The Associations between Physiological Recovery Indicators during Sleep and Self-Reported Work Stressors

Rönkä T[1], **Rusko H**[1], **Feldt T**[1a], **Kinnunen U**[2], **Mauno S**[2], **Uusitalo A**[3] **and Martinmäki K**[1]
[1] Department of Biology of Physical Activity, University of Jyväskylä, Jyväskylä, Finland
[a] Department of Psychology, University of Jyväskylä, Jyväskylä, Finland
[2] Department of Psychology, University of Tampere, Tampere, Finland
[3] Helsinki University Central Hospital, HUSLAB Meilahti/Division of Clinical Physiology and Nuclear Medicine, Helsinki, Finland

terhi.ronka@sport.jyu.fi

The present study investigated whether physiological recovery during night sleep is associated with self-reported work stressors during the following working day. The sample consisted of 17 hospital employees. The physiological recovery during sleep was analyzed with Firstbeat PRO Wellness Analysis Software® (WAS; 1). Self-reported work stressors were measured by a 15-item Daily Hassles –scale (2). Sleep duration was negatively related to the work stressors. In addition, the longer the relaxation time, the less work stressors were perceived. Thus, the present study suggests that relaxation detected by WAS might be an objective method to study recovery.

Keywords: recovery, sleep time, work stressors, WAS

Introduction

The inability to rest and recover from work demands may have severe negative effects on an individual's health and well-being (3-5). The Effort-Recovery Model developed by Meijman and Mulder (5) suggests that recovery processes play an important role in predicting our health and well-being. Accordingly, our efforts during the working day lead to specific stress reactions (physiological, behavioral and subjective responses). When an individual is no longer confronted with work demands, his or her psychobiological systems previously affected by the demands return to their pre-demand level and recovery occurs, for example fatigue and other effects of stressful situations are reduced. However, no recovery can occur when the demands do not cease but are continuously faced by the individual. Insufficient recovery can cause accumulated stress reactions and impaired well-being. Recent results have confirmed the importance of recovery during evening and day-off (6-9). These studies have prompted further discussion on recovery during sleep (6, 8).

Recently, new promising software has been introduced for the analysis of individuals' recovery and stress during sleep. Firstbeat PRO Wellness Analysis Software® (WAS; 1) detects relaxation and stress states of the autonomic nervous system (ANS) by analyzing heart rate (HR) and heart rate variability (HRV) -based indices from ambulatory recording of R-to-R heartbeat intervals (RRI).

Objectives

The major aim was to investigate whether physiological recovery measured during the sleep time is related to self-reported work stressors during the following working day and to evaluate the validity of WAS (1), which was used to measure the physiological recovery indicators. Based on the Effort-Recovery Model (5), it was reasonable to hypothesize that the more physiological recovery is recognized during the sleep time, the less work-related stressors are reported during the following working day.

Methods

Procedure and participants. The study was part of a ”Heart Rate and Work Stress” research project currently in progress at the University of Jyväskylä, Finland. The participants of the present study were 17 employees from the Central Hospital of Central Finland. Measurements included two working days and one day-off, during which physiological data (RR-intervals) and psychological questionnaire data was collected. The present study focuses on data collected during the second night at the end of the working week, when the importance of recovery during sleep is emphasized. Using data from the second night allowed us to avoid the so-called first night effect (10). Five participants of the original sample were rejected due to sickness that influenced RRI-data or a high error percentage of the RRI recording, and thus, the final number of participants was 17. Most of the participants were nurses (n=15), one worked as a practical nurse and one as a physician. The average age was 42 years (ranging from 24 to 57 years). The participants' work experience ranged between 1 and 27 years (mean 10 years). 82% of the participants were permanently employed and 18% were temporarily employed.

Physiological recovery variables during sleep. Relaxation and stress times during sleep were analyzed with Firstbeat PRO Wellness Analysis Software version 1.4.1 (www.firstbeat.fi) based on Heart Rate (HR) and Heart Rate Variability (HRV) from the RRI data. The analysis of relaxation and stress is based on the detection of sympathovagal reactivity that exceeds momentary metabolic requirements for the autonomic nervous system (ANS). The program calculates HRV indices second-by-second using the short-time Fourier Transform method (STFT), and HR- and HRV-derived variables that describe respiration rate and oxygen consumption (VO_2) using neural network modeling of data (11-14). The program also calculates second-by-second indices of relaxation and stress, reflecting activities of the sympathetic (absolute stress vector, ASV) and parasympathetic (absolute relaxation vector, ARV) nervous system. ASV is calculated from HR, high frequency power (HFP), low frequency power (LFP) and HRV-derived respiratory variables. ASV is high when HR is elevated, HRV is reduced and there are inconsistencies in the frequency distribution of HRV due to changes in respiratory period. ARV is calculated from HR and HFP and it is high when HR is close to the basic resting level and HRV is great and regular. For more details, see Kettunen and Saalasti (12) and the Wellness Analysis Software User Manual (1).

Based on the above-mentioned variables, the program draws conclusions on the duration of the different physiological states of the body during the night by segmenting the data into stationary segments. The data segments, including movement, physical activity at different intensities and recovery from physical activity, are detected using HR, HRV-derived respiration rate, estimated VO_2 and movement-related ANS responses. For non-exercise data segments, continuous indices of stress (ASV) and relaxation (ARV) are used to identify the time when the body is in a stress state (ST, Stress Time), relaxation state (RT, Relaxation Time) or an unrecognized state (URS). The stress state is defined as increased activation in the body, induced by external and internal stress factors (stressors), during which sympathetic nervous system activity is dominating and parasympathetic (vagal) activation is reduced. This definition does not take into account the nature of the stress response, that is, whether it is positive or negative. The relaxation state is defined as decreased activation in the body during relaxation, rest and/or peaceful working, related to the lack of external and internal stress factors when parasympathetic (vagal) activation is dominating. In the present study, *relaxation* and *stress times* were calculated for the hours during night sleep. In addition, we utilized information on *sleep duration* and *average heart rate* during sleep.

Work stressor variables were assessed with a 15-item questionnaire modified from the Daily Hassles and Uplifts scale (2). From the original 53 items, only work-related items were chosen to the current study (e.g. your workload, your supervisor, the nature of your work;

“How much of a hassle was this item for you today?”). The items were rated on a scale ranging from 0 (none or not applicable) to 3 (a great deal). All of the 15 items formed a sum score describing *work stressors*. In addition, two other sum scores were formed, which described *workload stressors* (including 2 items of the 15 items; amount of work, working pace) and *social stressors* (including 4 items of the 15 items; co-worker, supervisor, atmosphere, patients). The Cronbach alpha coefficients were 0.84, 0.85 and 0.77, respectively.

Results
The descriptive analyses of WAS are shown in Table 1. The sleep duration ranged between 343 minutes (5h 43min) and 522 minutes (8h 42min), with the average sleep duration being 438 minutes (7h 18 min). During sleep, the relaxation period recognized by WAS was longer than the stress period. Table 1 shows that the variation between subjects in recognized relaxation and stress periods during sleep was great.

Table 1. WAS parameters during sleep time (n=17).

	Mean	**SD**	**Minimum**	**Maximum**
Sleep Duration (minutes)	438	51	343	522
RelaxationTime (minutes)	262	110	97	410
StressTime (minutes)	126	101	0	317
AverageHR (times/minutes)	61	5	53	73

As expected, the Pearson correlations showed that the work stressors correlated negatively with sleep duration (r= -.541*, p- value .025) and tended to correlate negatively also with relaxation time (r= -.424, p-value .090). In other words, the more the subjects slept at night, the less they reported work stressors during the following working day. When the work stressors were separated into workload stressors and social stressors, social stressors correlated (Spearman correlations) negatively with sleep duration (r= -.564*, p- value .018) and workload stressors tended to correlate negatively with relaxation time (r= -.481, p-value .050). The more the subjects slept at night, the less they reported social stressors during the following working day.

Discussion and Conclusions
This study examined the connection between physiological recovery during night sleep and self-reported work stressors during the following working day. The results showed that sleep duration was related to perceived work stressors, particularly to social stressors. In addition, relaxation time during sleep tended to correlate with workload stressors. The results supported the assumption that sleep duration has an effect on work stressors. Based on HR and HRV analysis from ambulatory RRI recordings, it can be possible to determine the relaxation and stress states of sleep. In further studies, however, we should investigate larger samples and individuals who have some baseline chronic stress, i.e. overcommitment to work.

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Contact information:
Terhi Rönkä, M.A. (Psychology)
Department of Biology of Physical Activity, University of Jyväskylä
Jyväskylä, Finland
Email: terhi.ronka@sport.jyu.fi
Phone: +358142602059
Postal Address: P.O. Box 35 (LL), 40014 University of Jyväskylä, Finland
Street Address: Rautpohjankatu 8, 40700 Jyväskylä, Finland