pleasure.

Within the context of work, appraisals of poor progress on tasks can stimulate cognitive demands requiring significant regulation of attention and actions, as well as emotional demands requiring the regulation of anxiety, frustration and other affective experiences. These cognitive and emotional demands are likely to influence sleep behaviour and quality through several pathways. For example, adults facing work tasks demanding high cognitive effort may have difficulty disengaging from them to attend to sleep preparations that evening (Sonnentag & Bayer, 2005). Work-related emotional

demands may impair sleep through their impact on physiological processes influencing sleep and, in particular, pre-sleep arousal (Winwood & Lushington, 2006). For example, negative emotions arising from work demands can evoke sympathetic arousal (Waters, Adams, Binks, & Varnado, 1993), which could foster pre-sleep arousal and earlier waking times. In contrast, positive emotions arising from work activities can enhance parasympathetic regulation (Lopez & Snyder, 2009) that, in turn, reduces pre-sleep arousal and promotes sleep quality (Kivisto, Harma, Sallinen, & Kalimo, 2008).

Some individuals may respond to the continuing challenge of juggling work and sleep demands by setting a high priority for sleep. Individuals who are concerned about sleep deprivation and place sleep as an important goal may be more likely to disengage with the pursuit of work goals and initiate the sleep preparation process each night.

Guided by these theoretical principles, we investigated how work-related demands, work-related emotions and sleep prioritization predict sleep indicators on a daily basis, and whether they do so independently of more general states of mental distress (e.g. anxiety, depression, perceived stress and fatigue) that are known to interfere with sleep (Stein, Belik, Jacobi, & Sareen, 2008). Adults with full-time office jobs first completed baseline measures of sleep prioritization, general mental distress, pre-sleep arousal and sleep quality. They then completed daily measures of work goal conflict, cognitive and emotional demands at work, positive and negative emotions experienced at work and sleep behaviour over the course of 10 workdays. They completed measures of pre-sleep arousal on Day 9 and sleep quality on Day 10. Using analyses that controlled for demographic and general distress variables, we tested the following hypotheses:

Hypothesis 1: Higher sleep prioritization will predict better sleep behaviours and quality over the 10-day period.

Hypothesis 2: Higher levels of work goal conflicts, cognitive demands, emotional demands, negative emotions, and lower levels of positive emotions during a workday will independently predict poorer sleep behaviours and quality that night.

Hypothesis 3: Work-related demands and emotions will influence pre-sleep arousal reported on Day 9.

Hypothesis 4: Pre-sleep arousal will in turn reduce sleep duration and quality on Day 10.

Method

Survey design and procedure

A Human Participants Ethics Committee approved this internet-based study. We utilized a prospective design with a baseline survey followed by repeated daily measures over the next nine workdays (that is, not including non-work days) and a follow-up survey on the tenth day. All surveys were emailed to participants at 3p.m. each day and completed by the end of the workday.

Participants

Adults were recruited through advertisements circulated by five companies and non-profit organizations in New Zealand. These organizations included a law firm, a corporate travel

agency, a university and two sports organizations; the five businesses included a total of 5407 employees. The advertisements encouraged employees who were interested in answering questions about how their work may be affecting their sleep to go to the study website, which provided additional study information and access to the consent form and baseline measures. Eligibility criteria were: (i) ability to read and write in English; (ii) full-time employment; (iii) daytime work shifts (participants were excluded if they worked night shifts through their organizations or through secondary jobs); (iv) a primarily sedentary job (to maintain consistency in work-related physical activity, given the impact of physical exertion on sleep) that provided daily access to email; (v) no identified biological cause of current sleep deprivation (e.g. sleep apnoea, narcolepsy, restless leg syndrome, periodic limb movement disorder or pregnancy); (vi) no identified psychological disorder; and (vii) no participation in any sleep-related study within the last two months.

Of the 75 employees initially recruited, two further participants were excluded because they did not meet inclusion criteria (due to pregnancy and depression). The 73 participants (48 women and 25 men) ranged in age from 21 to 65; 43% (n = 31) were 26 to 30. Most were in de facto relationships (38%, n = 28) or married (27%, n = 20); the rest were single, divorced/widowed or did not specify (34%, n = 25). Ethnicities included New Zealand European (80%, n = 58), Asian (15%, n = 11) and other (Maori/Samoan/Australian; 6%, n = 4). Occupations included professionals such as accountants, lawyers, teachers, consultants or technical staff (37%, n = 27), office workers (25%, n = 18), sales or technical staff (19%, n = 14) and market or science researchers (19%, n = 14). Average time in the position was 2.8 years (SD = 3.1) with 24 (33%) being in the first year. Most people indicated that their combined income was NZD$51,000–$100,000 (44%; n = 32), 31% (n = 22) reported a combined income of NZD$100,000 or higher, and that for 23% (n = 17) their combined income was under $51,000 per annum; two participants (3%) did not specify. No participants reported having insomnia or another sleep-related disorder in the previous two weeks.

Measures

The baseline survey included measures of demographic characteristics; general mental distress (depression, anxiety, perceived stress and fatigue); sleep prioritization; pre-sleep arousal; and the Pittsburgh Sleep Quality Index (PSQI; sleep quality, time of lights out, time to sleep, hours of sleep, time of waking and global PSQI scores). Daily measures included work-related demands (cognitive and emotional), work goal conflict and work-related emotions and sleep-related measures for the previous night: sleep quality, time of lights out, time taken to get to sleep, hours of sleep and time of waking that morning. Pre-sleep arousal was measured again on Day 9. The follow-up survey on Day 10 included the daily measures and the PSQI.

Demographic and personal characteristics. The baseline survey included items assessing age, gender, marital status, occupation, employment length, household income (e.g. combined income of participant and partner if applicable), presence of children at home, existing medical conditions, insomnia, restless legs syndrome, sleep apnoea and narcolepsy.

General mental distress. Participants completed measures of anxiety (State-Trait Anxiety Index Short Form for State Anxiety, e.g. "I am worried"; α = .84; Marteau & Bekker, 1992), depression (Centre for Epidemiological Studies in Depression Short Form, e.g. "I could not get going"; α = .82; Kohout, Berkman, Evans, & Cornoni-Huntley, 1993), perceived stress (Perceived Stress Scale, e.g. "how often have you felt that things were going your way?"; α = .81; Cohen, Kamarck, & Mermelstein, 1983) and fatigue (subscale of the Profile of Mood States, e.g. "worn out"; α = .86; McNair, Lorr, & Droppleman, 1992). Item ratings were averaged for all scales.

Sleep prioritization. A purpose-built measure of sleep prioritization consisted of 10 items (α = .79), rated from 1 (*strongly disagree*) to 5 (*strongly agree*), focusing on daily sleep quality as a goal. Items were selected from a larger pool of preliminary items based on content validity evaluations provided by 29 employees and by nine researchers trained in self-regulation, sleep and health. The measure was designed to assess two facets of sleep prioritization: sleep importance and sleep in relation to other activities. Together, these two components represent both the general and relative importance of sleep. Principal components analyses with direct oblimin rotation revealed two factors. These were a sleep general importance factor (with six items, e.g. "getting a good night's sleep is one of my top priorities"; factor loadings ranging from .50 to .83) and a sleep relative importance factor (with four items, e.g. "I would rather use my time to do other things rather than spend the time sleeping"; factor loadings ranging from .54 to .90). The two subscales were correlated (r = .31, $p < .05$), and they were combined with an average of all ratings representing sleep prioritization.

Pre-sleep arousal. The Glasgow Content of Thoughts Inventory (Harvey & Espie, 2004) was used at baseline and follow-up to measure pre-sleep arousal. The 25 items are rated from 0 (*never*) to 3 (*always*) to indicate how often the listed thoughts kept one awake over the past two weeks (baseline) or past week (follow-up); e.g. "things that happened during the day" and "how you can't stop your mind from racing"; at baseline, α = .91. Item ratings were averaged.

Sleep behaviour and quality. The PSQI (Buysse, Reynolds, Monk, Berman, & Kupfer, 1989) was used to assess sleep quality, sleep duration, sleep latency and the frequency and severity of specific sleep-related problems. The baseline version assessed sleep behaviours and quality over the past two weeks (including non-work days). Items are assessed individually as well as combined to create overall scores of sleep quality. The 19 items are combined to form seven component scores, each of which ranges from 0 (*no difficulty*) to 3 (*severe difficulty*). The components are sleep quality (e.g. "how would you rate your sleep quality overall?"), sleep latency (e.g. "how long in minutes did it take you to get to sleep each night on average?"), sleep duration (e.g. "how many hours sleep did you get per night on average?"), habitual sleep efficiency (compares the time in bed against sleep duration), sleep disturbances (e.g. "how often have you had trouble sleeping because you … feel too cold"), use of sleeping medication (e.g. "have you taken medicine to help you sleep?") and daytime dysfunction (e.g. "have you had trouble staying awake while driving, eating meals or engaging in social activity"). For Sleep Disturbances and

Daytime Dysfunction, the item ratings in these subscales were averaged. Component scores were then averaged to provide a global score ranging from 0 (*no difficulty*) to 21 (*severe difficulties in all areas*). It has shown to have excellent reliability and validity with samples of good and poor sleepers, including those who are employees (Doi, Minowa, & Tango, 2003). For the global PSQI scores at baseline, α = .74. For daily assessments, the following PSQI items were adapted to assess the previous night's sleep: sleep quality (ratings ranged from 1 to 10), time of lights out (coded using a 24-hour clock), time taken to get to sleep (minutes from lights out until falling asleep), total hours of sleep and time of waking (coded using a 24-hour clock).

Cognitive and emotional demands at work. Subscales from the Copenhagen Psychosocial Questionnaire (Kristensen, Hannerz, Høgh, & Borg, 2005) were used to assess cognitive and emotional demands experienced at work that day. Participants rated items from 1 (*to a very small extent*) to 5 (*to a very large extent*). The cognitive demand subscale included eight items assessing task difficulty (e.g. "does your work require you to make difficult decisions?"); α = .86 to .91 over the nine days. A ninth item from the original subscale, "do you have a responsible job?" was not used because it was unlikely to change on a daily basis. The emotional demands subscale included four items (e.g. "is your work emotionally demanding?"); α = .76 to .88 over the nine days. Variables were computed by taking the average of the item ratings for each subscale.

Work goal conflict. Experience of work goal conflict was assessed with the item "How much did this event conflict with your 12 month workplace goal?" This question came after participants had listed a 12-month work goal (e.g. "Making my business successful") and also a work-related event occurring that day (e.g. "trouble with a large delivery"). Responses ranged from 1 (*not at all*) to 5 (*completely*).

Work-related positive and negative emotions. Each day, participants completed a modified version of the Job Emotions Scale (Fisher, 2000) to rate their experience of 16 emotions relating to a work event that the participant selected as the most significant event of the day. Eight terms related to positive emotions (happy, content, enthusiastic, pleased, proud, optimistic, liking for someone or something and enjoying something) and eight terms related to negative emotions (depressed, frustrated, angry, disgusted, unhappy, disappointed, embarrassed and worried). Responses ranged from 0 (*not at all*) to 10 (*extremely*). For each subscale, ratings were averaged to generate positive and negative emotion scores. Principal components analyses revealed that the items loaded as intended onto two factors, one with positive emotion items and one with negative emotion items. Over the nine days, α = .87–.94 for the positive emotion subscale and α = .80–.89 for the negative emotion subscale.

Statistical analyses

SPSS statistical software version 15.0 and SAS statistical software version 9.1.3 were used to analyze the data. All statistical tests utilized a 95% confidence interval. When generating scores using item ratings, missing values were replaced with the mean of the

participant's ratings on the other scale items. Overall, 66% of participants completed 70% or more of the daily surveys. A priori analysis indicated that a sample size of $N = 73$ provided sufficient power to detect medium-sized associations (Cohen's $d = .50$).

Correlation analyses were used to assess bivariate relationships among work and sleep variables at baseline and Day 1. To identify potential covariates for the final analyses, we conducted multiple regressions of the dependent variables with age, gender, ethnicity, marital status, occupation, income level, employment length, anxiety, depression, perceived stress and fatigue as predictor variables. Marital status (being in a de facto relationship versus other status) was associated with global PSQI scores (those in de facto relationships reported poorer sleep quality), and perceived stress positively predicted pre-sleep arousal. These variables were therefore included in the corresponding analyses. Marital status was not a significant predictor of global PSQI scores in these analyses and so it was not included in the final models.

Multi-level, mixed-model analyses were used to test whether, over the course of the 10 days, sleep prioritization and the daily reports of work-related cognitive demands, emotional demands, positive emotion, negative emotion and work goal conflict predicted sleep behaviour and quality for the corresponding night. These analyses take into account the non-independence of the individual-level data. The modelling of time-specific associations assumed a first-order autoregressive process, which was deemed most appropriate from a theoretical perspective given the likelihood that the daily sleep variables would be correlated (Gueorguieva & Krystal, 2004).

Multiple linear regression analysis was used to test whether work goal conflict, cognitive demands, emotional demands and positive and negative work-related emotions experienced over the past week predicted pre-sleep arousal over the past week (assessed on Day 9). For this analysis, the daily reports of a variable (e.g. cognitive demand) for Days 2–8 were averaged to generate a weekly score. Pre-sleep arousal at baseline and perceived stress at baseline were entered as covariates. A final set of regression analyses tested whether pre-sleep arousal and sleep prioritization independently predicted sleep quality at follow-up (Day 10).

Results

Descriptive statistics and correlations for the work and sleep variables

Participants varied in their sleep quality and prioritization of sleep, as indicated by the moderate variance in global PSQI scores, pre-sleep arousal and sleep prioritization at baseline (see Table 1). Depression, anxiety, perceived stress and fatigue were positively associated with global PSQI scores and levels of pre-sleep arousal. Higher levels of depression and perceived stress were associated with higher sleep prioritization.

Day 1 reports of work-related experiences (see Table 2) revealed that work goal conflict was generally low and its occurrence was associated with greater emotional demands and negative emotions. Cognitive demands were relatively high, whereas emotional demands, on average, were moderate. Positive and negative emotions were only moderately correlated, supporting their conceptual distinctiveness. Analyses of sleep experiences that night (i.e. following the reports) revealed that sleep quality levels were moderate, although the average time taken to get to sleep was almost 30 minutes, which suggests some difficulty in sleep initiation on average. Although participants reported just under seven hours of sleep on average for this initial night of the study, analyses of sleep

Table 1. Correlations between sleep difficulty (Global PSQI), pre-sleep arousal, sleep prioritization and general mental distress at baseline.

	Measure	1	2	3	4	5	6	7
1.	Global PSQI	-						
2.	Pre-sleep arousal	.49**	-					
3.	Sleep prioritization	.02	.36**	-				
4.	Depression	.39**	.49**	.27*	-			
5.	Anxiety	.33**	.32**	.09	.54**	-		
6.	Perceived stress	.29**	.52**	.28*	.66**	.59**	-	
7.	Fatigue	.52**	.34**	.20	.47**	.36**	.41**	-
	M (*SD*)	1.50 (0.30)	0.17 (0.51)	3.32 (0.74)	0.58 (0.43)	1.97 (0.59)	1.75 (0.53)	1.90 (0.85)
	Possible score range	0–3	0–3	1–5	0–3	1–4	0–4	0–4

Notes: PSQI = Pittsburgh Sleep Quality Index. For Global PSQI scores, higher scores reflect poorer sleep quality. For all other measures, higher scores reflect higher levels of that construct. *M* and *SD* represent averaged scores.
*$p < .05$; **$p < .01$.

Table 2. Correlations between work-related measures on Day 1, sleep measures for the night of Day 1, pre-sleep arousal on Day 9 and global PSQI scores on Day 10.

	Measure	1	2	3	4	5	*M* (*SD*)	Score range
1.	Work goal conflict	-					1.20 (1.67)	1–5
2.	Cognitive demands	.12	-				2.18 (0.90)	1–5
3.	Emotional demands	.27*	.47**	-			1.88 (0.97)	1–5
4.	Positive work emotions	−.19	.24*	−.07	-		4.88 (2.04)	0–10
5.	Negative work emotions	.46**	−.04	.19	−.42**	-	2.16 (1.74)	0–10
6.	Sleep quality TN	−.08	.03	.05	.09	−.09	6.28 (1.96)	1–10
7.	Time of lights out TN	.11	.15	−.03	.14	−.15	22.87 (0.94)	20–25[a]
8.	Time to sleep TN	−.02	−.17	−.13	.22	−.19	26.19 (32.88)	1–180[a]
9.	Hours of sleep TN	−.20	−.26*	−.15	−.04	−.13	6.93 (1.32)	2.5–9.0[a]
10.	Time of waking TN	−.21	−.03	−.28*	.24	−.22	6.59 (0.81)	5–9[a]
11.	Pre-sleep arousal Day 9	.26	.25	.46**	−.16	.39**	0.78 (0.60)	0–3
12.	Global PSQI at FU	.10	.08	.09	−.04	.16	0.71 (0.38)	0–3

Notes: PSQI = Pittsburgh Sleep Quality Index. TN = That night; FU = Follow-up. Inter-correlations between the sleep-related variables (measures 6–12) are not reported here. Scores reflect the mean ratings on the measure. [a]reflects actual range of scores, as the possible range is infinite; the remaining score ranges are theoretical.
*$p < .05$; **$p < .01$.

duration over the 10-day period suggest that short sleep duration was a problem for a proportion of the sample, with 24% ($n = 17$) reporting that they had less than six hours of sleep on the majority of the 10 days. Higher cognitive demands were associated with fewer total hours of sleep and higher emotional demands were related to both an earlier time of waking the next morning and higher levels of pre-sleep arousal on Day 9. Negative work-related emotions were also associated with higher levels of pre-sleep arousal.

Work-related experiences as predictors of sleep-related indicators

Mixed-model analyses (see Table 3) tested Hypothesis 1 that higher sleep prioritization would predict better sleep behaviours and quality over the 10-day period and Hypothesis 2, that higher levels of work goal conflicts, cognitive demands, emotional demands and negative emotions and lower levels of positive emotions during a workday would independently predict poorer sleep behaviours and quality that night. Consistent with these hypotheses, higher sleep prioritization and positive work-related emotions were both associated with higher sleep quality that night. In further support of Hypothesis 2,

Table 3. Mixed-model analyses of sleep prioritization and work-related experiences as predictors of sleep-related outcomes.

	Sleep prioritization	Work-goal conflict	Cognitive demands	Emotional demands	Positive work-related emotion	Negative work-related emotion
Sleep outcomes	Est. (*SE*) [CI] *t*	Est. (*SE*) [CI] *t*	Est. (*SE*) [CI] *t*	Est. (*SE*) [CI] *t*	Est. (*SE*) [CI] *t*	Est. (*SE*) [CI] *t*
Sleep quality[a]	.10 (0.03) [.04, .15] 3.35**	.05 (0.08) [−.10, .20] 0.65	−.03 (0.02) [−.07, .02] −1.19	.03 (0.04) [−.04, .11] 0.95	.19 (0.07) [.05, .32] 2.65**	.01 (0.09) [−.17, .19] 0.12
Time of lights out[b]	−.02 (0.02) [−.05, .01] −1.32	.03 (0.04) [−.05, .11] 0.75	.04 (0.01) [.01, .06] 3.09**	−.04 (0.02) [−.08, −.01] −2.25*	.02 (0.04) [−.05, .10] 0.63	−.06 (0.05) [−.16, .04] −1.15
Time to get to sleep[b]	−.35 (0.39) [−1.12, .42] −0.91	−.06 (0.78) [−1.60, 1.48] −0.08	−.12 (0.28) [−.66, .43] −0.42	.20 (0.41) [−.60, 1.01] 0.50	.66 (0.82) [−.96, 2.29] 0.81	.73 (1.01) [−1.26, 2.73] 0.72
Hours of sleep[b]	−.03 (0.03) [−.09, .04] −0.81	−.11 (0.11) [−.33, .11] −0.98	−.02 (0.03) [−.08, .04] −0.55	−.08 (0.05) [−.18, .02] −1.62	.09 (0.09) [−.09, .27] 0.97	.27 (0.13) [.02, .53] 2.12*
Time of waking[c]	−.00 (0.01) [−.03, .03] −0.11	−.06 (0.02) [−.10, −.02] −2.67**	.01 (0.01) [−.01, .02] 0.62	−.03 (0.01) [−.05, .01] −2.54**	.00 (0.03) [−.05, .05] 0.16	.03 (0.03) [−.03, .08] 0.90

Notes: Analyses include 315[a], 317[b] or 318[c] observations from 73 employees over 10 days. Independent measures are entered into the model together. Est. = Estimate, (*SE*) = Standard Error, [CI] = Upper and Lower Estimate.
*$p < .05$; **$p < .01$.

Table 4. Regression analyses of key predictors of pre-sleep arousal over the past week, as measured on Day 9.

Measure	*B*	*SE B*	*B*	*t*	Model *F*	R^2
Pre-sleep arousal Day 9					10.26**	.56
Pre-sleep arousal (B)	0.46	0.11	0.45	4.30**		
Perceived stress (B)	0.09	0.10	0.09	0.93		
Sleep prioritization (B)	−0.17	0.07	−0.23	−2.46*		
Work goal conflict (Days 2–8)	−0.07	0.04	0.16	−1.63		
Cognitive demands (Days 2–8)	−0.05	0.08	−0.07	−0.63		
Emotional demands (Days 2–8)	0.27	0.08	0.44	3.53**		
Positive work emotions (Days 2–8)	−0.02	0.02	−0.11	−1.18		
Negative work emotions (Days 2–8)	0.07	0.03	0.21	2.12*		

Notes: B = Baseline; Days 2–8 = mean scores over days 2 to 8.
*$p < .05$; **$p < .01$.

higher cognitive demands were associated with a later time of lights out that night, and work goal conflict predicted an earlier time of waking. Contrary to Hypothesis 2, however, higher emotional demands were associated with an earlier time of lights out and an earlier time of waking the next day; and higher levels of negative work-related emotions were associated with greater total hours of sleep.

Regression analysis of pre-sleep arousal over the past week (reported on Day 9) with baseline pre-sleep arousal and perceived stress as covariates (Table 4) revealed that, consistent with Hypothesis 1, higher sleep prioritization predicted lower pre-sleep arousal. Further, and consistent with Hypothesis 3, higher levels of both emotional demands at work and negative work emotions over the past week predicted higher pre-sleep arousal. The other work-related variables did not significantly predict pre-sleep arousal over the previous week.

Regression analyses of sleep outcomes controlling for baseline levels (Table 5) revealed that, consistent with Hypothesis 4, pre-sleep arousal predicted fewer hours of sleep and higher global PSQI scores at the Day 10 follow-up. In further support of Hypothesis 1, higher sleep prioritization at baseline was associated with faster times to get to sleep, more hours of sleep and lower global PSQI scores at the Day 10 follow-up.

Discussion

The present findings provide new insights into psychological factors involved in the self-regulation of sleep and, in particular, how sleep prioritization and daily work experiences may contribute to sleep behaviours and experiences. Consistent with Hypothesis 1, sleep prioritization emerged as an important predictor of sleep, with higher sleep prioritization predicting better sleep quality on a daily basis, as well as more hours of sleep, faster time to get to sleep and less sleep difficulty (indicated by global PSQI scores as measured at follow-up on Day 10). Sleep prioritization was also associated with lower pre-sleep arousal on Day 9. Although some experts recommend against attempts to increase motivations to sleep well due to concerns that they will increase pre-sleep arousal in the short term (Espie, 2002), these findings suggest that enhancing sleep prioritization could prove beneficial for sleep and can decrease pre-sleep arousal over time. The correlational findings from the current study demonstrate only that individuals who naturally prioritize

Table 5. Regression analyses of pre-sleep arousal and sleep prioritization as predictors of sleep-related measures at follow-up (Day 10), controlling for baseline levels.

Measure	β	*SE* β	β	*t*	*Model F*	R^2
Time of lights out, FU					12.74***	.31
Time of lights out, B	.57	.10	.56	6.03***		
Sleep prioritization, B	.01	.11	.01	0.13		
Pre-sleep arousal, Day 9	.00	.01	.01	0.07		
Time to get to sleep, FU					13.97***	.33
Time to get to sleep B	.33	.06	.49	5.27***		
Sleep prioritization, B	−4.66	2.10	−.20	−2.21*		
Pre-sleep arousal, Day 9	.13	.10	.12	1.28		
Hours of sleep, FU					12.58***	.31
Hours of sleep, B	.34	.10	.34	3.49**		
Sleep prioritization, B	.38	.15	.23	2.45*		
Pre-sleep arousal, Day 9	−.02	.01	−.25	−2.54*		
Sleep quality, FU					3.42*	.11
Sleep quality, B	.18	.09	.22	2.08*		
Sleep prioritization, B	.20	.31	.07	0.63		
Pre-sleep arousal, Day 9	−.03	.02	−.19	−1.83		
Time of waking, FU					9.74***	.26
Time of waking, B	.51	.10	.50	5.35***		
Sleep prioritization, B	.04	.13	.03	0.26		
Pre-sleep arousal, Day 9	−.01	.01	−.07	−0.73		
Global PSQI, FU						
Global PSQI, B	.32	.07	.44	4.72***	14.74***	.34
Sleep prioritization, B	−.78	.38	−.18	−2.07*		
Pre-sleep arousal, Day 9	.05	.02	.25	2.66**		

Notes: B = Baseline, FU = follow-up as measured on Day 10.
*$p < .05$, **$p < .01$, ***$p < .001$.

sleep have better sleep quality and sleep longer, however; and so it remains an empirical question as to whether attempts to increase the priority of sleep will improve sleep for individuals who naturally give it a low priority. Future research should investigate the efficacy of interventions aimed at enhancing sleep priorities, either as an individual strategy or as part of a broader self-regulation programme for improving sleep behaviour through goal-setting, planning and monitoring of adaptive behaviours.

The findings further indicate how psychological experiences in the workplace could impact on health and well-being via their effects on sleep. They provide partial support for Hypothesis 2 that work goal conflict, cognitive and emotional demands and work-related emotions predict poorer sleep behaviours and sleep quality that night. The patterns suggest that cognitive and emotional work demands have distinctive relationships with sleep behaviour, further strengthening the argument that work demands can affect sleep in addition to the reciprocal relationship of sleep predicting work difficulties demonstrated in previous research (Hanson et al., 2011). These patterns of findings are consistent with those of a recent study of young adults demonstrating that higher work demands are negatively associated with recovery from work (as indicated by fatigue and low vigour), whereas higher levels of pleasure at work were positively related to recovery (van Hooff, Geurts, Beckers, & Kompier, 2011). Cognitive demands appear to be more clearly

implicated in prolonging decisions to go to bed, whereas emotional demands may precipitate earlier bedtimes and earlier waking. Although the idea that emotional and cognitive demands affect people differently is not new (Vohs, Baumeister, & Ciarocco, 2005), the current research adds evidence regarding how these types of demand may differentially influence behaviour within the domain of sleep.

Work goal conflict was linked to an earlier time of waking, suggesting that events occurring in the workplace that disrupt progress towards work goals could alter sleep patterns. It is likely that emotional reactions (e.g. frustration) generated by work goal conflicts triggered the early waking. Alternatively, they may also have triggered motivations and behaviours (e.g. setting an alarm for an earlier time) to get up earlier in order to deal with a more demanding work situation. In contrast to the association between work goal conflict and earlier waking, negative work-related emotions were associated with more hours of sleep (although it was unrelated to sleep quality). Individuals experiencing these negative emotions may require longer sleep in order to meet their sleep needs. In contrast, positive work-related emotions predicted higher sleep quality (but not more sleep hours), suggesting the opposite influences on sleep quality and quantity. These differential relationships of negative and positive work emotions with sleep quality and behaviour support further research on the distinctive influences of negative and positive emotions on sleep.

The findings are consistent with Hypothesis 3 that work-related demands and emotions would be associated with pre-sleep arousal, in that higher levels of work-related emotional demands and negative emotions independently predicted higher pre-sleep arousal. Pre-sleep arousal is an important outcome in its own right because it can be considered aversive even when sleep is not impaired. Consistent with Hypothesis 4, the findings indicate that pre-sleep arousal could also undermine both the quantity and quality of sleep, as it predicted longer time to get to sleep, fewer hours of sleep and higher global PSQI scores at follow-up. The long length of the pre-sleep arousal measure precluded its use in the daily assessments; however, the fact that it emerged as an important predictor of sleep behaviour suggests the utility of developing a shorter measure for use in daily assessments. It may be that interventions aimed at stress reduction and managing emotional demands of work will be most likely to reduce pre-sleep arousal, whereas strategies for simply reducing cognitive demands (e.g. simplifying work tasks) may be less effective.

Strengths, limitations and practical implications

Several strengths and limitations of the present study warrant comment. The completion rate was reasonably high for surveys involving daily assessments, with two-thirds of participants completing most of the daily surveys. The use of mixed-model analyses to evaluate relationships between daily assessments of work-related factors and sleep experiences that night (as opposed to other types of repeated measures analyses or reliance on measures of behaviours over a longer time frame) provided more powerful tests of the hypotheses. The primary value of this design is that it takes into account the daily fluctuations inherent in work experiences and sleep patterns, that can be lost in a design in which analyses test predictors of daily reports of work experiences and sleep that are averaged over a period of time (Gueorguieva & Krystal, 2004). Given that the sample was limited to New Zealanders working in a select number of organizations,

however, caution is needed before generalizing the observed patterns to adults in other work cultures. For example, the average income level was reflective of a middle- to upper middle-class population. Although the sample was relatively small, it is comparable to those of other studies using mixed-model analysis to evaluate daily observations over extended periods of time (Bower, Bylsma, Morris, & Rottenberg, 2010; Schlatter & Cameron, 2010) and it yielded a large sample of daily observations. The findings support the construct validity of the sleep prioritization measure by demonstrating that it predicts multiple sleep outcomes. Its use in further research could expand our understanding of the role of sleep prioritization in guiding sleep behaviour.

The findings further our understanding of the self-regulation of the (often competing) demands of work and sleep. The absence of uniformly consistent associations between the work demand and sleep variables suggests that work demand effects on sleep are subtle and nuanced, with specific types of work demand influencing specific steps of the sleep process. Guided by these results, future research could further hone in on how cognitive and emotional demands and emotions at work differentially influence bedtime, hours of sleep, time of waking and general sleep quality.

Conclusion

This study highlights the need to develop and test self-regulation techniques that minimize the detrimental effects of work-related demands and conflicts on sleep-related behaviours, in ways that reduce sleep deprivation and its increasingly recognized consequences for health and well-being. Developing goal-setting strategies that help individuals to prioritize sleep may be one way to improve their sleep experiences. Interventions aimed at improving coping and emotional regulation skills for managing cognitive and emotional demands and conflicts at work could accelerate recovery after work and improve sleep (Cameron & Jago, 2008; van Hooff et al., 2011). Recent evidence supports the efficacy of a mental imagery intervention for implementing adaptive sleep hygiene patterns in improving sleep for working adults (Loft & Cameron, 2013). These self-regulation strategies could be tested alone and in combination to determine an optimal intervention package for improving the sleep habits of working adults.

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References

Åkerstedt, T. (2006). Psychosocial stress and impaired sleep. *Scandinavian Journal of Work, Environment and Health*, *32*, 493–501. doi:10.5271/sjweh.1054

Barber, L. K., Munz, D. C., Bagsby, P. G., & Powell, E. D. (2010). Sleep consistency and sufficiency: Are both necessary for less psychological strain. *Stress and Health*, *26*, 186–193. doi:10.1002/smi.1292

Basner, M., Fomberstein, K. M., Razavi, R. M., Banks, S., William, J. H., Rosa, R. R., & Dinges, D. F. (2007). American time use survey: Sleep time and its relationship to waking activities. *Sleep*, *30*, 1085–1095.

Bower, B., Bylsma, L. M., Morris, B. H., & Rottenberg, J. (2010). Poor reported sleep quality predicts low positive affect in daily life among healthy and mood-disordered persons. *Journal of Sleep Research*, *19*, 323–332. doi:10.1111/j.1365-2869.2009.00816.x

Brindle, R. C., & Conklin, S. M. (2012). Daytime sleep accelerates cardiovascular recovery after psychological stress. *International Journal of Behavioral Medicine*, *19*(1), 111–114. doi:10.1007/s12529-011-9150-0

Buysse, D. J., Reynolds, C. F., Monk, T. H., Berman, S. R., & Kupfer, D. J. (1989). The Pittsburgh Sleep Quality Index: A new instrument for psychiatric practice and research. *Psychiatry Research*, *28*, 193–213. doi:10.1016/0165-1781(89)90047-4

Cameron, L. D., & Jago, L. (2008). Emotion regulation interventions: A common-sense model approach. *British Journal of Health Psychology*, *13*, 215–221. doi:10.1348/135910708X288800

Cameron, L. D., & Leventhal, H. (2003). Self-regulation, health, and illness. In L. D. Cameron & H. Leventhal (Eds.), *The self-regulation of health and illness behaviour*. New York: Routledge, Taylor & Francis Group.

Cohen, S., Kamarck, T., & Mermelstein, R. (1983). A global measure of perceived stress. *Journal of Health and Social Behavior*, *24*, 385–396. doi:10.2307/2136404

Copinschi, G. (2005). Metabolic and endocrine effects of sleep deprivation. *Essential Psychopharmacology*, *6*, 341–347.

de Lange, A. H., Kompier, M. A. J., Taris, T. W., Geurts, S. A. E., Beckers, D. G. J., Houtman, I. L. D., & Bongers, P. M. (2009). A hard day's night: A longitudinal study on the relationships among job demands and job control, sleep quality and fatigue. *Journal of Sleep Research*, *18*, 374–383. doi:10.1111/j.1365-2869.2009.00735.x

Doi, Y., Minowa, M., & Tango, T. (2003). Impact and correlates of poor sleep quality in Japanese white-collar employees. *Sleep*, *26*, 467–471.

Espie, C. A. (2002). Insomnia: Conceptual issues in the development, persistence, and treatment of sleep disorder in adults. *Annual Review of Psychology*, *53*, 215–243. doi:10.1146/annurev.psych.53.100901.135243

Fisher, C. D. (2000). Mood and emotions while working: Missing pieces of job satisfaction? *Journal of Organizational Behavior*, *21*, 185–202. doi:10.1002/(SICI)1099-1379(200003)21:2<185::AID-JOB34>3.0.CO;2-M

Gueorguieva, R., & Krystal, J. H. (2004). Move over ANOVA: Progress in analysing repeated-measures data and its reflection in papers published in the archives of general psychiatry. *Archives of General Psychiatry*, *61*, 310–317. doi:10.1001/archpsyc.61.3.310

Hagger, M. S. (2010a). Sleep, self-regulation, self-control and health. *Stress and Health*, *26*, 181–185. doi:10.1002/smi.1345

Hagger, M. S. (2010b). Self-regulation: An important construct in health psychology research and practice. *Health Psychology Review*, *4*, 57–65. doi:10.1080/17437199.2010.503594

Hanson, L. L. M., Akerstedt, T., Naswall, K., Leineweber, C., Theorell, T., & Westerlund, H. (2011). Cross-lagged relationships between workplace demands, control, support, and sleep problems. *Sleep*, *34*, 1403–1410.

Harvey, K. J., & Espie, C. A. (2004). Development and preliminary validation of the Glasgow Content of Thoughts Inventory (GCTI): A new measure for the assessment of pre-sleep cognitive activity. *British Journal of Clinical Psychology*, *43*, 409–420. doi:10.1348/0144665042388900

Jones, F., Burke, R. J., & Westman, M. (2006). *Work-life balance: A psychological perspective*. New York, NY: Psychology Press.

Kivisto, M., Harma, M., Sallinen, M., & Kalimo, R. (2008). Work-related factors, sleep debt and insomnia in IT professionals. *Occupational Medicine*, *58*, 138–140. doi:10.1093/occmed/kqm150

Kohout, F. J., Berkman, L. F., Evans, D. A., & Cornoni-Huntley, J. (1993). Two shorter forms of the CES-D depression symptoms index. *Journal of Aging and Health*, *5*, 179–193. doi:10.1177/089826439300500202

Kristensen, T. S., Hannerz, H., Høgh, A., & Borg, V. (2005). The Copenhagen Psychosocial Questionnaire—A tool for the assessment and improvement of the psychosocial work environment. *Scandinavian Journal of Work, Environment and Health*, *31*, 438–449. doi:10.5271/sjweh.948

LeBlanc, M., Merette, C., Savard, J., Ivers, H., Baillargeon, L., & Morin, C. M. (2009). Incidence and risk factors of insomnia in a population-based sample. *Sleep*, *32*, 1027–1037.

Loft, M. H., & Cameron, L. D. (2013). Using mental imagery to deliver self-regulation techniques to improve sleep behaviors. *Annals of Behavioral Medicine*, *46*, 260–272. doi:10.1007/s12160-013-9503-9

Lopez, S. J., & Snyder, C. R. (2009). The central role of the heart in generating and sustaining positive emotions. In R. McCraty & R. A. Rees (Eds.), *Oxford handbook of positive psychology* (2nd ed., pp. 527–536). New York, NY: Oxford University Press.

Marteau, T. M., & Bekker, H. (1992). The development of a six-item short-form of the state scale of the Spielberger State-Trait Anxiety Inventory (STAI). *British Journal of Clinical Psychology*, *31*, 301–306. doi:10.1111/j.2044-8260.1992.tb00997.x

McNair, D. M., Lorr, M., & Droppleman, L. F. (1992). *POMS manual: Profile of Mood States*. San Diego, CA: Edits.

Norra, C., Kummer, J., Boecker, M., Skobel, E., Schauerte, P., Wirtz, M., … Forkmann, T. (2011). Poor sleep quality is associated wtih depressive symptoms in patients with heart disease. *International Journal of Behaviour Medicine*, *19*, 526–534. doi:10.1007/s12529-011-9205-2

SAS (9.1.3) [Computer software]. http://www.sas.com/offices/europe/uk/software/index.html

Scheier, M. F., & Carver, C. S. (2003). Goals and confidence as self-regulatory elements underlying health and illness behaviour. In L. D. Cameron & H. Leventhal (Eds.), *The self-regulation of health and illness behaviour* (pp. 17–41). New York, NY: Routledge.

Schlatter, M. C., & Cameron, L. D. (2010). Emotional suppression tendencies as predictors fo symptoms, mood and coping appraisals during AC chemotherapy for breast cancer treatment. *Annals of Behavioral Medicine*, *40*(1), 15–29. doi:10.1007/s12160-010-9204-6

Sonnentag, S., & Bayer, U.-V. (2005). Switching off mentally: Predictors and consequences of psychological detachment from work during off-job time. *Journal of Occupational Health Psychology*, *10*, 393–414. doi:10.1037/1076-8998.10.4.393

SPSS (15.0) [Computer software]. http://www-01.ibm.com/software/analytics/spss/

Stein, M. B., Belik, S.-L., Jacobi, F., & Sareen, J. (2008). Impairment associated with sleep problems in the community: Relationship to physical and mental health comorbidity. *Psychosomatic Medicine*, *70*, 913–919. doi:10.1097/PSY.0b013e3181871405

Taylor, D. J., Lichstein, K. L., & Durrence, H. H. (2003). Insomnia as a health risk factor. *Behavioral Sleep Medicine*, *1*, 227–247. doi:10.1207/S15402010BSM0104_5

van Hooff, M. L. M., Geurts, S. A. E., Beckers, D. G. J., & Kompier, M. A. J. (2011). Daily recovery from work: The role of activities, effort and pleasure. *Work & Stress*, *25*, 55–74. doi:10.1080/02678373.2011.570941

Vohs, K. D., Baumeister, R. F., & Ciarocco, N. J. (2005). Self-regulation and self-presentation: Regulatory resource depletion impairs impression management and effortful self-presentation depletes regulatory resources. *Journal of Personality and Social psychology*, *88*, 632–657. doi:10.1037/0022-3514.88.4.632

Waters, W. F., Adams, S. G., Binks, P., & Varnado, P. (1993). Attention, stress and negative emotion in persistent sleep-onset and sleep maintenance insomnia. *Sleep*, *16*, 128–136.

Winwood, P. C., & Lushington, K. (2006). Disentangling the effects of psychological and physical work demands on sleep, recovery and maladaptive chronic stress outcomes within a large sample of Australian nurses. *Journal of Advanced Nursing*, *56*, 679–689. doi:10.1111/j.1365-2648.2006.04055.x