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Does a stressful psychosocial work environment mediate the effects of shift work on cardiovascular risk factors?

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Peter R, Alfredsson L, Knutsson A, Siegrist J, Westerholm P. Does a stressful psychosocial work environment mediate the effects of shift work on cardiovascular risk factors? *Scand J Work Environ Health* 1999;25(4):376—381.

Objectives Associations between shift work, chronic psychosocial work stress, and 2 important cardiovascular risk factors, hypertension and atherogenic lipids were studied.The hypothesis was tested that psychosocial work stress, as defined by the model of effort-reward imbalance, mediates the effects of shift work on cardiovascular risk.
Methods Altogether 2288 male participants aged 30—55 years in the baseline screening of the Swedish WOLF (work organization, lipids, and fibrinogen) study underwent a clinical examination and answered a standardized questionnaire measuring shiftwork schedules, effort-reward imbalance at work, and health-adverse behavior.
Results In addition to the direct effects of shift work on cardiovascular risk, mediating effects of effort-reward imbalance at work were found. The respective odds ratios (OR) ranged from 2.18 to 2.27 for hypertension and from 1.34 to 1.45 for atherogenic lipids. While the effects remained significant after extensive confounder control concerning hypertension, part of the observed effect on atherogenic lipids was due to behavioral influences.
Conclusions Despite obvious limitations, the results indicated that a stressful psychosocial work environment acts as a mediator of health-adverse effects of shift work on hypertension and, partly, atherogenic lipids. In terms of occupational health the findings call for a more comprehensive assessment of the health risks associated with shift work.

Key terms atherogenic lipids, hypertension, shift schedules, stressful psychosocial work environment.

Most investigations into the effects of shift work on cardiovascular health have found elevated risks of coronary heart disease morbidity and mortality among shift workers (1—10). [For inconsistent findings see references 4, 11, and 12.] Yet some questions still remain unresolved. First, are these effects attributed to the specific condition of shift work or rather to a combined effect of shift work and the workplace exposures often associated with shift schedules, such as noise or a stressful psychosocial work environment (13—15)? Second, how are these effects mediated; in particular, what is the role of major cardiovascular risk factors such as hypertension, atherogenic lipids, and elevated fibrinogen, in this process? In part, this latter question has been analyzed. Several cross-sectional studies found associations of shift work with elevated blood lipids (11, 16—18) and, to a less degree, hypertension (12, 19, 20).

In this paper, we report the results of a study on the association between shift work and 2 main cardiovascular risk factors, hypertension and elevated blood lipids. Moreover, we were interested in testing the possible mediating effect of a stressful psychosocial work environment on this association. This latter task was of particular interest since only a few studies have analyzed this question (8, 21), and the ways stressful psychosocial work environment are conceptualized are still subject to scientific debate (22).

One widely used approach, the demand-control model, assumes that exposure to workplaces with a specific task profile (high quantitative demands in combination with low control) contributes to elevated stress-related cardiovascular risk (23, 24). An alternative theoretical

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approach, the model of effort-reward imbalance, analyzes both situational (extrinsic) and personal (intrinsic) factors with relevance to stressful experience at work (25). The model maintains that lack of reciprocity between costs and gains (ie, high cost and low gain conditions) defines a state of emotional distress with special propensity to autonomic arousal and neuroendocrine responses.

As people cope differently with these conditions, it is important to assess the ways they cope with job demands and reward expectancies. In this regard, the concept of "overcommitment" has been included as the intrinsic component of this model (25). Overcommitment defines a set of attitudes, behaviors, and emotions that reflects excessive striving in combination with a strong desire to be approved and esteemed. People characterized by "overcommitment" exaggerate their efforts beyond levels usually considered appropriate. There is evidence that excessive efforts result from perceptual distortion (eg, underestimation of challenge), which in turn may be triggered by an underlying motivation to experience recurrent esteem and approval (26). The notion of overcommitment bears some resemblance to the well-known type A behavior pattern, but it is clearly more focused. [For a discussion, see reference 25.] In terms of measurement, the 2 concepts show moderate statistical association (27).

Regarding costs, 3 dimensions of reward experience or expectancy are distinguished: money, esteem, and career opportunities. Thus, in contrast to the demand-control model, stressful work experience is conceptualized as somewhat broader to include more distant labor market conditions (eg, wage differentials, promotion prospects, or job insecurity), as well as the socioemotional dimension of esteem and recognition considered important for successful self-regulation.

In this study a stressful psychosocial work environment was analyzed in terms of effort-reward imbalance. To test the mediating influence of a stressful psychosocial work environment, we investigated the association between effort-reward imbalance and cardiovascular risk factors in subgroups with different shift schedules. Moreover, the direct effect of shift work on cardiovascular risk factors was analyzed in the total group of the male study population. Findings concerning direct associations between effort-reward imbalance and cardiovascular risk factors in the larger male and female study population have been reported elsewhere (28).

Subjects and methods

Study sample

Occupational health service units in the greater Stockholm area serving a population that was considered suitable for the aims of the study were invited to take part in the WOLF (work organization, lipids, and fibrinogen) study as cooperative centers. A total of 20 units accepted the invitation and 3 did not. The study population consisted of employees at almost 40 companies served by these 20 occupational health service units representing several different branches and a wide range of occupations. Subjects who were on a more or less permanent leave from the workplace (eg, stationed abroad or chronically ill) were not included in the study population. The baseline data collection started in November 1992 and ended in June 1995. Altogether 3250 men and 2470 women aged 19—70 years and living in the greater Stockholm area were included.

The present analysis on shift work, effort-reward imbalance and cardiovascular risk was restricted to men aged 30—55 years because both the prevalence of shift work (ie, daytime work and late shift or rotating shift including night shift) and of cardiovascular risk factors was too low for appropriate statistical analysis among the women. Moreover, the age group 30—55 years was chosen since associations between work-related factors and cardiovascular risk are expected to be strongest in this age interval (25, 29). Previous analyses of data from the WOLF study confirmed this assumption (28). Thus the present study sample consisted of the male population of this age group (ie, 2288 men).

Shift work

Shift work was assessed by a set of standardized categorical questions asking for regular work during the daytime (0600 to 1800), late afternoon and evening (1800 to 2200), and night (2200 to 0600). A categorical index was constructed dividing the study population into the following 3 shift work groups: (i) daytime work only, (ii) 2-shift work (ie, workhours in the late afternoon or evening with daytime work, (iii) rotating 3-shift work (ie, workhours night, late afternoon or evening, and during daytime).

Less than 2% of the male shift workers had permanent late afternoon or evening shifts or permanent night-shift work. Exclusion of these subjects did not change the findings. Thus they were included in the analysis presented in the Results section.

Psychosocial and behavioral questionnaire data

All the psychosocial and behavioral information was collected by well-tested standardized self-administered questionnaires.

The personal or intrinsic component of the model of effort-reward imbalance — "overcommitment" — was assessed by the scale "need for control and approval" containing 29 Likert-scaled items which define 4 unidimensional subscales: (i) need for approval, (ii) competitiveness and latent hostility, (iii) impatience and disproportionate irritability, (iv) inability to withdraw from work obligations. These 4 subscales were repeatedly found to form 1 latent factor (26, 28).

Extrinsic effort and reward were measured by 13 Likert-scaled or categorical items. Effort concerned the frequency of being stressed by time pressure, responsibility, overtime work, and increasing responsibility. Measures of occupational rewards covered the frequency of esteem by colleagues and superiors, and insufficient career reward (job insecurity and undesirable job change).

According to the theoretical considerations stated in the Introduction, 2 aggregate measures were constructed to estimate the effects of effort-reward imbalance on health. First, a sum score of the intrinsic component measuring overcommitment (scale need for control and approval) (26) was computed. According to test-statistical indication, a score ranging in the upper tertile (≥13, scale range 0—29) was considered a psychosocial risk condition as 2 independent studies documented elevated cardiovascular risk among subjects whose scores exceeded this threshold (28, 30). Second, a ratio of extrinsic efforts (nominator) and rewards (denominator) was calculated to assess the degree of imbalance between high cost and low gain at work. As a result, a ratio value above 1 indicated the theoretically important condition of high cost:low gain. Previous studies found evidence of adverse effects on cardiovascular health produced by effort-reward imbalance (28—32).

Information on duration and the intensity of cigarette smoking, frequency per week and type of physical exercise, medication according to hypertension and hyperlipidemia, medical history and genetic risk concerning hypertension, and hyperlipidemia and coronary heart disease was obtained from standardized questions.

Table 1. Age, cardiovascular risk factors, and indicators of effort-reward imbalance among male shift and daytime workers.

	Daytime workers		Day and late shift workers		Day, late, and night shift workers	
	N	%	N	%	N	%
Age						
30—40 years	498	37.7	281	42.7	137	49.6
41—45 years	237	17.9	123	30.1	49	17.8
46—50 years	304	23.0	152	23.1	56	20.3
51—55 years	283	21.4	102	15.5	34	12.3
Hypertension (≥160/95 mm Hg)[a]	81	6.1	53	8.1	13	4.7
Total cholesterol (≥5.7 mmol/l)	632	48.3	274	41.9	113	40.9
Ratio of total cholesterol and HDL cholesterol (≥4.62)	466	35.4	245	37.5	110	40.0
Socioeconomic group						
Blue collar	529	41.0	125	19.6	132	48.9
Indicators of effort-reward imbalance						
Effort-reward ratio (> 1)	328	25.9	296	48.2	102	39.2
Need for control and approval (upper tertile)	384	30.2	240	38.0	69	26.0

[a] 1 mm Hg ≈ 0.133 kPa.

Clinical examination data

A clinical examination was carried out at the occupational health service unit. Height, weight, waist, hip, and blood pressure were measured. Blood samples were collected for the determination of lipids. Blood pressure was measured on the right arm with the subject in the supine position after 5 minutes of rest. Measurements were repeated after 1 minute of intermission. Blood lipids were determined enzymatically, high-density lipoprotein cholesterol (HDL-C) after precipitation by phosphotungstic acid and magnesium chloride. All the analyses were carried out blindly by the CALAB Medical Laboratories, which are accredited by the SWEDAC (Swedish Board for Accreditation and Conforming Assessment).

In the present study the data analysis was based on categorical biomedical factors. The analysis concentrated on 2 major risk factors of coronary heart disease, hypertension (33, 34) and the ratio of elevated total cholesterol (TC) to HDL-C (35, 36). While the categorization for hypertension according to the criteria of the World Health Organization (WHO) is well established, we are aware that the cut points defining normal and elevated levels of blood lipids are still under discussion. The decision on a cut point for the TC:HDL-C ratio was based on the distribution of the data. The upper tertile was chosen (ie, ≥4.61).

Table 1 characterizes the study sample in terms of shift schedules, age, cardiovascular risk factors, and indicators of effort-reward imbalance. The shift workers were younger than the daytime workers, and elevated total cholesterol levels were less common in both groups of shift workers. The highest proportion of blue-collar men was observed in the group of 3-shift workers, whereas the lowest proportion of blue-collar men was found for the 2-shift workers. Both indicators of effort-reward imbalance, need for control and approval (upper tertile of respective scale), and unfavorable effort-reward ratios (ie, >1) were more prevalent among the shift workers than among the men with daytime work.

Statistical methods

Multivariate logistic regression models were calculated to adjust the effects of shift work and indicators of effort-reward imbalance on cardiovascular risk factors for confounders. Confounding variables were entered into the analysis en bloc. The respective model fit was estimated with the likelihood ratio difference test (37).

A logistic regression analysis was performed in 2 steps. First, to test the direct impact of shift schedules on the outcome measures, the main effect of shift work was calculated for the total group of male middle-aged daytime and shift workers without the influence of effort-reward imbalance being taken into consideration (model 1 in tables 2 and 3). Second, to test the mediating influence of a stressful psychosocial work environment, the effect of effort-reward imbalance on the cardiovascular risk factors was estimated in separate logistic regression models in 3 subgroups with different shift schedules (models 2 to 4 in tables 2 and 3).

Results

Table 2 shows the results for hypertension. A direct effect of shift work on hypertension was observed in the group of day and evening shift workers only (model 1). According to our main hypothesis, model 3 shows an association between the extrinsic component of effort-reward imbalance (ie, effort:reward ratio >1) and hypertension in the group of day and evening shift workers. The odds ratios of the effort:reward ratio were higher than those of daytime workers (model 2); thus a mediating effect for a component of effort-reward imbalance was suggested. These results held true after adjustment for confounders. A respective analysis with the group of night workers was not calculable since there were too few hypertensive men (model 4). No substantial effect of the intrinsic component of effort-reward imbalance, need for control and approval, was observed.

Table 3 shows a direct effect of shift work on the TC:HDL-C ratio after adjustment for age and hypertension (model 1). In congruence with our main hypothesis, a mediating effect of the extrinsic component of effort-reward imbalance was observed in the group of day and late shift workers. Exposure to effort-reward ratio values of >1 was associated with the TC:HDL-C ratio after adjustment for age (model 3). Controlling for hypertension and, in particular, behavioral risk factors (eg, cigarette smoking, lack of physical exercise) decreased the odds ratio. This finding indicated an influence of adverse health behavior on the association between shift work, effort-reward imbalance, and elevated TC:HDL-C values. Again, no substantial effect of need for control and approval on atherogenic lipids was observed.

Additional analyses not presented in detail in this report revealed a healthy worker effect concerning the association between shift work and hypertension (ie, a decreasing frequency of hypertension with increasing age among shift workers). The relative risk of hypertension among shift workers, particularly for 3-shift workers, compared with daytime workers, decreased beyond the age of 45 years. The respective relative risks in the age group 41—45 years were 4.34 (day and late shift) and 3.63 (day, late and night shift). In the age group 46—55 years the relative risks of belonging to the group of hypertensives were 1.45 (day and late shift) and 1.03 (day, late, and night shift), respectively.

Discussion

This study found preliminary evidence of a mediating effect of a stressful work environment in terms of effort-reward imbalance on the association of shift work with 2 important cardiovascular risk factors. Significant effects of the effort:reward ratio, the measure of the extrinsic component of the model, on hypertension and the TC:HDL-C ratio were observed in the group of day and late shift workers. With regard to hypertension, the me-

Table 2. Results of the multivariate logistic regression analysis for shift work and indicators of effort-reward imbalance in association with hypertension (≥160/95 mm Hg, 21.28/12.64 kPa) among the employed Swedish men aged 30—55 years — main effects of shift work and effects of effort-reward imbalance in groups with different shift schedules. (OR = odds ratio, 95% CI = 95% confidence interval)

Model	Multivariate prevalence[a]		Multivariate prevalence[b]		Multivariate prevalence[c]		Multivariate prevalence[d]	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Model 1 (N=2177)[e]								
Daytime work	1.00		1.00		1.00		1.00	
Day and late shift	1.55	1.07—2.25	1.66	1.14—2.42	1.59	1.08—2.33	1.70	1.15—2.50
Day, late and night shift	0.97	0.53—1.79	1.01	0.55—1.87	1.00	0.54—1.87	1.06	0.57—1.98
Model 2 (N=1215)[f, g]								
Effort-reward ratio (>1)	1.40	0.82—2.38	1.31	0.76—2.26	1.43	0.83—2.47	1.35	0.77—2.36
Need for control and approval (upper tertile)	0.84	0.48—1.47	0.87	0.50—1.53	0.88	0.50—1.55	0.91	0.51—1.61
Model 3 (N=597)[h, g]								
Effort-reward ratio (>1)	2.27	1.16—4.46	2.26	1.14—4.45	2.18	1.09—4.36	2.21	1.10—4.42
Need for control and approval (upper tertile)	1.25	0.66—2.36	1.28	0.67—2.44	1.07	0.55—2.09	1.13	0.58—2.20
Model 4 (N=245)[i, j]								
Effort-reward ratio (>1)								
Need for control and approval (upper tertile)								

[a] Adjusted for each other and age. [b] Adjusted each other, age and medical risk factor (total cholesterol). [c] Adjusted for each other, age and behavioral risk factors (cigarette smoking, lack of physical exercise, overweight). [d] Fully adjusted. [e] Model 1: main effect of shift work. [f] Model 2: main effects of indicators of effort-reward imbalance in day workers. [g] Reference group: men with effort-reward ratio values ≤1 and values in the middle and lower tertile of need for control and approval respectively. [h] Model 3: main effects of indicators of effort-reward imbalance in day and late shift workers. [i] Model 4: main effects of indicators of effort-reward imbalance in day, late, and night shift workers.
[j] Not calculable because of too low numbers of hypertensives in the group with night shifts.

diating effect was not attributable to a higher prevalence of biomedical or behavioral risks among shift workers.

The cross-sectional design of the present investigation did not allow adequate control for possible selection effects of the study population with regard to shift schedules. The inconsistent relation between shift work, in particular 3-shift work, the effort:reward ratio, and cardiovascular risk factors may be explained by a healthy worker effect. Such an effect was reported in a study analyzing the relation between shift work and cardiovascular mortality (3). In our study, the evidence of a healthy worker effect was at least present in the group of night shift workers in that they were significantly younger than daytime workers and showed decreasing rates of hypertension with increasing age. Similar, but less clear trends were observed with regard to atherogenic lipids.

Second, our findings addressing the main hypothesis were not consistent. The theoretical concept of effort-reward imbalance assumes that 2 summary measures, an extrinsic component (ie, effort:reward ratio) and an intrinsic component (ie, need for control and approval), exert adverse effects on cardiovascular health. In our study significant effects were restricted to the extrinsic component. Evidence from a broader sample of the WOLF study population including women suggests gender-specific effects of these measures. For the women, the intrinsic component was more important in explaining cardiovascular risk, whereas, for the men, it was the extrinsic component that was more important (28). The mediating effect of effort-reward imbalance on hypertension was more robust than the one on atherogenic lipids. In part, this result may be due to the well-known effect of smoking on atherogenic lipids (38, 39).

Third, our study failed to control adequately for additional relevant factors associated with shift work. In particular, information on diet (8, 12) and physical or chemical hazards (13, 14) was not available. Yet it can be argued that two-thirds of the study population were employed in the service sector, where exposure to physical and chemical hazards is usually low. In fact, adjusting for white-collar versus blue-collar status in the multivariate analysis did not change our results.

Finally, the questionnaire information on extrinsic effort and reward was not fully identical with the original measures. Yet the criterion validity of our measures was successfully tested in an earlier study (28). The convergent validity of the original questions in comparison with the measures used by us is currently under study.

In conclusion, despite obvious limitations, our results indicate that a stressful psychosocial work environment may act as a mediator for the adverse health effects of shift work on hypertension and, partly, on atherogenic lipids. In terms of occupational health, our findings call for a more comprehensive assessment of the health risks associated with shift work.

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Table 3. Multivariate logistic regression analysis for shift work and indicators of effort-reward imbalance in association with elevated total cholesterol high density lipoprotein cholesterol ratio (upper tertile, ≥4.62) among the employed Swedish men aged 30—55 years — main effects of shift work and effects of effort-reward imbalance in groups with different shift schedules [multivariate prevalence odds-ratios (OR) and 95% confidence intervals (95% CI)].

Model	Multivariate prevalence[a]		Multivariate prevalence[b]		Multivariate prevalence[c]		Multivariate prevalence[d]	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Model 1 (N=2183)[e]								
Daytime work	1.00		1.00		1.00		1.00	
Day and late shift	1.14	0.94—1.39	1.12	0.92—1.36	1.24	1.00—1.53	1.22	0.99—1.51
Day, late and night shift	1.33	1.01—1.74	1.33	1.01—1.74	1.27	0.95—1.69	1.27	0.95—1.69
Model 2 (N=1185)[f, g]								
Effort-reward ratio (>1)	1.18	0.90—1.56	1.17	0.89—1.54	1.28	1.08—1.52	1.17	0.88—1.56
Need for control and approval (upper tertile)	1.14	0.88—1.48	1.16	0.89—1.51	1.07	0.90—1.27	1.14	0.87—1.51
Model 3 (N=576)[h, g]								
Effort-reward ratio (>1)	1.45	1.03—2.06	1.40	0.98—1.98	1.37	0.94—1.99	1.34	0.92—1.95
Need for control and approval (upper tertile)	1.06	0.75—1.52	1.07	0.74—1.52	1.00	0.68—1.47	0.99	0.67—1.46
Model 4 (N=244)[i, g]								
Effort-reward ratio (>1)	0.89	0.52—1.54	0.87	0.50—1.51	0.95	0.53—1.71	0.95	0.53—1.71
Need for control and approval (upper tertile)	1.49	0.81—2.72	1.49	0.81—2.72	1.47	0.77—2.80	1.48	0.77—2.82

[a] Adjusted for each other and age. [b] Adjusted each other, age and medical risk factor (hypertension). [c] Adjusted for each other, age and behavioral risk factors (cigarette smoking, lack of physical exercise, overweight). [d] Fully adjusted. [e] Model 1: main effect of shift work. [f] Reference group: men with effort-reward ratio values ≤1 and values in the middle and lower tertile of need for control and approval, respectively. [g] Model 2: main effects of indicators of effort-reward imbalance in day workers. [h] Model 3: main effects of indicators of effort-reward imbalance in day and late shift workers. [i] Model 4: main effects of indicators of effort-reward imbalance in day, late, and night shift workers.

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