How about work demands, recovery, and health? A neuroendocrine field study during and after work

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Chapter 4

Work stress and recovery in long-distance coach drivers

4.1 Work stress and recovery measured by urinary catecholamines and cortisol excretion in long-distance coach drivers

Abstract

Objectives To evaluate coach drivers' work stress during work and in the course of recovery from work by measurement of urinary catecholamines and cortisol.
Methods The urinary excretion rate of adrenaline, noradrenaline, and cortisol of 10 coach drivers was studied during a long distance trip of three days and two consecutive days off. Each driver was asked to provide seven urine samples on the working days and six urine samples on the days off. The second day off was considered as base line.
Results An occupationally induced disturbance of the circadian rhythmicity was found for adrenaline and noradrenaline but not for cortisol. The mean excretion rates of adrenaline on the first working day and most individual time samples on all working days were higher than the base line. For both adrenaline and noradrenaline the mean excretion rates on the first day off was lower than the base line. For cortisol, the mean excretion rate on all working days was higher than the base line. A trend towards accumulation of cortisol excretion from the first working day to the third working day was found. A backward shift in peak concentrations was found for adrenaline and noradrenaline on the second working day, as was a forward shift in peak concentration of cortisol on both days off.
Conclusions Long distance coach drivers showed occupationally induced reactivity in urinary adrenaline, noradrenaline, and cortisol excretion rates. After the outward journey the catecholamines excretion rates did not return to baseline values. The course of recovery in adrenaline excretion after the journey revealed a new phenomenon, which has been called 'fatigue debt'. It is recommended to plan longer resting times in shuttle bus trips and fixed days off after these kinds of trips. Extensive future research should be focused on the additional relationships between fatigue debt and health complaints.

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Introduction

A recent review based on 32 studies (1) showed a high prevalence of a variety of disorders in city bus drivers, both psychological (fatigue, sleeping problems, tension, and mental overload), gastro-intestinal, and musculoskeletal (back and knees). These health complaints were found to be associated with work stress, caused by the combination of high demands, low control and low support in the job (1). Neuroendocrine responses to stressors include reactions of the pituitary adrenocortical system and the sympathetic adrenomedullary system. The measurable physiological changes accompanying stress are elevated excretion levels of cortisol and adrenaline (1-3). The beneficial effects of appropriate adjustment to novel situations by heightened excretion levels of adrenaline and cortisol are assumed to turn into adverse effects on health if these levels are chronically elevated or prolonged activity is asked for (2). Noradrenaline reactivity mainly takes place in physically demanding tasks and therefore provides additional information about task demands (6,7). Evaluations of work stress by means of excretion of catecholamines or cortisol during work have been performed in studies on city bus drivers, but also on truck drivers (1,4-10).

In contrast with city bus drivers, truck drivers and coach drivers mostly perform long-distance trips. These trips often exceed several twenty-four hours' periods, which means that the task demands are high and the work continues during night hours. In their classical study, Mackie and Miller (4) investigated twelve truck drivers and six bus drivers during long-term trips. They concluded that due to circadian rhythmicity, excretion rates of adrenaline and noradrenaline were lower during the late night/early morning on irregularly scheduled trips when compared to the regularly scheduled trips mainly performed during daytime. Furthermore, a cumulative fatigue effect was found in combination with high adrenaline excretion during the final regular trip. Vivoli (5) studied three long-distance lorry drivers. Although individual differences were great, increases in excretion rates of adrenaline and noradrenaline were found in all subjects in the afternoon hours and in conditions like driving in fog. For cortisol, the normal circadian rhythm was found and no stress-related increases were reported. Due to circadian rhythmicity, plasma secretion rates of cortisol are high in the early morning and low in the late evening (13,14,18). Circadian rhythmicity in adrenaline and noradrenaline show peak concentrations in the early afternoon (2-14, 17,18).

Reactivity in levels of catecholamines and cortisol during work are seen as normal and essential neuroendocrine responses enabling contextual coping. Recovery from work is the rate at which return to the base line levels of these hormones after work takes place. When the subjects are unable to unwind completely, this is described in terms of a spillover of neuroendocrine activity. This spillover has been found in catecholamines (6,7) but not in cortisol. Repeated insufficient recovery from work-related fatigue is seen as the take-off of a vicious circle in which extra effort has to be exerted at the beginning of every new working period to rebalance the sub-optimal psycho-physiological state, and to prevent performance breakdown (6,7). Time seems to be the crucial variable in recovering from occupationally exerted efforts. The question of whether repeated insufficient unwinding of catecholamine levels during the off-work recovery period is responsible for the onset of long-term health complaints, has been raised more frequently lately (2,6,7). This same question should be raised and investigated for cortisol.

A questionnaire study of long-distance truck drivers (11) revealed that excessive sleep of more than 14 h occurred after trips in 40% of drivers and usually more than two days were necessary for complete recovery after prolonged trips in 80% of drivers. Less attention has been paid to the course of recovery from work as measured by catecholamines and cortisol excretion (6,7,12). Hartley et al. (12) investigated three long-distance truck drivers, i.e. one solo driver and one two-up crew. The solo driver showed a greater proportional increase over the journey in catecholamines than the two-up crew. Furthermore, it was suggested that between the start from the outward and the start from the return journey some recovery in catecholamines excretion took place. Finally, Kuiper et al. (7) emphasised the role of recovery from work in their study on 28 truck drivers. They showed the relation between elevated sympathoadrenal activation *after* work and health problems: spillover of sympathoadrenal activation, as assessed by urinary excretion of adrenaline and noradrenaline, was positively related to self-reported psychosomatic health complaints. Thus, the rate of return to baseline of catecholamine concentrations after work, equalling the subject's ability to unwind after stressful work, may be an important predictive factor for health in the long run.

Work stress studies which evaluated the course of recovery during more days by measurements of catecholamines and cortisol have not been performed before. Because the work of coach drivers has characteristics like longer duration of trips, irregularity in working hours, and longer distances that have to be covered, occupationally induced fatigue and the ensuing needs for recovery can be expected in coach drivers. The aim of this study was to evaluate work stress and corresponding recovery by means of urinary excreted adrenaline, noradrenaline, and cortisol. This was tested in long-distance coach drivers.

Methods

Subjects

Ten Dutch coach drivers, involved in five long-distance shuttle trips from The Netherlands to Spain, were selected by random sampling from all coach companies in the private passenger sector. Conditions for subjects to be included were: (i) minimum one year experience in driving long-distance shuttle trips, (ii) knowledge of the route, and (iii) one day off prior to the trip, and two days off after the trip. Informed consent was given by all subjects.

Description of journeys

The routes from the south of The Netherlands, via Belgium, Luxembourg, France, to Spain were identical for each driver. Data were collected within six weeks in October and November 1996. All trips were driven in a two-up operation configuration. Continuous observation of tasks and activities of both drivers took place by means of the observation system TRAC [17] (Task Recording and Analysis on Computer). All details concerning road conditions (motorways, suburban roads, town roads, traffic jams) and visibility (clear, fog, rain, night) were noted in a diary. During the trip at times of urine-sampling, drivers were asked to self-report on an experienced workload scale (from 0=no effort at all, 150=extremely strenuous), active-exhaustive scale (10 points scale), and relaxed-tense scale (10 points scale). Departures for Spain were on Friday around noon and arrival in Spain was on Saturday morning. Departures for The Netherlands were on the same Saturday in the early evening after a resting time during the afternoon, and arrival in The Netherlands was on Sunday around noon. A timetable of working days and days off is shown in figure 1.

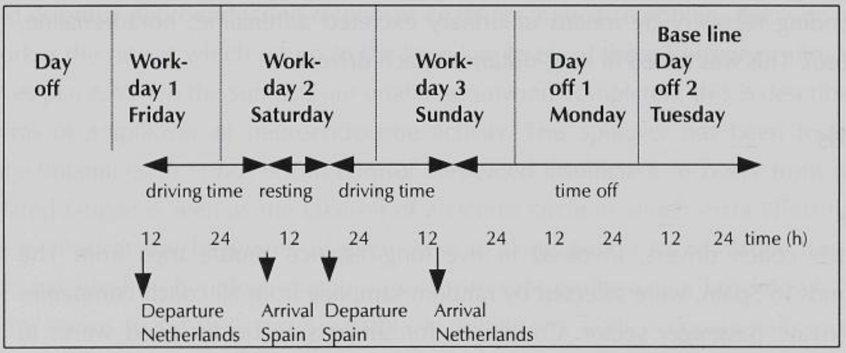

Figure 1. **Overall time table of two-up crew's journey The Netherlands - Spain. Driving and resting time (h), and consecutive time off (h).**

Urinary collection and measurements

Measurements of catecholamines and cortisol were performed during daily work routine, during a resting period in Spain as well as during a two day off-work period after the trip, viz. to establish the within-subjects recovery and baseline concentrations of catecholamines and cortisol. Thus, urine was collected during a consecutive period of five days, i.e. each driver was studied for one journey equalling three working days, and two consecutive days off. They were asked to collect all urine in this period and to provide samples (1) around 07 00 h, (2) around 11 00 h, (3) around 14 00 h, (4) around 17 00 h, (5) around 20 00 h, and (6) around 23 00 h. Because the journeys covered two nights, the drivers were additionally asked to provide samples around 04 00 h on these nights. The drivers were asked to record the time of the last urination in the night before the journey. Because of the 'real life character' of the study, it was decided not to restrict the drivers in behavioural habits. Obviously, data on consumption of coffee, tea, alcohol, and medicine during all five days were collected to be able to control for differences. Furthermore, it was asked whether emotional events, like a quarrel or other traumatic incidents, had occurred. All times of urination were recorded and all samples were collected in different jars containing 0.7 g of citric acid. After collection, jars were kept as cold as possible until further preparation started within 24 h. After assessment of the volume per urine jar, 40 ml was kept, of which 20 ml was acidified with 0.1 ml 10 M HCl. These 20 ml samples were kept frozen (-20^0 C) until analysis. The urinary catecholamine concentrations were determined from the acidified 20 ml part by high performance liquid chromatography with fluorescence detection by the method of Boos *et al.* (15). The urinary cortisol concentrations were determined from the unacidified 20 ml part by high performance liquid chromatography upon a C_{18} column with UV detection (240 nm).

Data analysis and statistics

The urinary concentrations (ng/ml) were multiplied by the volume of the corresponding urine sample (ng). This amount was divided by the period of time between the urination of this sample and the previous urination, to obtain the mean excretion rate for that period (ng/min). All statistical analyses were performed with the SPSS-package for Windows. Firstly, the overall mean excretion rate per day was calculated for all five days. Differences between these overall means were tested by means of paired t-tests. Secondly, for each day a repeated measures analysis of variance (MANOVA; F test) was performed to test whether there were diurnal differences. If so, differences per sample time between the three working days and first day off were compared with Day off 2 (base line) by means of paired t-tests. To control for differences in coffee, tea, alcohol, and medicine intake between the five days, a repeated measures analysis of variance (MANOVA; F test) was performed. To control for differences in relative duration of the performance of the main tasks between the five journeys, an analysis of variance (MANOVA; F test) was performed. In all analyses differences were accepted as significant at $p<0.05$. Because of sample size, marginal significancy is reported for $0.05<p<0.10$.

Results

Subjects

The ten male subjects were on average 47 years of age (SD 7 years) and had a mean driving experience on long-distance shuttle coach trips of 11 years (SD 9 years). Although the absolute 24 h levels of the consumption of coffee, nicotine, and alcohol were high (averaging 11 cups, 16 cigarettes, and 4 glasses per day respectively), no differences (MANOVA, repeated measures) in consumption were found between the three working days and Day off 1 when compared to the base line (Day off 2).

Journey

The activities of the crews were broadly similar: travelling comparable routes on comparable days and times, loading and unloading, taking breaks according to the regulations governing driving hours, and taking resting time in Spain. No differences were found in relative duration of the main tasks performed between the five journeys (MANOVA; F test). Mean journey time was 49 h (SD 3) with mean driving time as main task of 16.5 h (SD 2.5) and mean resting time at destination in Spain of 8.5 h (SD 1.5). During resting time on Workday 2, the drivers slept on average 5.4 h (SD 0.9) during day time hours. Total trip duration, and the time spent at destination varied up to 4 h between the five trips. No excessive weather or traffic circumstances were observed.

Adrenaline

Figure 2 shows the mean (SD) of urinary excretion rates of adrenaline on the five consecutive days (see appendix A1 for the exact values). The overall mean excretion rate of adrenaline on Workday 1 was significantly higher than the overall excretion rate on the other four days ($p<0.01$ compared to Workday 2 and Day off 1; $p<0.05$ compared to Workday 3 and Day off 2). The overall mean excretion rate of adrenaline on Day off 1 was significantly lower than the overall excretion rate on the other four days ($p<0.01$ compared to Workday 1 and Day off 2; $p<0.05$ compared to Work day 2 and 3). On all five days, a circadian rhythmicity was notable ($p<0.05$ for all days). The peak concentration was reached around midday (sample 14 00 h; 15.2, 12.9, and 8.9 ng/min on Workday 1 and 3, and Day off 2 respectively). On Workday 2 disturbance of the circadian rhythmicity was notable: The drivers slept between around 11 30 h and 16 30 h and peak concentration was reached before 11 00 h (12.4 ng/min). On Day off 1, peak concentration was reached around tea time (sample 17 00 h; 7.9 ng/min). Significant differences ($p<0.05$) between the working days and the baseline concentration were found for the 14 00 h, 20 00 h, and 23 00 h sample on Work day 1, for all samples on Workday 2, and for the 07 00 h, 11 00 h, and 23 00 h samples on Workday 3. Furthermore, marginal differences were found for the 11 00 h and 17 00 h sample on Workday 1, and the 20 00 h sample on Work day 3.

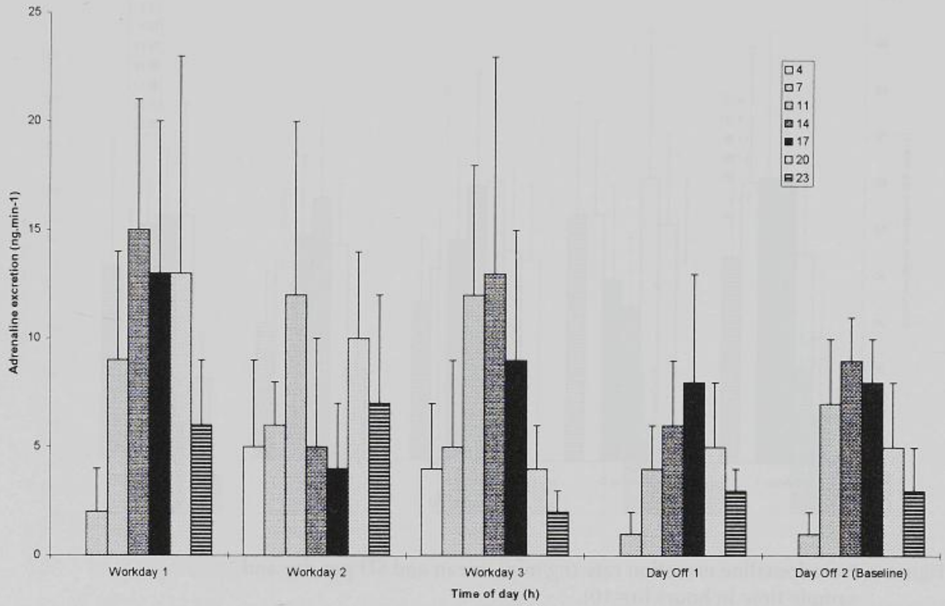

Figure 2. Adrenaline excretion rate (ng/min), mean and SD per day and sample time in hours (n=10).

Noradrenaline

In figure 3 the mean (SD) of urinary excretion rates of noradrenaline on the five consecutive days is shown (see appendix A2 for the exact values). On all five days a circadian rhythmicity was notable ($p<0.05$ for all days). The overall mean excretion rate of noradrenaline on Workday 1 was marginally significantly higher than the overall excretion rate on both days off. Peak concentration was reached around midday on Day off 1 and Day off 2 (sample 14 00 h: 56.4 and 52.1 ng/min respectively), and before 11 00 h on Workday 2 and Workday 3 (61.2 and 59.8 ng/min respectively). On Workday 1, peak concentration was reached around tea time (sample 17 00 h; 60.8 ng/min). Significant differences between working days and the base line excretion rates were found for: Workday 1 (07 00 h and 20 00 h), Workday 2 (04 00 h, 07 00 h and 14 00 h), and Workday 3 (04 00 h and 07 00 h) (all $p<0.05$). Compared to the base line, a marginally significant difference was found for the 17 00 h sample of Workday 2.

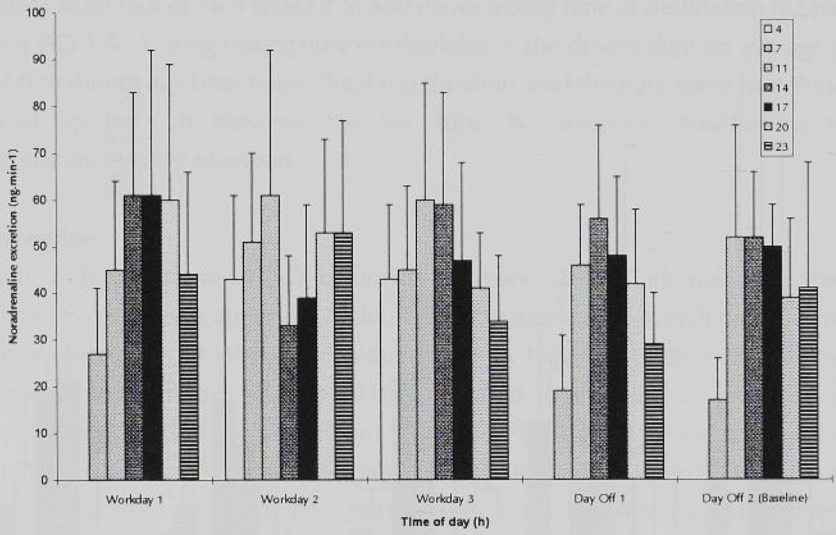

Figure 3. Noradrenaline excretion rate (ng/min), mean and SD per day and sample time in hours (n=10).

Cortisol

Figure 4 shows the mean (SD) of urinary excretion rates of cortisol on the five consecutive days (see appendix A3 for the exact values). The overall mean excretion rate of cortisol on Workday 1 was marginally significantly higher than the overall excretion rates on both days off ($p=0.05$). The overall mean excretion rate on Workday 2 and 3 were significantly higher than the overall excretion rate on Day off 2 ($p<0.01$ and $p<0.05$ respectively). The overall mean excretion rate of cortisol on Day off 1 was significantly lower than the overall mean excretion rate on Workday 2 and 3 ($p<0.01$). For all five days a circadian rhythmicity was found ($p<0.001$). Peak concentration was reached in the early morning on Workday 1, 2, and 3 (sample 7 00 h: 31.4, 51.2 and 55.8 ng/min respectively), and around 11 00 h on Day off 1 and 2 (30.9 and 32.2 ng/min respectively). Compared to both days off, excretion rates early in the morning were significantly higher on the three working days (07 00 h: $p<0.05$). Marginally significant differences were found between the 07 00 h samples of Workday 2 and 3 compared to Workday 1, the excretion rate on Workday 1 being lower.

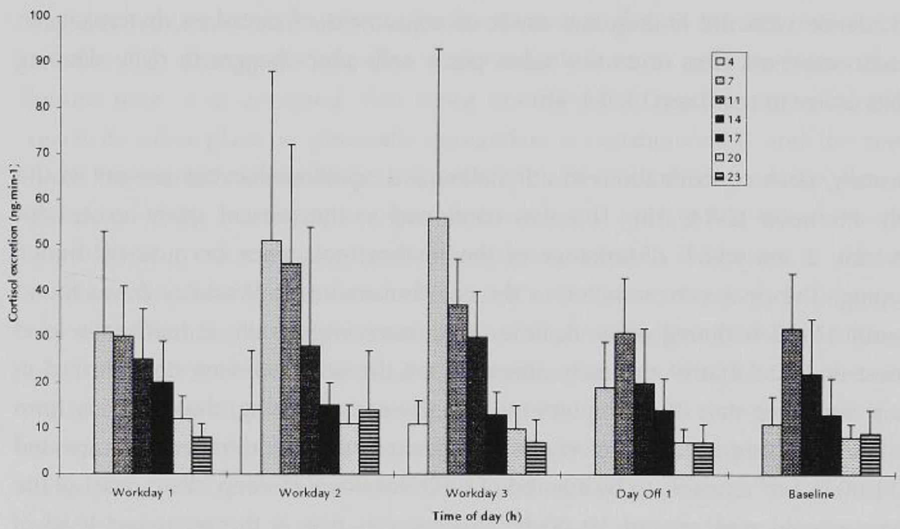

Figure 4. Cortisol excretion rate (ng/min), mean and SD per day and sample time in hours (n=10).

Self-reports

On Workday 3 the drivers experienced significantly ($p<0.05$) more workload than on Workday 1, and on Workday 2 they felt significantly ($p<0.05$) less active compared to Workday 1. No differences between the days were found for the active-tense scale.

Discussion

The relationship between catecholamines and cortisol, and their reactivity patterns in off-work recovery periods of time remains unclear so far. In this study of 10 coach drivers, it was therefore decided to assess both urinary catecholamines and cortisol during work as well as after work to investigate the course of recovery. In accordance with most earlier studies (2-10, 12, 17-19), normal circadian rhythms were found for the excretion rates of adrenaline and noradrenaline in four out of five days, and absolute levels of adrenaline and noradrenaline were comparable as well (6-8). Because subjects slept during day time on the second working day, the circadian rhythmicity was highly disturbed on this day. However, the cortisol levels on this day showed the same, normal pattern as on the other days, which is in accordance with the finding that onset of adjustment of circadian rhythmicity in plasma secretion rates of cortisol takes place only after changes in daily sleeping habits of five to ten days (13, 14, 18).

Normally, peak concentrations in adrenaline and noradrenaline are present in the early afternoon (2-14, 19). This was confirmed in the present study, except for Workday 2, on which disturbance of the rhythm took place because of diurnal sleeping. The peak concentration of the catecholamines on Workday 2 was found around 11 00 h during off-work time, and, more importantly, it reached a level almost equal to that of the early afternoon on the other working days. Arrival in Spain (equalling start of resting time) was in the early morning, thus recovery from work with accompanying relatively lower excretion rate would have been expected at 11 00 h. Furthermore, to be assured of sufficient hours of sleep, sleep onset of the drivers should start around 10 00 h. This suggests that at the registered level of activation, quality of sleep was not optimal.

Peak concentration in cortisol is normally reached in the early morning (13,14), and sleep deprivation for one or two nights did not prevent the sharp rise of cortisol in the early morning hours in a study Weitzman (18) described. However, in the present study peak concentration in cortisol on both days off was reached around 11 00 h in contrast with the earlier peaks on the working days. A hypothetical explanation for this finding is that the drivers needed prolonged sleep on their days off. Thus, physiologically there was no need to be 'ready for action' earlier. This line of argumentation could also explain the 'slow' start in adrenaline excretion on Day off 1 compared to baseline. This latter finding is in accordance with the findings of Milosevic (11). 'Fatigue-debt' is the term proposed here for this phenomenon, namely that adrenaline excretion rates lag behind and remain at a sub-base line level during a large part of the first day of recovering from work. It is unclear whether there is an additional relationship between lack of recovery time and (development of) health complaints of workers. The number of subjects in this study did not allow assessment of this relationship. More extensive studies are called for. It is hypothesised that starting work repeatedly in a state of fatigue debt requires extra exertions, which in the long run could have adverse effects on health. Future longitudinal research should confirm this hypothesis. In a questionnaire study among 363 coach drivers (20) subjective needs for recovery were positively related to complaints of general health, sleep quality, and emotional exhaustion.

The differences found in the overall mean excretion rates of the catecholamines per day were in accordance with outcomes of some studies (4,9), and different from another (12). During working days, these mean excretion rates are higher than in leisure time. It is accepted, that more noradrenaline reactivity than adrenaline reactivity takes place in physically demanding occupations (6,7) and the reverse holds for mentally demanding occupations (2). Because driving can be seen as a mainly mentally demanding occupation, it was not surprising that fewer differences were found in noradrenaline than in adrenaline reactivity. Therefore, in this study noradrenaline was a useful control variable and indicated equal disturbances in circadian rhythmicity as did adrenaline. Although cortisol excretion is believed to occur in short-term bursts when people meet stressful events (17, 21), the overall mean excretion of cortisol in this study was significantly higher on working days compared to baseline. As was shown in figure 4, there seems to be an accumulation of excretion in cortisol from Workday 1 to Workday 3, although the drivers slept and rested during daytime at Workday 2. Although not significantly, all excretion rates of Workday 2 remained higher compared to their baseline. Recovery of the observed accumulated excretion rates of cortisol took place after the journey.

The self-reports indicated that, although the resting time theoretically should have been sufficient to recover, more workload was experienced by the drivers during the return journey when compared to the outward journey. To get a natural picture in this 'real life study', no constraints were put upon the subjects with regard to their normal behavioural habits. However, the self-reported use of stimulants did not differ between the days.

In order to evaluate recovery, the procedure of urine collection on consecutive days, as outlined in the methods section, seems to be successful. This procedure is promising for investigation of short-term effects from work like spillover (6, 7), but also effects in the course of recovery from work like 'fatigue debt'. Although Hartley *et al.* (12) also investigated long distance trips, recovery time between outward and return journey was not taken into account. In the study of Mackie and Miller (4), urine was collected on six consecutive days, but again no recovery time was accounted for. The same goes for Vivoli *et al.* (5). Extension of this study among other workers with the method outlined here is therefore asked for.

Conclusion and recommendations

Coach drivers showed occupationally induced reactivity in urinary adrenaline and noradrenaline excretion rates, when controlled for stimulants. Urinary cortisol excretion rates accumulated during the three working days, regardless of offered resting time in between outward journey and return journey. The course of recovery, as measured on a consecutive day off, revealed a 'fatigue debt' in adrenaline excretion and similar reactions in cortisol excretion. In the resting time after the outward journey the catecholamines excretion rates did not return to baseline values, which seems to indicate incomplete recovery. It is recommended to plan longer resting times on shuttle bus trips and at least one day off after these kind of trips. Finally, in future research projects it is recommended to focus on recovery from work in addition to reactivity during work. This focus on recovery implies assessments of consecutive days in which more than one work shift and more than one day off-work are included. It remains to be established whether adrenaline or cortisol is the best standard to measure recovery from work. Furthermore, more extensive research should be focused on the additional relationships between fatigue debt, spillover, or incomplete recovery, and health complaints.

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Appendices

Appendix A1. Adrenaline excretion rate (ng/ min), mean (SD) per day and sample time in hours (n=10).

	Adrenaline Excretion rate (ng/min)				
	Workday 1 Mean (SD)	**Workday 2** Mean (SD)	**Workday 3** Mean (SD)	**Day off 1** Mean (SD)	**Day off 2** Mean (SD)
Sample time (h):					**Base line**:
04 00	-- (--)	4.64 (4.4)	4.17 (3.0)	-- (--)	-- (--)
07 00	1.62 (1.8)	6.05 (2.4)	5.01 (4.3)	0.93 (0.5)	0.80 (0.6)
11 00	8.72 (4.7)	12.41 (7.8)	12.03 (6.2)	4.36 (2.0)	6.74 (3.3)
14 00	15.24 (6.0)	5.27 (5.4)	12.93 (10.2)	5.58 (2.8)	8.94 (2.0)
17 00	12.52 (7.4)	3.78 (3.2)	9.46 (5.6)	7.94 (5.0)	7.99 (1.9)
20 00	13.16 (10.1)	9.83 (3.8)	3.75 (1.8)	5.05 (2.8)	5.34 (2.8)
23 00	5.86 (3.0)	7.32 (4.9)	1.83 (0.6)	2.76 (1.3)	3.37 (1.6)

Appendix A2. Noradrenaline excretion rate (ng/ min), mean (SD) per day and sample time in hours (n=10).

	Noradrenaline Excretion rate (ng/min)				
	Workday 1 Mean (SD)	**Workday 2** Mean (SD)	**Workday 3** Mean (SD)	**Day off 1** Mean (SD)	**Day off 2** Mean (SD)
Sample time (h):					**Base line**:
04 00	-- (--)	42.58 (17.5)	43.15 (16.1)	-- (--)	-- (--)
07 00	26.54 (13.6)	51.33 (19.3)	44.90 (17.9)	19.45 (11.9)	17.30 (8.7)
11 00	44.80 (19.0)	61.20 (31.4)	59.79 (25.3)	46.33 (13.4)	51.99 (23.6)
14 00	60.61 (21.6)	33.22 (15.2)	59.09 (24.0)	56.44 (20.4)	52.08 (14.4)
17 00	60.84 (30.5)	39.05 (20.3)	47.44 (21.0)	47.69 (17.0)	50.40 (8.9)
20 00	59.96 (29.1)	53.44 (20.4)	41.43 (11.5)	42.38 (16.0)	38.63 (16.8)
23 00	44.23 (21.5)	53.15 (24.0)	34.00 (13.7)	29.19 (10.8)	41.49 (27.3)

Appendix A3. Cortisol excretion rate (ng/min), mean (SD) per day and sample time in hours (n=10).

	Cortisol Excretion rate (ng/min)				
	Workday 1 Mean (SD)	**Workday 2** Mean (SD)	**Workday 3** Mean (SD)	**Day off 1** Mean (SD)	**Day off 2** Mean (SD)
Sample time (h):					**Base line**:
04 00	-- (--)	14.44 (12.7)	10.99 (5.2)	-- (--)	-- (--)
07 00	31.42 (22.4)	51.16 (37.2)	55.82 (37.4)	18.60 (9.8)	10.60 (5.9)
11 00	30.14 (18.6)	45.69 (26.6)	37.21 (13.4)	30.89 (16.4)	32.17 (27.3)
14 00	24.58 (11.0)	28.06 (26.0)	30.13 (10.3)	20.14 (12.4)	22.25 (12.0)
17 00	20.20 (9.0)	15.21 (5.2)	12.54 (4.8)	13.80 (7.4)	13.47 (7.7)
20 00	11.94 (5.0)	11.11 (4.0)	10.13 (5.1)	7.16 (2.6)	7.62 (3.3)
23 00	7.51 (2.8)	13.64 (13.0)	7.41 (5.2)	7.21 (4.4)	8.56 (4.8)

4.2 The influence of work characteristics on the need for recovery and experienced health: a study on coach drivers.

Abstract

Work characteristics, occupationally induced fatigue, and health complaints were investigated on the basis of questionnaire data from 363 randomised coach drivers. The hypothesis was tested that, apart from high job demands and low job control, need for recovery is an indicator of occupationally induced health complaints. Multiple linear regression analyses showed that need for recovery was a major predictor of psychosomatic complaints, sleep complaints, and complaints of emotional exhaustion in coach drivers. The influence of job demands and job control on health problems was moderately confirmed. The results of this study draw attention to the role of need for recovery, as a sign of occupationally induced fatigue and predictor of health complaints, in future research on occupational stress.

Keywords: Recovery, Drivers' fatigue, Occupational Stress, Subjective fatigue, Bus/Coach drivers, Experienced health

Sluiter JK, Van der Beek AJ, Frings-Dresen MHW. Ergonomics 1999; 42(4):573-583.

Introduction

Exposure to occupational risk factors has often been demonstrated to be related with adverse reactions of short- or long-term psychological strain (e.g. fatigue and illness). These complaints have been reported most frequently when the psychological demands of the job are high and the worker's decision latitude is low (Karasek 1979, Karasek and Theorell 1990). Signs of fatigue are mostly experienced during or after a day of work, which need not be a problem if enough time to recover is offered in between two periods of work (Meijman 1989, Brown 1994, Frankenhaeuser 1994). Thus, time seems to be the crucial variable in recovery from occupationally exerted efforts (Meijman 1989, Miloševic 1997).

Repeated insufficient recovery from work-related fatigue, however, is seen as the take-off of a vicious circle where extra effort has to be exerted at the beginning of every new working period to rebalance the sub-optimal psycho-physiological state, and to prevent performance breakdown. The consequential cumulated fatigue from repeated insufficient recovery is found to be related to health problems (Meijman 1989, Van der Beek et al. 1995). Here, the hypothesis is that experienced needs for recovery during and after a period of working is an essential symptom of occupationally induced fatigue. Furthermore, as the perceived load at the end of a day of work and the need for recovery after a day of work can be seen as short-term effects of work, and general health complaints (sleep complaints, psychosomatic complaints and mental overload) can be seen as long-term effects of work, a relation should be found between needs for recovery and reported health complaints. This assumed relationship is modelled in figure 1 and was tested in coach drivers.

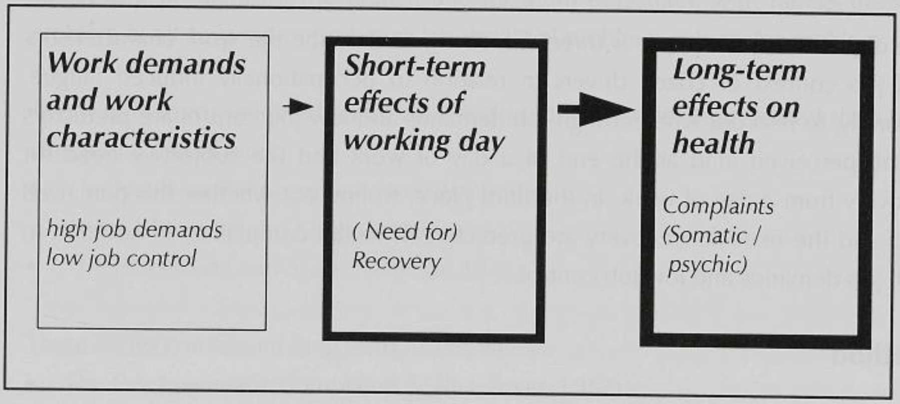

Figure 1. The assumed relationship between work characteristics, short-term effects of a working day, and long-term effects on health.

In most occupations, micro-pauses can be taken in between tasks, apart from longer breaks that allow temporary recovery from work related fatigue. In driving, general fatiguing factors are prolonged driving hours, time of day and monotony (Mackie and Miller 1978, Miller and Mackie 1980, Feyer et al. 1993, Brown 1994, Feyer and Williamson 1995). Driving is mentally demanding because it requires long periods of alertness and sustained attention, which does not allow micro-pauses to be taken. Numerous studies on bus drivers' work and health have been undertaken (Feyer et al. 1993, Kompier 1996). Many of these studies, however, were directed towards city bus drivers. These studies found that the drivers have strong feelings of fatigue, tension and mental overload. Furthermore, work schedules, the work-leisure relationship and irregular working hours are major inconveniences for many city bus drivers (Kompier & Di Martino 1995, Kompier 1996). Little research has been performed on coach drivers (Feyer et al. 1993). After several accidents involving Dutch coaches had occurred, a research project was initiated to investigate the aspects of workload of coach drivers. The demands imposed upon coach drivers in the private passenger sector vary according to the kind, the duration, and the combination of trips these drivers have to perform. In contrast with public bus companies, which perform fixed scheduled bus trips, companies in the private passenger sector have to deal with tour operators and private customers. Therefore, long-term work planning is difficult and drivers are not only exposed to long and irregular working hours, but also to different kinds of trips and to irregular work schedules. The driver's control over timing and duration of breaks varies in accordance with the type of trip and the needs of the customers.

The objective of this paper is threefold. Firstly, to describe the work characteristics and job context of coach drivers in relation to occupationally induced fatigue. Secondly, to find out whether high job demands and low job control are predictors of the perceived load at the end of a day of work and the subjective need for recovery from a day of work. In the third place, to find out whether this perceived load and the need for recovery are predictors of health complaints, in addition to high job demands and low job control.

Method

Subjects

A random sample was taken of all Dutch coach drivers working in the private passenger sector. In all, a questionnaire was sent to 750 drivers and a reminder followed a fortnight after that. The response rate was 55.1%.

Questionnaire

The questionnaire was designed to obtain information about work characteristics, needs for recovery from work, work-related fatigue, and long-term health complaints. The ad hoc questions were partly self-formulated and partly adopted from other questionnaires. The self-formulated questions asked for details of drivers' personal life, work experience and aspects of work characteristics as well as details of the number of working hours during the high season, during the off-season and during their last working week. Work characteristics were made operational in terms of job demands and job control. Job demands were reflected by mean number of working hours per week. In the 'working condition' questions about controlling time and duration of breaks, drivers had to make a choice between 'never', 'sometimes', 'often' or 'always'. The question about 'anticipation on work scheduling' was translated into "how long in advance is work scheduling known", and gave the option between '1 day', '2-3 days', '4-7 days' and 'more than 1 week'. Job control was reflected by both 'break control' and 'work anticipation'. Following Feyer et al. (1993), fatigue was defined to include feelings of sleepiness, drowsiness, being tired, being unable to concentrate, being unable to sustain attention or feeling mentally slowed down. Also analogously to Feyer et al.(1993), drivers were asked for: (i) their views and experience of driver fatigue, including the effects of fatigue on driving, (ii) what factors contribute to their fatigue, and (iii) what strategies they use to combat driver fatigue. One question asked the drivers to rate to what extent they thought fatigue is a problem for the branch and for them personally, with ratings from 'no problem at all' to 'a minor problem', 'a substantial problem' or 'a major problem'.

Five widely used, validated scales were included. Two scales represented short-term effects of a day of work:

- The Need for Recovery Scale (see Appendix) (Van Veldhoven and Meijman 1994)
- The Perceived Load Scale (Meijman 1991),

Three scales considered long-term health effects:

- The Psychosomatic Complaints Scale (Dirken 1967)
- The Sleep Quality Scale (Meijman 1988)
- Part of the Maslach Burnout Inventory: the Emotional Exhaustion Scale (Schaufeli and Van Dierendonck 1994)

Data analysis and statistics

'Break control' was the sumscore of control over timing of breaks and control over duration of breaks. All variables were recoded in such a way that higher scores meant 'more complaints', analogously to the health complaints scores (e.g. older, more Job Demands, less Job Control and less 'anticipation on work scheduling', more 'perceived load' and more 'need for recovery'). The scores on the health scales were transformed to percentage scores of the maximum possible scores per scale.

All statistical analyses were performed with the SPSS-package for Windows 6.1. Firstly, a description of the entire sample of drivers was made. Secondly, Forced Multiple Linear Regression Analyses were performed with the following objective independent variables: 'Age', 'mean number of working hours per week', 'break control' and 'anticipation on work scheduling'. Dependent variables in the first phase of testing the assumed relationship of figure 1 were the self-reported 'perceived load' and 'need for recovery'. In the second phase of testing, 'perceived load' and 'need for recovery' were the independent variables in addition to the independent variables used in phase one. 'Psychosomatic complaints', 'sleep quality', and 'emotional exhaustion' were used as dependent variables. In this second phase, the independent variables were entered hierarchically, of which 'perceived load' and 'need for recovery' were entered in the second step. In all analyses differences were considered significant at $p < 0.05$.

Results

Sample population and work characteristics

The drivers had a mean age of 44 years (SD 10.4) and their driving experience was on average 11 years (SD 8.4). Ninety-five percent of the sample was male. Long distance trips were performed by 68% of the drivers, of which 22% were tour drivers and 46% were express drivers. The remaining 32 % of the drivers performed combinations of mainly short domestic trips. Almost half of the drivers (43%) were not employed on a permanent basis and 22% performed jobs, different from driving, for other employers as well. On average, the coach drivers worked 51 hours per week (SD 27.1) where the long distance trip drivers averaged 61 hours per week (SD 25) and the short domestic trip drivers averaged 28 hours per week (SD 16). Work scheduling was known not more than one day ahead by 62 % of the drivers. Furthermore, 50% of the drivers could plan timing and length of pauses 'never or sometimes'.

Work related fatigue

The majority (62%) of the drivers thought fatigue was a 'substantial' or 'major' problem in the branch, while only 23% of drivers reported fatigue as a 'substantial' or 'major' personal problem. Most drivers (72%) reported that occupationally induced fatigue adversely affected their driving. As symptoms of adversely affected driving, they indicated reduced attention, slower reactions, and poorer steering. More than one third of the drivers (38%) had on one occasion almost fallen asleep behind the wheel. To combat fatigue temporarily, most drivers (>70%) adjust temperature or ventilation, or take a short break. One third of the drivers reported that on one occasion their sense of mental overload had been such that they felt they could not make the next trip planned.

The relationship between work characteristics, perceived load, and need for recovery

Only 7% of variance in 'perceived load' scores was explained by 'age', 'need for break control', 'low anticipation of work' and 'work hours per week'. Of these factors, 'age' contributed significantly ($p<0.01$), as did 'need for break control' ($p<0.05$). The regression equation was significant ($p<0.01$). 'Need for recovery' was predicted better than 'perceived load' by 'age', 'need for break control', 'low anticipation of work' and 'work hours per week'. The percentage of explained variance in 'need for recovery' was more than double (16%) that for 'perceived load'. The variables 'need for break control' ($p<0.01$), 'low anticipation of work' ($p<0.05$), and 'work hours per week' ($p<0.01$) contributed significantly. Only 'age' did not contribute significantly to 'need for recovery'. The regression equation was highly significant ($p<0.001$).

The relationship between work characteristics, recovery, and health complaints

Table 1 demonstrates that 15% of the variance in 'psychosomatic complaints' scores is explained in the first step of the hierarchical regression analysis with 'age', 'hours per week', 'low anticipation of work' and 'need for break control' as predictors. All variables contributed significantly ($p<0.01$), except for 'age'. A highly significant increase in R^2 (from 0.15 to 0.46, $p<0.01$) occurred by the second step, when the variables 'perceived load' and 'need for recovery' were entered into the regression model. The contribution of 'perceived load' was marginally significant ($p=0.08$) and that of 'need for recovery' highly significant ($p<0.001$). Only 'need for break control' remained a significant contributor ($p<0.05$) to the explained variance of 'psychosomatic complaints' scores, once 'perceived load' and 'need for recovery' were taken into account. The regression equation containing all six of the independent variables was significant ($p<0.001$).

Table 1. Step-wise multiple regression with Psychosomatic Complaints as dependent variable and work hours per week, need for break control, low anticipation of work, age, perceived load and need for work recovery as independent variables (n=258).

	Step One		Step Two	
	Beta	**Sign.**	**Beta**	**Sign.**
Work hours / week	0.25	0.000	0.08	0.109
Need for Break control	0.26	0.000	0.11	0.024
Low Anticipation of Work	0.15	0.009	0.06	0.214
Age	-0.05	0.406	-0.07	0.153
Perceived Load			0.09	0.077
Need for Work Recovery			0.58	0.000
R2	0.15		0.46	
Significance of change		0.001		
F of regression equation	11.49		36.33	
Significance of F	0.00		0.00	

Table 2 shows that 11% of the variance in 'sleep quality' scores was explained by 'age', 'hours per week', 'low anticipation of work' and 'need for break control'. Again, all variables contributed significantly ($p<0.01$), except for 'age'. The regression equation was significant ($p<0.001$). Again, a highly significant increase in R^2 (from 0.11 to 0.40, $p<0.001$) occurred by the second step, when the variables 'perceived load' and 'need for recovery' were entered into the regression model. None of the contributors of the first step remained statistically significant. Both 'perceived load' and especially 'need for recovery' contributed significantly.

Table 2. Step-wise multiple regression with Sleep Quality (SQS) as dependent variable and work hours per week, need for break control, low anticipation of, age, perceived load and need for work recovery as independent variables (n=255).

	Step One			Step Two	
	Beta	Sign.		Beta	Sign
Work hours / week	0.23	0.000		0.04	0.416
Need for Break control	0.19	0.002		0.04	0.454
Low Anticipation of Work	0.16	0.007		0.07	0.170
Age	0.03	0.599		0.02	0.704
Perceived Load				0.12	0.017
Need for Work Recovery				0.55	0.000
R2	0.11			0.40	
Significance of change			0.000		
F of regression equation	7.91			27.66	
Significance of F	0.00			0.00	

Table 3 shows that 18% of the variance in 'emotional exhaustion' scores was explained in the first step of the hierarchical regression analysis by 'age', 'hours per week', 'low anticipation of work' and 'need for break control'. Again, all variables contributed significantly ($p<0.01$), except for 'age'. The regression equation was significant ($p<0.001$). Here also, a highly significant increase in R^2 (from 0.18 to 0.59, $p<0.001$) occurred by the second step, when the variables 'perceived load' and 'need for recovery' were entered into the regression model. Both 'perceived load' ($p<0.05$) and 'need for recovery' ($p<0.001$) contributed significantly. Only 'need for break control' remained a significant contributor ($p<0.01$) to the explained variance of 'emotional exhaustion' scores, once 'perceived load' and 'need for recovery' were taken into account. The regression equation containing all six of the independent variables was significant ($p<0.001$).

Table 3. Step-wise multiple regression with MBI: Emotional Exhaustion as dependent variable and work hours per week, need for break control, low anticipation of work, age, perceived load and need for work recovery as independent variables (n=249).

	Step One			Step Two	
	Beta	**Sign.**		**Beta**	**Sign.**
Work hours / week	0.26	0.000		0.08	0.065
Need for Break control	0.29	0.000		0.11	0.008
Low Anticipation of Work	0.17	0.004		0.05	0.256
Age	0.08	0.166		0.06	0.192
Perceived Load				0.10	0.024
Need for Work Recovery				0.67	0.000
R2	0.18			0.59	
Significance of change			0.000		
F of regression equation	13.73			58.50	
Significance of F	0.00			0.00	

In figure 2, the relationships found between work characteristics, short-term effects of a working day, and long-term effects on health, are summarised. Although separate analyses were performed for the different health scales, the direct relations are presented simultaneously in the figure. As was shown in the tables 1 to 3, most of the relations between the work characteristics and health complaints in the first steps of the analyses, appeared to be indirect relations when needs for recovery were entered into the analyses.

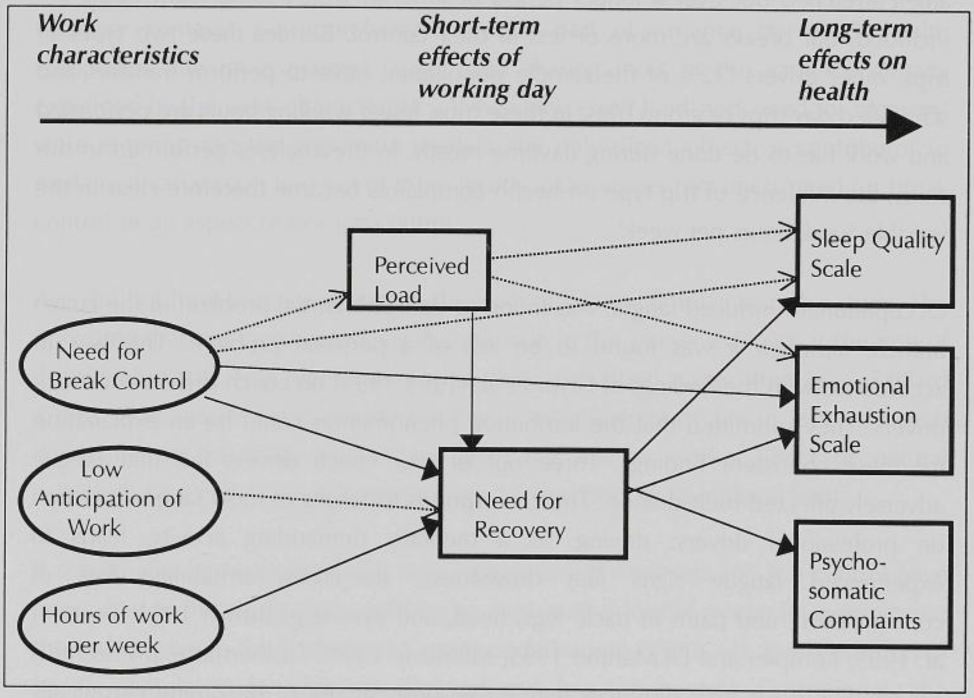

Figure 2. The direct relations between work characteristics, subjective short-term effects of the working day, and subjective long-term effects on health in coach drivers, corrected for age. The arrows show direct significant contributions to explained variance in Health Scales scores. (⟶ = $p < 0.01$, - - -> = $p < 0.05$)

Discussion

The responding coach drivers averaged 51 working hours per week. As the drivers' task demands in the private passenger sector depend on the kind, duration and combination of trips these drivers have to perform, there was variation in amount of working hours per week, level of job demands, and level of job control. For the majority of the coach drivers, work scheduling was only known one day ahead, and timing or duration of pause planning was 'never or sometimes' possible. Express drivers (46% of the sample population) for instance, have to perform long distance shuttle trips. They provide a commuter service, as an alternative to rail or air travel, and their working hours often include night hours and breaks are often preset. By contrast, tour drivers (22% of the sample population) provide a tourist service, the focus being the travel itself rather than the transportation. For several days they move around with the same group of passengers. They also travel long distances albeit stretched out over a longer period of time, in which some night hours are included, but breaks are more or less in their control. Besides these two types of trips, other drivers (32% of the sample population) have to perform transfers and scheduled day trips or group trips. In these trips, fewer working hours are performed and work has to be done during daytime mostly. In the analyses performed in this study, the influence of trip type on health complaints became therefore clear in the variable 'work hours per week'.

Occupationally induced fatigue was found to be a substantial problem in the coach branch, although it was found to be less of a personal problem. This was in accordance with the findings of Feyer et al. (1993 1995) on coach drivers and truck drivers. They submitted that the attribution phenomenon could be an explanation for these consistent findings. Three out of four coach drivers felt that fatigue adversely affected their driving. This corresponds to results of most fatigue research on professional drivers: driving, as a mentally demanding activity, leads to experienced fatigue signs like drowsiness, sleepiness, irritability, loss of concentration, and pains in back, legs, head, and eyes (e.g. Brown 1994, Feyer et al. 1995, Kompier and Di Martino 1995, Miloševic 1997). Furthermore, professional drivers who drive long distances may be seriously at risk of becoming chronically fatigued due to an inappropriate work-rest ratio, and thus inappropriate recovery, because their job demands often involve irregular hours of work, and they are not free to determine their own work schedules (Brown 1994, Feyer and Williamson 1995). In the present study, one third of the drivers reported mental overload as cause for their sense of being unable to make the next trip planned for them. This finding corresponds to the fact that mental overload is reported as one of the main health problems of city bus drivers (Kompier 1996).

Recovery takes a central place in theories on adverse influences on health and well-being induced by cumulated fatigue (e.g. Frankenhaeuser 1994). Long-distance truck drivers, for instance, reported that complete recovery from a trip usually took them more than two days, and excessive sleep of more than 14 h appeared in 40% of these drivers (Miloševic 1997). Occupationally induced health complaints were predicted far better in this study when, in addition to high job demands and low job control, the reported needs for recovery were taken into account: the proportion of explained variance in the different health scales increased from 29% up to 41%. The disappearance of most of the earlier found significant contributors to explained variance in 'psychosomatic complaints', as well as in 'sleep quality' and 'emotional exhaustion', raises the possibility of a position of subjective recovery in between work characteristics and long-term health complaints. Apparently, subjective recovery contains a comprehensive unique part of variance by which health complaints can be explained, apart from sharing most of the variance already explained by the work characteristics. When 'perceived load' and 'need for recovery' were entered into the regression models, the only direct objective contributor to explained variance in two out of three health scales scores remained 'need for break control' as an aspect of low job control.

Age did not have a major impact in the level of health complaints in this study. The only time that age contributed significantly was in the 'perceived load' at the end of the working day. This phenomenon has been described more often (e.g. Gaillard 1996). One reason for not finding a significant influence of age in level of health complaints in this study could have been the 'healthy worker effect' or 'natural selection', or a non-linear influence of age as described by Kompier (1988).

It should also be recognised that only aspects of job demands and job control have been used in this study. This could be an explanation for the moderate support that these data gave to the findings of Karasek and Theorell (1990), viz. the prediction of health complaints by high job demand and low job control. Furthermore, the occupation of professional driver could have been a reason for the larger influence of the reported 'need for recovery' after a day of work in comparison with the 'perceived load' at the end of a day of work. In professional driving, the end of a day of work implies, apart from finishing the job, a safe return home. It could be possible therefore that more occupationally induced fatigue or complaints are felt after the work is done compared with during the work. This is in accordance with Bartlett, who, as early as 1953, stated that occupationally induced fatigue is often felt after work instead of during work. Shifting of attention in the research field towards 'subjective recovery' is therefore recommended in future research on occupationally induced health complaints. Furthermore, to support the relationships found here, more objective variables of recovery should be incorporated in future research. This follows the objective findings in psycho-physiological workload research, in which unwinding (recovery) in truck drivers after the working day was found to be insufficient and spillover of sympathoadrenal activation assessed by catecholamines appeared to be related to psychosomatic complaints (Kuiper et al. 1997).

The reported experienced influence of fatigue, problems of sleep quality, and symptoms of emotional exhaustion, raises expectations of increased risk of accidents and safety hazards in the coach branch. Relatively few coach accidents have taken place in the past, but in the last seven years 18 accidents with Dutch involvement, exclusively in long distance coach trips were responsible for 29 fatalities and 236 people injured on European roads (Sluiter et al. 1997). Of these accidents, seven happened in the night or early morning hours, and driver fatigue probably played a role in four accidents. A study on lorry drivers (Hamelin 1987) showed that the risk of accident involvement increases with the number of hours worked, and the time of the day. Circadian influence was also recognised as a factor increasing risk of accidents in studies by Miller and Mackie (1980) and Storie (1984). Because the sub population of express coach drivers in this study averaged 93 working hours per week during the high season, and driving during night hours is normal practice in long distance trips these drivers perform, the risk of accidents for these drivers is considered relatively high.

Conclusion

Need for recovery proved to be a powerful predictor of experienced health complaints in coach drivers. Follow-up studies are recommended in coach drivers as well as in other workers: (i) to investigate whether these findings are generalisable to other occupations, and (ii) to include objective measurements of recovery. Furthermore, attempts should be made to find out which work-rest ratios are optimal to prevent occupationally induced health problems.

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Appendix

Need for Recovery scale: 11 items, dichotomous (yes/no).
Translated from Dutch into English (with permission from the author)
(item 4 has to be recoded; scale score is the sumscore of "yes"-items):

1. I find it hard to relax at the end of a working day — yes / no
2. At the end of a working day I am really feeling worn-out — yes / no
3. My job causes me to feel rather exhausted at the end of a working day — yes / no
4. Generally speaking, I'm still feeling fresh after supper — yes / no
5. Generally speaking, I am able to relax only on a second day off — yes / no
6. I have trouble concentrating in the hours off after my working day — yes / no
7. I find it hard to show interest in other people when I just came home from work — yes / no
8. In general, it takes me over an hour to feel fully recovered after work — yes / no
9. When I get home, people should leave me alone for some time — yes / no
10. After a working day I am often too tired to start other activities — yes / no
11. During the last part of the working day I cannot optimally perform my job because of fatigue sometimes — yes / no

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(numbers used in text are placed in [brackets] behind each reference)

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