

Need for recovery from work related fatigue and its role in the development and prediction of subjective health complaints

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Productivity per worker per time unit has been rising almost continuously during the past three decades. Accordingly, it should be no surprise that over 40% of the 21 500 interviewed EU workers experience too much workload on a daily basis.¹ In the Netherlands, this figure is close to 60%.²

Too much workload may result in increased neurophysiological activity levels with or without additional stress reactions, depending on the individual coping strategies.³⁻⁶ Subjectively, these increased neurophysiological activity levels are associated with additional exerted efforts during work. When people, neuroendocrinologically spoken, unwind too slowly after exertions, spillover of neuroendocrine reactivity is manifest (sustained activation) and recovery to baseline levels may be labelled as incomplete.⁶⁻⁸ Humans are tailored to perform almost any (work) task because our (neuro)physiological systems are very adaptive to extreme situations, at least in single situations and in the short term. However, the assumption is that repeated insufficient recovery invokes cumulated

Aims: To present the available empirical evidence for the assumed position of the concept of work related fatigue as: (1) short term effect of the working day; and (2) an intermediate variable between work demands and the development of subjective health complaints and sickness absence.

Methods: Results from six single occupation studies, conducted between 1996 and 2002, are presented. Work demands (working hours, decision latitude, break control/autonomy, and mental, emotional, and physical demands) were assessed through validated scales. Work related fatigue was represented and assessed by means of the need for recovery after working time scale in all studies. Subjective health complaints and duration of sickness absence were quantified with the same instruments in most studies as well. Both cross sectional studies (four) as well as prospective studies (two; up to two years follow up) were performed. Cross sectional data of 3820 workers, in total, were available. Prospective data were accessible for 1200 workers in industry and health care. Models were tested with stepwise multiple regression analyses.

Results: Strong associations between work demands and need for recovery were found in different occupations. The variance explained in need for recovery by work demands, age, and (baseline) need for recovery ranged between 14% and 48% in both types of studies. The amount of explained variance by work demands, age, and (baseline) need for recovery in subjective health complaints ranged between 24% and 58% in the different occupations. The prospective data showed the prognostic value of need for recovery in relation to subjective health complaints (in terms of psychosomatic complaints, emotional exhaustion, or sleep problems) and duration of future sickness absence.

Conclusions: The hypothesised role for work related fatigue as a link in the causal string of events, that is assumed to exist between repeated adverse work demands and the development of work related stress reactions, (psychological) overload and, eventually, health problems, was confirmed.

fatigue and will lead to subjective complaints and health deterioration on the longer term.^{6 9-12}

In relation to health, everyday fatigue by itself is not a worrying concept. However, although prolonged fatigue as a complaint or symptom is observed in many chronic diseases (for example, rheumatoid diseases, cancer, depression), the prevalence of these chronic fatigue complaints outplays the sum of prevalences of the aforementioned chronic diseases by far.¹³⁻¹⁵ In today's society, occupationally induced fatigue is thought to play a major role in the aetiology of work related psychological overload. Specifically, it is assumed that overload may develop when insufficient opportunities to recover from exertions during work are encountered as usual practice.^{3 10 12 16}

Validated measures of both work related fatigue and general fatigue have been developed over the past years in the Netherlands.^{15 17 18} For the assessment of the short term effects of fatigue caused by work actions, the "need for recovery scale" was developed in the early 1990s.¹⁷ The need for recovery after working time concept represents work related fatigue. A significant within subjects relation was shown between the scores on the need for recovery scale and urinary neuroendocrine recovery parameters.¹⁹

Main messages

- Occupation specific work demands show strong prognostic value on the level of work related fatigue.
- Work related fatigue has a strong prognostic value on subjective health complaints in terms of psychosomatic complaints, emotional exhaustion, and sleep problems.
- An intermediate position of work related fatigue between work demands and future health status was confirmed.
- Work related fatigue is measurable in a quick and cheap way.

Policy implications

- Educational strategies about recovery complaints as early signalling effects may be introduced and serve as preventive measure for antecedents of employees' ill health.
- Knowledge about the (age and) occupation specific effects on work related fatigue may be used in future policy programmes that deal with promotion of health, work ability, and wellbeing of the (ageing) worker.

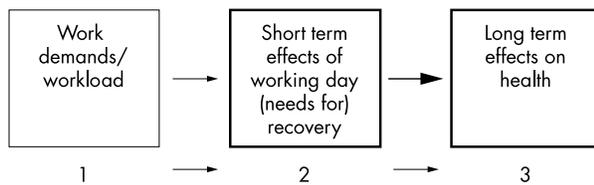


Figure 1 The assumed relation between work (1), short term effects of a working day (2), and long term effects on health (3).

One of the empirical problems in the multidisciplinary field of (work) stress research is the urgent need for bridge functioning between disciplines to close the gaps in knowledge between research on acute bodily effects and research on chronic effects on health of work exertions and stress reactions.⁸ Two theories exist which, in combination, may form the pillars of this bridge. One theory on acute stress comes from the field of biological psychology (cognitive activation theory of stress²⁰) and one theory on chronic stress comes from the field of neuroendocrinology (allostatic load theory⁷). Both use the (neuroendocrine) recovery concept in their explanation of the adverse reactions caused by acute or chronic stressful situations. An overview of studies that measured neuroendocrine reactivity and recovery during and after different types of work was published recently by Sluiter and colleagues.⁵ What is still missing, however, is an overview of the available studies that actually measured the concept of need for recovery with the purpose to provide evidence of the aforementioned hypotheses. The results of this overview may constitute the roadway between the two pillars of this “(work) stress” bridge.

In summary, recovery is seen as an important variable in the hypothetical causal string of events between: (1) adverse work demands; (2) the development of work related (stress) reactions; and (3) (psychological) overload or other health problems in the longer run (see fig 1).^{6, 9, 10, 21–23} Repeated insufficient recovery from work related fatigue is conceived as the take off of an unfavourable vicious circle, in which extra effort has to be exerted at the beginning of every new working period to rebalance the suboptimal psychophysiological state, and prevent performance breakdown.^{10, 22} The consequence is cumulated fatigue, which might be expressed as higher needs for recovery after working time. Subsequently, these higher needs for recovery are seen as a precursor of ill health in the longer term.

The aim of the present study, therefore, is to present an overview of empirical evidence for the assumed place of need for recovery in the theories on adverse influences on health, wellbeing, and sickness absence induced by cumulated work demands. The results will be presented in analogy with the three concepts as are presented in fig 1.

METHODS

Six studies, aimed at assessing the workload of different occupational groups, were conducted between 1996 and 2002 in the Netherlands. Four cross sectional and two prospective studies (up to two years follow up) were performed by at least one of the present authors and new data analyses for the present study were performed.

Studies and participants

The random samples in the occupational groups under study consisted of 750 coach drivers, 1500 public bus drivers, 900 construction workers, 85 ambulance workers of a municipal ambulance service, 1500 hospital nurses of a municipal academic medical centre, and 2000 truck drivers. The methods of these original studies have been outlined extensively in De Croon and colleagues,^{24, 25} Ginkel and colleagues,²⁶ and Sluiter and colleagues.^{12, 19, 22, 27, 28}

Cross sectional studies

Coach drivers

As the first phase of a cross sectional study, a random sample was taken of all Dutch coach drivers working in the private passenger sector. A questionnaire was sent to 750 drivers in 1996 and a reminder followed a fortnight after that. The response rate was 55%.

Public bus drivers

A random sample was taken of all Dutch public bus drivers for the purpose of a cross sectional study. A questionnaire was sent to 1500 drivers in 2001 and a reminder followed a fortnight after that. The response rate was 66%.

Construction workers

A cross sectional study was conducted and a random sample was taken of all construction workers in the finishing part of the construction industry. A questionnaire was sent to 900 construction workers in 2000. The response rate was 66%.

Ambulance workers

As the first phase of a cross sectional study, a questionnaire was sent to all ambulance workers of a municipal ambulance service in 1998. All 85 ambulance workers received a questionnaire followed by a reminder 14 days later. Of the workers, 65% responded.

Prospective studies

Hospital nurses

In a prospective questionnaire study covering two years, a first questionnaire was sent to all 1512 nurses working in one academic hospital in 2000 (response was 70%). In 2001, a second questionnaire was sent to the available 973 nurses, of whom 79% responded.

Truck drivers

For the purpose of a prospective study, questionnaires were sent to a random sample of 2000 Dutch truck drivers in 1998, of whom 61% responded. In 2000, a second questionnaire was sent to the approachable 1123 truck drivers, of whom 72% responded.

Dependent variables

Need for recovery after working time

In all studies, work related fatigue was represented and assessed by means of the scale “need for recovery after working time” (11 item scale), which is a subscale in a test battery of the Dutch Questionnaire on the Experience and Assessment of Work: VBBA¹⁷ and was translated in Sluiter and colleagues.¹² This measure has been found reliable and valid,²⁹ and contains items in which the after-results of the working day are asked for (see Appendix).

Subjective health complaints

In all studies, general subjective health complaints scales or subsets of somewhat more specific health complaints scales were included. The general health complaints scales that were used in combinations in all studies, were: the VOEG³⁰ or the RAND³¹ (both scales measure general psychosomatic complaints), Lack of Sleep Quality (GSKS: Groninger Sleep Quality Scale),³² Emotional Exhaustion (subscale of the Maslach Burnout Inventory³³), and the CIS (Checklist Individual Strength).¹⁸ Analogous to Sluiter and colleagues,¹⁹ a composite, weighted, subjective health complaints score was computed in the studies of coach drivers, construction workers, ambulance workers, and hospital nurses. For these four populations, individual percentage scores on three of the aforementioned health scales were summed up and divided by three. For public bus drivers, the RAND scores were used as an indicator of subjective health complaints.

Table 1 Descriptives of the six occupations under study; mean scores at T1

Variables	Coach drivers (n=327)		Public bus drivers (n=930)		Construction workers (n=402)		Ambulance workers (n=53)		Hospital nurses (n=922)		Truck drivers (n=1186)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Work demands												
No. work hours/week	51.14	27.09	36.88	7.01	40.50	7.26	45.48	5.90	31.28	5.75	57.33	11.73
Physical demands												
Mental/emotional demands			45.15	15.65	49.86	29.25			42.12	11.65	44.94	16.46
Lack of decision latitude	75.75	29.33	78.67	13.79			76.81	14.97	54.51	18.48	61.15	21.57
Lack of autonomy/break control	69.50	29.67			19.80	24.26					53.59	21.14
Age at T1	43.22	10.37	46.46	7.53	42.05	10.59	43.58	6.75	39.36	9.00	39.11	10.12
Need for recovery	34.66	30.29	27.27	31.92	30.05	31.28	39.62	26.87	43.34	29.79	36.64	33.52
Subjective health complaints	25.30	19.79	23.41	14.95	19.42	26.71	30.59	17.15	33.61	15.40	-	-

All scale scores are recoded as percentage scores and range from 0 = "no demands or complaints" to 100 = "maximal demands or complaints".

Sickness absence

For the prospective cohorts, ordinal data on the duration of sickness absence were available. This ordinal information was used in the prospective data analyses on the cohorts of truck drivers and hospital nurses.

Independent variables

All work characteristics that were assessed were scored in terms of work "demands", meaning that higher scores are unfavourable and could be seen as "demands" in the literal sense of the word. Work demands were split up into different characteristics of specific job demands and lack of job control. All job demands were measured by means of an exposure variable (mean number of working hours per week) and additional subscales of the test battery "Dutch Questionnaire on the Experience and Assessment of Work" (VBBA).¹⁷ These subscales were developed and validated for the Netherlands from, to a large degree, existing items of the JCQ³⁴ (for characteristic items, see Appendix).

In summary, *job demands* were assessed by means of: (1) an exposure variable (mean number of working hours per week) and/or by means of the following VBBA scales in the different studies: (2) "physical demands" (seven item scale); and/or (3) "mental demands (pace and amount of work)" (11 item scale, VBBA) or "emotional demands" (seven item scale).

Lack of job control was assessed by means of: (1) decision latitude components (a scale as reported in Sluiter and colleagues¹⁹ or by means of the VBBA scale "lack of decision control" (eight item scale)); and/or (2) by means of the "lack of autonomy" (a nine item scale) or an 11 item scale developed by Jackson and colleagues.³⁵

Reliability and validity of the scales

The psychometric qualities of the VBBA scales are good; during construction of the scales rho varied between 0.82 and 0.95 and Loewinger's H varied between 0.42 and 0.95, which means that consistency with underlying unidimensional constructs exists.²⁹ The construct validity of the need for recovery scale has been studied by Schaufeli and Van Dierendonck³³ and by Beurskens and colleagues.¹⁸

Analyses

For 3820 workers in total, a descriptive analysis and cross sectional analyses were possible for the independent and dependent variables. Prospective analyses could be conducted for 1239 workers, from both industry and health care.

As recommended by Wegman,³⁶ it was decided to examine age related differences in need for recovery within populations first. Because age is highly correlated with years of experience in the job ($r \approx 0.80$), the decision about whether or not years of experience should be included in the analyses, was dependent of the results of preliminary analyses in the different age categories. Differences in mean scores of need for recovery were

observed between four age groups in the occupations construction workers (ANOVA; $p < 0.00$) and hospital nurses (ANOVA; $p < 0.05$). Therefore, age was included as independent variable, and years of experience was not included in further analyses. In all populations under study, except for the hospital nurses, the respondents were predominantly males. It was decided not to include sex as a variable in further analyses because no differences in recovery scores were observed in the sample of hospital nurses and coach drivers (ANOVA; $p > 0.05$).

In order to make optimal usage of the available continuous information, stepwise multiple regression analyses were conducted.³⁷ Furthermore, conclusions about the impact of changes in explained percentages of the variance in scores on the dependent variables are possible on the basis of these types of analyses. The analyses were performed in two ways.

Firstly, need for recovery was used as dependent variable to examine the cross sectional association or prospective relation between work demands and work related fatigue. The different work demands and age were the independent variables. Work demands were entered in the first step of this analysis. In the second step of the analysis, age was entered into the equation. In the prospective analysis, baseline values of need for recovery were entered as the last step.

Secondly, examination of the prospective and intermediate relation of need for recovery chronologically in between work demands and subjective health complaints (or sickness absence) took place. In these stepwise multiple regression analyses, subjective health complaints and sickness absence were the dependent variables. The different work demands, age, and need for recovery were used as independent variables. In the first step of these analyses, the different work demands variables were entered as the first model. In the second step of the analysis, age was entered into the equation. In the final step, the baseline need for recovery was entered to complete the hypothesised model.

RESULTS

Cross sectional data on 3820 workers and prospective data on 1239 workers are presented. After descriptions of the populations and relevant variables under study are shown, results are presented in conformity with the hypothesised relations between the three boxes of fig 1.

Demographic variables

In contrast with the study on hospital nurses (78% female), a comparatively small number of females have been studied in the samples of construction workers (0.002%), ambulance workers (2%), coach drivers (5%), and public bus drivers (11%). No significant differences in mean scores on need for recovery were found between the sexes, either in the hospital nurses or in the coach/public bus drivers.

Table 2 Final models of stepwise multiple regression analyses on cross sectional data

Variables	Coach drivers (n=327)		Public bus drivers (n=930)		Construction workers (n=402)		Ambulance workers (n=53)		Hospital nurses (n=922)		Truck drivers (n=1186)	
	Beta	p value	Beta	p value	Beta	p value	Beta	p value	Beta	p value	Beta	p value
<i>Work demands</i>												
Entered in step 1												
No. work hours/week	0.24	0.000	0.00	0.879	0.04	0.316	-0.08	0.518	0.01	0.649	0.01	0.602
Physical demands					0.54	0.000	0.51	0.000	0.22	0.000		
Mental/emotional demands			0.51	0.000	0.20	0.000			0.20	0.000	0.48	0.000
Lack of decision latitude	0.12	0.044	0.04	0.178			0.23	0.069*	0.22	0.000	0.17	0.000
Lack of autonomy/break control	0.21	0.000			0.08	0.039					0.03	0.428
Added in step 2												
Age at T1	-0.07	0.187	0.05	0.085	0.10	0.007	0.07	0.583	0.12	0.000	0.01	0.626
Model summary												
Total adjusted R ²	0.14		0.27		0.48		0.28		0.20		0.33	
Change from step 1 to step 2 in R ²	0.01		0.00		0.01		0.00		0.01		0.00	
Change from step 1 to step 2 in F	12.67		87.60		63.42		6.15		39.13		119.55	
Significance of F	0.000		0.000		0.000		0.000		0.000		0.000	
Need for recovery as dependent variable, and no. work hours/week, physical demands, mental/emotional demands, lack of decision latitude, lack of autonomy/break control, and age as independent variables.												
*Lost significance in second step.												

Description of the populations

Table 1 shows descriptive analyses of the independent and dependent variables in the six study populations. Mean age was highest in the ambulance workers and lowest in the hospital nurses. Mean number of working hours/week was comparatively high in truck drivers, coach drivers, and ambulance workers, and comparatively low in public bus drivers and hospital nurses. High variation in working hours was found in coach drivers (SD 27.1) and truck drivers (SD 11.7), while little variation in working hours was found in ambulance workers (SD 5.9) and hospital nurses (SD 5.8). As might be expected, relatively high mean physical demands were found in construction workers, but these workers experience relatively favourable autonomy and break control.

Relatively unfavourable mean scores on lack of decision latitude scales were found in coach and public bus drivers, and ambulance workers. On average, hospital nurses and ambulance workers, followed by truck drivers, showed the most need for recovery after working time. For comparative purposes, the mean score on need for recovery was found to be 26 in a representative sample of the Dutch working population.

Relation between work demands (1) and need for recovery after work (2)

Table 2 displays the cross sectional results of the stepwise multiple regression analyses, examining the statistical effects of the different work demands on the experienced need for recovery while taking age into account.

Between 14% and 48% of the variance in need for recovery is explained by specific aspects of work demands and age in the six occupations. Age contributed significantly and uniquely to the variance on this outcome in construction workers and hospital nurses only. The strongest unique contributions to the explained variance in need for recovery were found for mental demands in the public bus drivers ($\beta = 0.51$; $p < 0.001$) and truck drivers ($\beta = 0.48$; $p < 0.001$), and for physical demands in construction workers ($\beta = 0.54$; $p < 0.001$) and ambulance workers ($\beta = 0.51$; $p < 0.001$). In hospital nurses, different aspects of work demands contributed evenly to the explained variance in need for recovery (β values ≈ 0.20 ; $p < 0.001$).

Table 3 displays the prospective results of the stepwise multiple regression analyses examining the effects of specific

work demands on the experienced need for recovery while taking the baseline values of both age and need for recovery into account.

Before baseline scores on need for recovery were taken into account in the last step of the analysis, 14% and 13% of the variance in need for recovery at follow up was explained by differential baseline work demands and age in hospital nurses and truck drivers, respectively. These figures are comparable with the results in table 2, although somewhat less strong. Unique significant contributors to need for recovery at follow up were occupation specific aspects of work demands in hospital nurses (physical demands, emotional demands, and lack of decision latitude) and truck drivers (mental demands and lack of decision latitude).

When baseline need for recovery was introduced into the equation in the final step, 46% of the variance in need for recovery after one year was explained by baseline values of specific work demands, age, and baseline need for recovery in the study on hospital nurses. The total percentage of explained variance in the sample of truck drivers became as high as 36% when baseline need for recovery was introduced into the model in this final step. Once need for recovery at baseline was taken into account in the last step, only emotional demands and age remained significant independent contributors to the explained variance in need for recovery at follow up in hospital nurses ($p < 0.05$ in both cases).

Relation between need for recovery after work (2) and subjective health complaints (3)

Table 4 presents the cross sectional results of the stepwise multiple regression analyses examining the statistical predictive effects of need for recovery, and different aspects of work demands and age on subjective health complaints.

The stepwise multiple regression analyses of subjective health complaints in all six populations revealed significant increases in the adjusted percentages of explained variance (adjusted R²) when need for recovery was entered into the equation in step 3 of the analyses. These significant increases in explained variance in subjective health complaints ranged from an increase of 10% in the public bus drivers to 43% in the coach drivers. The total explained variance in subjective health complaints was 24% in public bus drivers, 39% in construction workers, 48% in hospital nurses, 52% in ambulance workers, and 58% in coach drivers. Both aspects of job demands (public bus drivers, construction workers, hospital nurses), job

Table 3 Final models of stepwise multiple regression analyses on prospective data

Baseline variables	Hospital nurses (n=611) Need for recovery, at one year follow up		Truck drivers (n=625) Need for recovery, at two years follow up	
	Beta	p value	Beta	p value
<i>Work demands</i>				
Entered in step 1				
No. work hours/week	0.03	0.363	0.02	0.626
Physical demands	-0.03	0.331*		
Mental/emotional demands	0.07	0.031	0.02	0.631*
Lack of decision latitude	0.01	0.846*	0.01	0.894*
Lack of autonomy/break control			-0.01	0.894
Added in step 2				
Age at T1	0.07	0.018	0.02	0.625
Added in step 3				
Need for recovery at T1	0.65	0.000	0.59	0.000
Model summary				
Total adjusted R ²	0.46		0.36	
Change from step 2 to step 3 in R ²	0.32		0.23	
Change from step 2 to 3		0.000		0.000
F of regression equation	87.53		60.47	
Significance of F		0.000		0.000

Need for recovery after one or two years follow up (T2) as dependent variable, and no. work hours/week, physical demands, mental/emotional demands, lack of decision latitude, lack of autonomy/break control, age, and baseline need for recovery as independent variables.

*Lost significance from first step.

Table 4 Final models of stepwise multiple regression analyses on cross sectional data

Variables	Coach drivers (n=327)		Public bus drivers (n=926)		Construction workers (n=402)		Ambulance workers (n=53)		Hospital nurses (n=922)	
	Beta	p value	Beta	p value	Beta	p value	Beta	p value	Beta	p value
<i>Work demands</i>										
Entered in step 1										
No. work hours/week	0.06	0.185*	-0.03	0.348	-0.00	0.975	0.04	0.704	-0.01	0.673
Physical demands					0.07	0.189*	0.11	0.356*	-0.01	0.825*
Mental/emotional demands			0.15	0.000	0.19	0.000			0.10	0.000
Lack of decision latitude	0.05	0.252*	0.05	0.106*			0.13	0.225*	0.15	0.000
Lack of autonomy/break control	0.08	0.071*			0.01	0.787				
Added in step 2										
Age at T1	-0.00	0.977	0.07	0.016	0.03	0.538	0.07	0.498	0.09	0.000
Added in step 3										
Need for recovery at T1	0.71	0.000	0.38	0.000	0.54	0.000	0.64	0.000	0.59	0.000
Model summary										
Total adjusted R ²	0.58		0.24		0.39		0.52		0.48	
Change from step 2 to step 3 in R ²	0.43		0.10		0.11		0.28		0.28	
Change from step 2 to step 3		0.000		0.000		0.000		0.000		0.000
F of regression equation	75.82		60.81		36.17		12.20		134.46	
Significance of F		0.000		0.000		0.000		0.000		0.000

Subjective health complaints as dependent variable and no. work hours/week, physical demands, mental/emotional demands, lack of decision latitude, lack of autonomy/break control, age, and need for recovery as independent variables.

*Lost significance after second step.

control (hospital nurses), and age (public bus drivers, hospital nurses) contributed uniquely to the explained variance in subjective health complaints.

Position of need for recovery (2) between work demands (1) and subjective health complaints (3)

Table 5 shows the results of the final analyses from the prospective studies. Dependent variables are subjective health complaints at follow up that were assessed in the hospital nurses, and duration of sickness absence at follow up that was assessed in both hospital nurses and truck drivers. The results of the analyses with subjective health complaints at follow up as dependent variable will be described, followed by the results of the analyses regarding sickness absence at follow up as the dependent variable.

Subjective health complaints

Baseline emotional demands and lack of decision latitude were significantly and uniquely associated with subjective

health complaints one year later in hospital nurses. In this first step these work demands explained 11% of the variance in subjective health complaints. The total percentage of explained variance in subjective health complaints in the hospital nurses increased to 30% after the last step in the analyses ($\beta = 0.49$; $p < 0.001$) when baseline need for recovery was introduced into the regression equation. Once need for recovery at baseline was taken into account in the last step, the significant contribution of emotional demands to the explained variance in subjective health complaints disappeared. This finding confirms the assumed intermediate position of need for recovery between work demands and subjective health complaints as depicted in fig 1.

Sickness absence

Baseline work demands explained the variance in duration of sickness absence one year later in hospital nurses ($R^2 = 4\%$) and two years later in truck drivers ($R^2 = 2\%$) to only a small

Table 5 Final models of stepwise multiple regression analyses on prospective data

Baseline variables	Hospital nurses (n=558) Subjective health complaints after one year		Hospital nurses (n=614) Sickness absence after one year		Truck drivers (n=625) Sickness absence after two years	
	Beta	p value	Beta	p value	Beta	p value
<i>Work demands</i>						
Entered in step 1						
No. work hours/week	0.01	0.759	-0.01	0.833	-0.02	0.581
Physical demands	-0.04	0.373	0.13	0.002		
Mental/emotional demands	0.08	0.035	-0.06	0.152	0.04	0.413
Lack of decision latitude	0.06	0.106*	0.01	0.781	0.06	0.221
Lack of autonomy/break control					-0.02	0.728
Added in step 2						
Age at T1	0.12	0.001	0.09	0.018	0.03	0.489
Added in step 3						
Need for recovery at T1	0.49	0.000	0.19	0.000	0.11	0.021
<i>Model summary</i>						
Total adjusted R ²	0.30		0.07		0.02	
Change from step 2 to step 3 in R ²	0.19		0.03		0.007	
Change from step 2 to step 3		0.000		0.000		0.021
F of regression equation	38.84		8.90		3.03	
Significance of F		0.000		0.000		0.006

Subjective health complaints after one year and sickness absence after one or two years as dependent variable and baseline no. work hours/week, physical demands, mental/emotional demands, lack of decision latitude, lack of autonomy/break control, age, and baseline need for recovery as independent variables.
*Lost significance from first step.

degree. The only significant unique contribution of work demands was found for physical demands in the study of hospital nurses ($\beta = 0.13$; $p = 0.002$). Age only had a significant and unique contribution to the explained variance in duration of sickness absence in hospital nurses ($\beta = 0.09$; $p = 0.018$). In both studies, however, a significant independent contribution to the variance in duration of sickness absence at follow up was discerned in the last step of the analyses when baseline need for recovery was introduced into the model ($p < 0.001$ and $p < 0.05$ in hospital nurses and truck drivers, respectively).

Conclusion

Evidence from prospective studies confirmed the cross sectional associations between work demands and need for recovery after working time on the one hand, and between need for recovery after working time and subjective health complaints on the other hand. Furthermore, the assumed position of work related fatigue in the causal theories on adverse influences from work demands on future health status was confirmed by the presented empirical data from the health care and the transport sector.

DISCUSSION

The main purpose of this study was to examine if work related fatigue is an intermediate variable between work demands and subjective health complaints. Data on almost 4000 workers were presented. Work related fatigue was represented in this study by the need for recovery after working time scale. Subjective health complaints comprised prolonged fatigue, deteriorated sleep quality, psychosomatic complaints, and emotional exhaustion. Both cross sectional and prospective results confirmed the hypothesised relation between work demands and work related fatigue in the short term. The intermediate role of work related fatigue between repeated exposures to unfavourable work demands and the development of subjective health complaints was confirmed. The prognostic value of work related fatigue with respect to the development of subjective health complaints and, to a lesser extent, duration of sickness absence, underlines the fact that the application of this measure in the field of occupational medicine could promote the prevention of subjective health complaints.

Interestingly, significant and substantial differences between the different occupations in (level of) work related fatigue as well as different perceptions of the specific work demands were observed in the present study. In addition, the strength of relations between the specific work demands on the one hand and work related fatigue and subjective health complaints on the other hand differed substantially between the occupations. In hospital nurses, for example, emotional demands appeared to be the most detrimental demands, while the number of working hours per week and mental demands seemed to be the most important work demands in coach and truck drivers, respectively. This is in accordance with the ideas of Sparks and Cooper³⁸ and De Croon and colleagues.²⁵ The implication of the occupation specific health related work demands, is that occupation heterogeneous studies on work stress and health should be interpreted cautiously. Comparable with age, analysis should be performed for the occupational groups separately in these studies. This argument was also set and proved by Theorell and colleagues³⁹ in their psychosocial and biomedical comparison of six service occupations.

Possible explanations of (neuro)pathological or psychobiological pathways as causal links from the existence of work stress (high demands and/or low control) towards chronic subjective health complaints have been described as the mechanisms that lead to allostatic load^{7, 40} and sensitisation.^{41, 42} With respect to our daily work situations, the frequency of stress would be the associate of allostatic load and is, as such, the most obvious description as given by McEwen.⁷ Chronic stress is caused by repeated stress moments, may cause chronic raised glucocorticoid levels, and will impede the action of insulin to promote glucose uptake. The rise in insulin levels that will follow, promotes the formation of atherosclerotic plaques in the coronary arteries in the long term. Another, more acute, effect of stress is adaptation of the blood pressure, but repeated rises and falls of blood pressure with repeated stressful situations promotes generation of atherosclerotic plaque that will damage the coronary artery walls. In the brain, chronic stress results in damage to brain structures such as the hippocampus region and impairment of cognitive functions.⁴⁰ A psychobiological mechanism to explain subjective health complaints is that neural pathways involved in the complaints under study, are sensitised.⁴²

Repeated use of synapses in the nervous system that are involved in sustained activation or “fatigue effects in the short term” may lead to changes in synaptic efficiency for long time periods and sensitisation (an increased efficiency in the synapse because of repeated use) is the answer. In relation to work demands, the changes in receptor sensitivity and regulation of corticotrophin releasing hormone in the hypothalamus-pituitary-adrenal axis are the relevant supplements to the sensitisation hypothesis.⁴²

In occupational stress research, health differences are often explained by differences in socioeconomic status (SES). Income, occupation, and education are three measures that are most often used to assess SES, and are said to capture different dimensions of social status. Independent of the measure used, people low in SES tend to suffer worse health.⁴³ For the present results, it is of interest to realise that all occupations under study were rather homogeneous in SES with respect to occupation and education. The group of public bus drivers, coach drivers, construction workers, and truck drivers would all have been categorised as low, and the hospital nurses and ambulance workers as intermediate or high in SES. Although subjective health complaints and morbidity or mortality seem to be partly dependent of SES,⁴⁴⁻⁴⁶ the unique contributions of different aspects of work demands in relation to work related fatigue and subjective health complaints in the present study shed an additional spotlight on the scientific stage where the concerns about quality of life and preservation of health are given.

Four other relevant topics need to be discussed, the first being the potential underlying effect of negative affectivity between self reports on both work demands and need for recovery or subjective health complaints. The relevant argument that could be made, is that subjects high on negative affectivity perceive their (work) environment as well as their health status more negatively compared to subjects low on negative affectivity. The possible influence of negative affectivity was reduced in the prospective analyses in the present study because baseline measures of need for recovery were adjusted for. Moreover, several other authors,⁴⁷⁻⁵² who controlled for negative affectivity in their studies, did not report the assumed underlying effects of negative affectivity in the field of occupational stress and health research. Spector and colleagues⁵² even reversed the main argument completely. They showed that negative affectivity should *not* be considered as bias in need of statistical control, and strongly recommended that negative affectivity measures should not automatically be included in analyses. Another strong argument against the additional measurement of negative affectivity in studies with work stress reactions as outcome measure is the content of the items in the scales of negative affectivity in which job strain reactions are literally asked for. The well known influence of self rated health as a predictor for both morbidity and mortality^{46 53} provides another argument for taking self reports seriously.

Secondly, the force of habit in epidemiological practice and statistical analyses results in faithful copying of treatment of variables in most studies.^{37 54} Age, however, was not seen as a confounder in this study. In most epidemiological studies, age is treated as a confounder without explicit knowledge about the effect size underlying this assumption. To the present authors' knowledge and opinion, no studies have concluded that age as a variable is associated with the exposure (work demands) per se. In this study, age was treated as a possible relevant independent variable and was found to have unique contributions in the different analyses. In future studies in which age is the subject of study, age might therefore be treated as a moderator or effect modifier instead of a confounder, namely on the causal pathway between exposure (work demands) and outcome (need for recovery).

An interesting third topic for discussion is the fact that duration of sickness absence could be predicted by the work

demands and work related fatigue to some degree only. A possible explanation of this finding is the long term nature of sickness absence, while follow up time was only 1–2 years in the two prospective studies. More importantly perhaps, is that sickness absence is the result of a multifactorial explanation model in which both severity of sickness and the complexity of illness behaviour play an important role. In addition, sickness absence may just not be a proper indicator for psychological ill health as measured by the different subjective health complaints in the present study. This argument is confirmed by a rather low Pearson's *r* (0.25) between baseline subjective health complaints and sickness absence at follow up. On the other hand, the occupations under study may also have played an important role in this context, because most tasks and activities may be quite easy to perform to some degree, even when hospital nurses or truck drivers are tired.

The fourth aspect that is relevant concerns the drop outs within each of the six populations under study. No information about reason for drop out was sampled in the studies on construction workers, coach drivers, and public bus drivers. In the two longitudinal studies on hospital nurses and truck drivers, however, information about possible differences between responders and non-responders at follow up was sampled. Because both studies used a full panel design, comparison on relevant variables at baseline was possible. No significant differences were found in both studies in mean scores of these relevant variables between the two groups of subjects.

Finally, the presented results provide evidence about the relation between work demands and work related fatigue on the one hand, and between work related fatigue and subjective health complaints on the other hand. In addition, being an older worker has additional implications for the chance to develop more work related fatigue and more subjective health complaints. Policy development on how informational strategies to employees should be used is desirable. Information should contain the specific risk factors with respect to short and long term effects of work and the signalling role of work related fatigue.

APPENDIX

Examples of characteristic items* used in the scales of work demands

(*items are translated from Dutch into English; answer categories are “never”; “sometimes”; “often”; “always”)

Job control scale

- Can you decide on the moment of taking breaks?
- Can you decide on the duration of taking breaks?
- Can you decide on the order in which you perform your tasks?

Job demands scale

- Do you have to perform too much work?
- Do you have to work under time pressures?
- Do you have to work very fast?

Social demands scale

- Is the relation with your colleagues good?
- Are your colleagues friendly to you?
- Can you rely on your supervisor when you perceive problems in your work?

Emotional demands scale

- Does your work put you in emotionally upsetting situations?
- Does your work demand a lot from you emotionally?

Physical demands scale

- Does your work require physical strength?
- Do you find your work physically strenuous?

Examples of characteristic items* of the need for recovery after working time scale

(*items are translated from Dutch into English; answer categories are "yes" or "no")

- At the end of a working day I am really feeling worn out.
- My job causes me to feel rather exhausted at the end of a working day.
- After a working day I am often too tired to start other activities.
- In general, it takes me over an hour to feel fully recovered after work.
- I find it hard to relax at the end of a working day.

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