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Research Article

Effort-Reward Imbalance at Work and Cardiovascular Disease Risk Factors: A Longitudinal Study in Iranian Fiber Manufacturing Workers

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Abstract

Introduction: Stress may adversely affect cardiovascular health. Therefore, effort-reward imbalance at work is expected to increase the risk of CVD. The study aims to determine whether ERI at work increase the risk factors of cardiovascular diseases.

Method: A longitudinal study was conducted among men working at fiber manufacturing company. The data collected during four repeated measures with six months' interval. Job stress was determined using Effort-reward imbalance (ERI) questionnaire. Blood pressure (BP), low-density lipoprotein (LDL) cholesterol, high-density lipoproteins (HDL) cholesterol, total cholesterol (TC), glucose, triglyceride (TGS) and body-mass index (BMI) as cardiovascular disease risk factors were measured by trained nurses. Growth mixture modeling was used to cluster individual. The association of ERI trajectory classes with cardiovascular disease risk factors was modeled using generalized estimating equations.

Results: A total of 261 workers were included in the longitudinal study. Of this group, 261 persons at time 1; 220 at time 2; 205 at time 3; 191 at time 4 filled out the questionnaires. A two-class solution demonstrated the best fit for ERI scores. A first class demonstrated a high-declining trajectory over phases. The second class of workers had low-increasing trajectory. For over-commitment scores we did not identify any good classification. Among the CVD risk factors, SBP, HDL cholesterol and TG_S significantly were associated with ERI trajectory classes. With regard to over-commitment, TG_S significantly was associated with over-commitment score.

Conclusion: The results of present study recommend that preventive measures and policies that address the imbalance between high efforts and low rewards might reduce CVD.

Keywords: *Effort-Reward Imbalance; Cardiovascular Disease Risk Factors; Fiber Manufacturing Company; Iran*

Introduction

Stressful conditions are main problem in the workplace especially in the lives of workers in modern economies [1]. Work stress has been evaluated mostly using two theoretical models: job strain and effort-reward imbalance (ERI) [2]. The job strain model invented by

Karasek [3] posits that a combination of high psychological demands (refers to the work quantity, intellectual necessities and time constraints) and low decision latitude (refers to the likelihood of making decision, being inventive and using and increasing one's capabilities) is a health risk for workers. The ERI model suggested by Siegrist [4] underlines that a stress is made by the recurring experience of a failed tradeoff between the effort consumed at work (e.g., work pace, amount of work, time devote at work) and the rewards received in turn ("high cost-low gain" condition). In this model, two different sources of effort at work have been defined, namely, extrinsic and intrinsic [5]. The source of extrinsic of effort is close to the psychological demands idea of the Karasek model and refers to time pressure, numerous interruptions, frequent responsibilities, higher workload and compulsory overtime [6]. Reward refers to respect and esteem, income and job opportunities including career security. The concept of balance between effort and reward had its theoretical basis in the concept of social reciprocity, which is an anticipation for all humans [7]. A second source of effort usually called ''over-commitment'' is an intrinsic psychological pattern of coping associated with the incapability to withdraw from work responsibilities [6]. Over-commitment is assumed, based on the theoretical ERI model, to modify (i.e., increase) the deleterious effect of ERI on health [2]. Many workers, obviously, are better at dealing with stressful situations than others and the ERI model can incorporate this. For example, people with "over-commitment" or high intrinsic effort, will exaggerate their hard works because of their desire for esteem and appreciation and will find the differences between efforts and rewards particularly stressful [7]. Long-lasting or high-dosage stress may adversely affect cardiovascular health [8]. The cardiovascular system is at risk to continuously increased activation of the autonomic nervous system following exposing to high cost/low gain situation [9]. Therefore, effort-reward imbalance at work is anticipated to increase the risk of CVD. An association between stressful working conditions and increased risk of subsequent coronary heart disease events among employees have been found in cohort studies carried out in different countries [8,10,11]. An increased risk of incident coronary heart disease or cardiovascular mortality have been reported by four individual prospective studies from Germany, Great Britain and Finland, for employees with an imbalance between high effort and low reward [12-15]. On the other hand, blood pressure (BP), low-density lipoprotein (LDL) cholesterol, high-density lipoproteins (HDL) cholesterol, total cholesterol (TC), glucose, triglyceride (TG_S) and obesity are reported as risk factors of cardiovascular disease (CVD) [16-18]. Findings of cross sectional and prospective studies have shown relationship between effort-reward imbalance with precursors of CVD, such as hypertension, high concentrations of LDL cholesterol, lowered vagal tone and impaired fibrinolytic capacity [19]. However, owing to the small number of sample size and independent studies, it is unclear whether these results are generalizable to different settings and across social class groups [10,11]. Furthermore, the current evidence is restricted because of a limited range of occupations, cross-sectional study designs and unadjusted measurements of effort-reward imbalance in some studies. Therefore, larger and better-characterized studies are required. The aim of the present study was to determine whether ERI at work increase the risk factors of cardiovascular disease that mentioned above in workers employed by Iranian Polyacryle Company.

Methods

A longitudinal study was conducted in Iran Polyacryle Company consisting of 1665 employees. Two hundred sixty one (15.6%) men working at different departments with different shift work schedule were randomly selected and invited to participate. The sample was a dynamic cohort that workers can leave or introduce over time. It consisted of both blue and white collar workers recruited between 1 August 1996 and 19 January 2004 and still was working. The data collected in five repeated measures including baseline data with six months' interval. All participants filled out the questionnaire at the morning shift (7 a.m. to 9 a.m.) before starting work. After signing and giving back the consent form, the participants completed two questionnaires: Socio-demographic questionnaire and Siegrist's job stress questionnaire. A self-administered Socio-demographic questionnaire comprised questions about age; marital status (single, married); number of children; education level (< high school, high school graduation, university); family income (low, middle, high); working duration in a week; and smoking status. Siegrist's job stress questionnaire entitled ERI [7] has been translated into Farsi and standardized by the research team that called F-ERIQ [20]. F-ERIQ has 23 items the same as its English version. There are three scales including effort, reward and over-commitment with 6, 11 and 6 items, respectively. Reward is measured by three subscales: esteem (4 items), job promotion (4 items) and job security (2 items). The self-administered F-ERIQ was completed by respondents in four phases. In each phase, for effort and reward scales, respondents were asked whether or not they agreed with the items, then to what extent they agreed.

Each item was scored on five-point scales based on the algorithm suggested by Siegrist., *et al*. Sum of the scores was computed for effort, reward and over-commitment and a ratio of the effort to reward as the ERI scale. To adjust for the number of items in the ERI scale, denominator-reward-was multiplied by 0.5454 (=6/11). The ratio indicates the core concept of theory of stress if there was a mismatch between effort and reward. Therefore, "effort" and "reward" scales ranged from 6 to 30 and 11 to 55, respectively. The over-commitment items were measured on a four-point Likert scale ranging from 1 "strongly agree" to 4 "strongly disagree." Higher effort, lower rewards and higher over-commitment indicate high job stress. CVD factors consist of systolic blood pressure (SBP), diastolic blood pressure (DBP), LDL cholesterol, HDL cholesterol, TC, glucose, TG_S and body-mass index (BMI) were measured by educated nurses before completing the questionnaires. Timing of measurement was from 7 a.m. till 9 a.m. Participation in the study was voluntary and all of subjects signed a consent form at every phase of study. The present study approved by ethic committee of Isfahan University of Medical Sciences (Project number 188160) and it was performed according to the Declaration of Helsinki. Assigned unique code to each subject was used in order to link data of phases together for follow up purposes.

Statistical analysis

Growth mixture modeling (GMM) was used to cluster individual into a set of trajectory classes that were representative of changes in work ERI scores over the four phases. GMM is a form of latent class analysis which classifying individual trajectories into subpopulations or classes based on the closeness of fit of their intra-individual changes across the study [21]. Determination of the best-fitting trajectory class solution was according to fitness criteria such as AIC, BIC and SSBIC and entropy score. Lower values of these criteria show better fitting. In addition, likelihood ratio tests can be done to test if the number of classes is statistically significant [22,23]. To identify latent class of ERI scores trend, we used Mplus v.6.12 which uses a maximum likelihood methodology for estimating GMM parameters. The association of ERI trajectory classes with CVD risk factors was modeled using generalized estimating equations (GEE) to account for correlation among data within an individual over four intervals. Models incorporated adjustment for Socio-demographic information and baseline measurements of CVD risk factors as potential confounders. GEE analyses were performed with SAS version 9.2 by proc GENMOD. Level of significant was considered at 0.05. Multiple imputation method was performed to impute missing data values for ERI scores. A Markov Chain Monte Carlo method using an expectation maximization algorithm was used to impute the missing data.

Results

A total of 261 workers were included in the longitudinal study. Of this group, 261 persons at time 1 (T1, July, 2011); 220 at time 2 (T2, Dec 2011); 205 at time 3 (T3, June 2012); 191 at time 4 (T4, Dec 2012) filled out the questionnaires. Baseline characteristics of workers are summarised in table 1 which shows mean age of the participants was 33.44 (SD = 6.69) years (ranged 19 to 35), mean of working hours in a week were 46.74 (SD = 5.01), Most of the workers had, at least, one child (56.8%) and had university education (50.2%). Table 2 shows the distributions of outcomes within the worker at four phases along with perceived job stress scores on the ERI questionnaire. With regard to classifying individual based on ERI scores across four phases, results of latent growth trajectory model are shown in figure 1. A two-class solution demonstrated the best fit to the ERI scores based on fitness criteria. A first class (Class1; 11.5%) demonstrated a high-declining trajectories over phases with the significant negative slope and the intercept slightly above 1 in ERI value. The majority of workers (Class2; 88.5%) having low-increasing trajectories with the significant positive slope and the intercept lower than 1 (Table 3). For over-commitment scores across four phases we did not identify any good classification based on fitness criteria. Table 4-11 show regression results exploring association of ERI trajectory classes with CVD risk factors. With regard to ERI, among the CVD risk factors, SBP, HDL cholesterol and TG_S significantly were associated with ERI trajectory classes. These associations were maintained significant after adjustment for individual characteristics. Compared with the low-increasing trajectory class, higher SBP and TG_S were seen in high-declining-ERI-trajectory class. However, high-declining-ERI-trajectory class had lower HDL cholesterol compared with low-increasing trajectory class. With regard to over-commitment, TG_S significantly was associated with over-commitment score with and without adjusting for individual characteristics. With increases of over-commitment score over the time, TG_S value was increased. Of the individual characteristics, by increasing age over time, DBP and BMI value were significantly increased (Table 5 and 11).

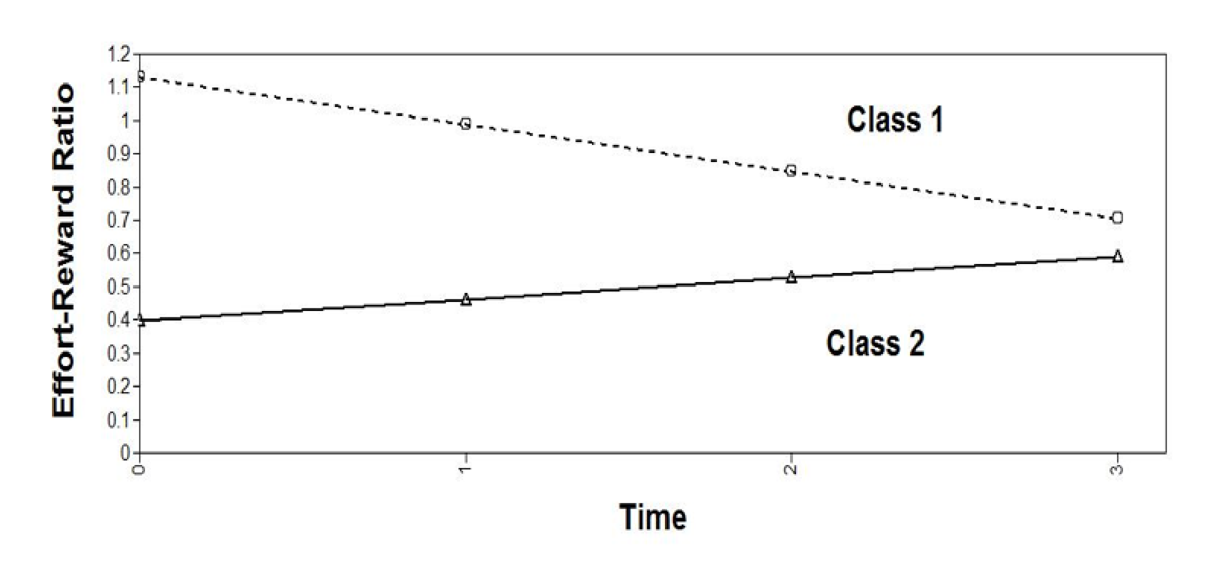

Figure 1: *Graphs showing mean trajectories for two-class growth mixture modeling for ERI.*

Age (mean, SD)	33.44	6.69
Working duration in a week (mean, SD)	46.74	5.01
Child at home (N, %)		
Have no children	98	43.2
Have children	126	56.8
Level of education (N, %)		
< High school	15	6.6
High school graduation	98	43.2
University	114	50.2
Marital status (N, %)		
Single	33	14.5
Merited	190	83.7
Divorced	4	1.8
Family income (N, %)		
Low	121	53.7
Middle	96	42.7
High	8	3.6
Smoking status (N, %)		
Current smoker	23	10.2
Former smoker	30	13.3
Never	172	76.4
Discrepancies in the totals are due to missing covariate values		

Table 1: *Baseline characteristics of employee.*

	Four phases							
	1		2		3		4	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Effort	10.46	3.51	11.01	3.75	11.14	3.95	10.44	3.17
Reward	42.30	8.89	42.06	8.23	42.84	7.97	20.73	8.64
Effort-reward imbalance	0.502	0.30	0.519	0.28	0.522	0.302	1.012	0.413
Over-commitment	14.09	2.44	14.08	2.58	13.34	2.69	13.89	2.04
SBP	116.85	11.60	117.37	13.15	115.35	11.56	115.02	12.27
DBP	76.7	10.5	77.6	9	79.1	9.3	78.5	8.1
HDL cholesterol	41.36	6.80	43.51	8.91	43.87	8.92	42.50	8.38
LDL cholesterol	109.52	28.87	98.03	28.67	101.28	26.90	97.83	65.16
TC	180.34	36.48	173.93	26.59	173.01	35.88	164.36	32.44
TG_s	161.58	106.65	122.88	62.69	139.37	78.71	145.38	79.40
Glucose	88.67	17.94	81.31	18.96	85.27	12.95	82.83	8.62
BMI	25.67	3.38	25.78	3.19	25.58	3.23	25.96	3.08

Table 2: *Job characteristic Scores and blood pressure measurements across four phases for worker responding.*

Class	Intercept		Slope	
ERI trajectory	Estimate	SE	Estimate	SE
1	1.131*	0.084	-0.143*	0.040
2	0.398*	0.015	0.065*	0.013

Table 3: *Results of latent growth models for ERI scores across four phases.*
**P < 0.001.*

	SBP					
	Model 1*			Model 2**		
	B	SE	p-value	B	SE	p-value
ERI trajectory						
High-Declining	2.70	1.25	0.036	2.57	1.30	0.048
Low-Increasing	REF	REF	REF	REF	REF	REF
Over-commitment	0.25	0.17	0.15	0.30	0.17	0.089
Age				0.052	0.10	0.62
Working duration in a week				0.12	0.10	0.27
Child at home						
Have children				-1.53	1.48	0.29
Have no children				REF	REF	REF
Level of education						
< High school				6.20	3.88	0.11
High school graduation				1.61	1.12	0.14
University				REF	REF	REF
Marital status						
Merited				1.46	1.43	0.30
Single				REF	REF	REF
Family income						
Low				-2.12	3.06	0.48
Middle				-2.89	2.89	0.31
High				REF	REF	REF
Smoking status						
Current smoker				-2.12	3.06	0.48
Former smoker				-2.89	2.89	0.31
Never				REF	REF	REF

Table 4: *Association of effort–reward imbalance trajectories across four phases with SBP.*
Model 1: No adjustments; Model 2**: Adjusted for demographic variables; All models were adjusted for baseline DBP, baseline LDL cholesterol, baseline HDL cholesterol, baseline TC, baseline TG_S, baseline Glucose and baseline BMI.*

	DBP					
	Model 1			Model 2		
	B	SE	p-value	B	SE	p-value
ERI trajectory						
High-Declining	0.183	0.91	0.84	0.60	1.00	0.54
Low-Increasing	REF	REF	REF	REF	REF	REF
Over-commitment	0.25	0.14	0.07	0.18	0.12	0.15
Age				0.20	0.07	0.005
Working duration in a week				0.10	0.055	0.052
Child at home						
Have children				1.10	0.93	0.24
Have no children				REF	REF	REF
Level of education						
< High school				-1.69	2.36	0.47
High school graduation				-1.88	0.79	0.81
University				REF	REF	REF
Marital status						
Merited				-2.48	0.94	0.009
Single				REF	REF	REF
Family income						
Low				1.69	2.09	0.43
Middle				0.44	1.98	0.82
High				REF	REF	REF
Smoking status						
Current smoker				-1.59	1.44	0.27
Former smoker				1.41	1.05	0.17
Never				REF	REF	REF

Table 5: *Association of effort-reward imbalance trajectories across four phases with DBP.*
Model 1: No adjustments; Model 2: adjusted for demographic variables.
All models were adjusted for baseline SBP, baseline LDL cholesterol, baseline HDL cholesterol, baseline TC, baseline TG_s, baseline Glucose, baseline BMI.

	LDL cholesterol					
	Model 1			Model 2		
	B	SE	p-value	B	SE	p-value
ERI trajectory						
High-Declining	1.52	2.79	0.58	2.05	3.00	0.49
Low-Increasing	REF	REF	REF	REF	REF	REF
Over-commitment	0.19	0.32	0.55	0.20	0.36	0.57
Age				0.17	0.200	0.36
Working duration in a week				-0.44	0.16	0.008
Child at home						
Have children				-4.31	2.53	0.088
Have no children				REF	REF	REF
Level of education						
< High school				3.06	3.87	0.42
High school graduation				0.23	2.16	0.91
University				REF	REF	REF
Marital status						
Merited				0.19	2.99	0.94
Single				REF	REF	REF
Family income						
Low				-1.39	3.60	0.69
Middle				-1.36	3.34	0.68
High				REF	REF	REF
Smoking status						
Current smoker				-0.99	2.71	0.71
Former smoker				-5.42	2.54	0.033
Never				REF	REF	REF

Table 6: *Association of effort–reward imbalance trajectories across four phases with LDL cholesterol.*
Model 1: No adjustments; Model 2: adjusted for demographic variables.
All models were adjusted for baseline SBP, baseline DBP, baseline HDL cholesterol, baseline TC, baseline TG_s, baseline Glucose, baseline BMI.

	HDL cholesterol					
	Model 1			Model 2		
	B	SE	p-value	B	SE	p-value
ERI trajectory						
High-Declining	-2.32	1.12	0.04	-2.78	1.22	0.023
Low-Increasing	REF	REF	REF	REF	REF	REF
Over-commitment	-0.17	0.14	0.22	-0.16	0.14	0.28
Age				0.17	0.094	0.063
Working duration in a week				0.078	0.078	0.31
Child at home						
Have children				-1.18	0.97	0.064
Have no children				REF	REF	REF
Level of education						
< High school				1.04	1.92	0.59
High school graduation					0.86	0.91
University				REF	REF	REF
Marital status						
Merited				-1.85	1.15	0.10
Single				REF	REF	REF
Family income						
Low				-3.58	2.37	0.13
Middle				-2.75	2.24	0.22
High				REF	REF	REF
Smoking status						
Current smoker				-0.80	1.32	0.54
Former smoker				-0.16	1.04	0.87
Never				REF	REF	REF

Table 7: *Association of effort-reward imbalance trajectories and job demand-control across interview waves with HDL cholesterol. Model 1: No adjustments; Model 2: adjusted for demographic variables. All models were adjusted for baseline SBP, baseline DBP, baseline LDL cholesterol, baseline TC, baseline TG_s, baseline Glucose, baseline BMI.*

	TC					
	Model 1			Model 2		
	B	SE	p-value	B	SE	p-value
ERI trajectory						
High-Declining	1.83	4.25	0.66	1.08	4.90	0.82
Low-Increasing	REF	REF	REF	REF	REF	REF
Over-commitment	0.34	0.56	0.54	0.26	0.59	0.65
Age				1.79	1.47	0.23
Working duration in a week				-0.22	0.32	0.48
Child at home						
Have children				-11.81	6.43	0.066
Have no children				REF	REF	REF
Level of education						
< High school				-16.14	19.45	0.40
High school graduation				-8.06	8.57	0.34
University				REF	REF	REF
Marital status						
Merited				0.018	5.16	0.99
Single				REF	REF	REF
Family income						
Low				3.80	8.08	0.63
Middle				8.96	10.33	0.38
High				REF	REF	REF
Smoking status						
Current smoker				-10.16	10.85	0.34
Former smoker				-6.44	5.23	0.21
Never				REF	REF	REF

Table 8: *Association of effort–reward imbalance trajectories across four phases with TC. Model 1: No adjustments; Model 2: adjusted for demographic variables. All models were adjusted for baseline SBP, baseline DBP, baseline LDL cholesterol, baseline HDL cholesterol, baseline TG_s, baseline Glucose, baseline BMI.*

	TG_s					
	Model 1			Model 2		
	B	SE	p-value	B	SE	p-value
ERI trajectory						
High-Declining	14.33	4.40	0.001	15.05	4.42	0.001
Low-Increasing	REF	REF	REF	REF	REF	REF
Over-commitment	1.78	0.69	0.01	1.91	0.80	0.017
Age				-0.32	0.49	0.509
Working duration in a week				0.032	0.39	0.93
Child at home						
Have children				-0.49	7.29	0.94
Have no children				REF	REF	REF
Level of education						
< High school				-16.40	8.88	0.065
High school graduation				2.38	4.85	0.62
University				REF	REF	REF
Marital status						
Merited				2.92	7.61	0.70
Single				REF	REF	REF
Family income						
Low				13.76	8.18	0.092
Middle				13.17	7.29	0.071
High				REF	REF	REF
Smoking status						
Current smoker				-3.09	5.81	0.59
Former smoker				-4.52	6.68	0.49
Never				REF	REF	REF

Table 9: *Association of effort–reward imbalance trajectories across four phases with TG_S.*
Model 1: No adjustments; Model 2: adjusted for demographic variables. All models were adjusted for baseline SBP, baseline DBP, baseline LDL cholesterol, baseline HDL cholesterol, baseline TC, baseline Glucose, baseline BMI.

	Glucose					
	Model 1			Model 2		
	B	SE	p-value	B	SE	p-value
ERI trajectory						
High-Declining	2.78	1.79	0.12	3.93	2.89	0.17
Low-Increasing	REF	REF	REF	REF	REF	REF
Over-commitment	0.26	0.19	0.17	0.11	0.20	0.57
Age				0.27	0.17	0.11
Working duration in a week				-0.05	0.20	0.81
Child at home						
Have children				1.73	1.51	0.25
Have no children				REF	REF	REF
Level of education						
< High school				-2.13	2.27	0.34
High school graduation				2.48	1.91	0.19
University				REF	REF	REF
Marital status						
Merited				4.15	1.61	0.010
Single				REF	REF	REF
Family income						
Low				-0.53	4.22	0.89
Middle				-5.02	2.38	0.035
High				REF	REF	REF
Smoking status						
Current smoker				-1.59	2.23	0.47
Former smoker				0.70	1.93	0.71
Never				REF	REF	REF

Table 10: *Association of effort–reward imbalance trajectories across four phases with Glucose.*
Model 1: No adjustments. Model 2: adjusted for demographic variables.
All models were adjusted for baseline SBP, baseline DBP, baseline LDL cholesterol, baseline HDL cholesterol, baseline TC, baseline TG_S, baseline BMI.

	BMI					
	Model 1			Model 2		
	B	SE	p-value	B	SE	p-value
ERI trajectory						
High-Declining	0.09	0.56	0.87	0.25	0.45	0.57
Low-Increasing	REF	REF	REF	REF	REF	REF
Over-commitment	0.08	0.06	0.21	0.04	0.06	0.51
Age				0.11	0.04	0.005
Working duration in a week				0.034	0.034	0.32
Child at home						
Have children				0.74	0.55	0.18
Have no children				REF	REF	REF
Level of education						
< High school				-1.23	1.65	0.45
High school graduation				-1.07	0.38	0.005
University				REF	REF	REF
Marital status						
Merited				1.08	0.58	0.063
Single				REF	REF	REF
Family income						
Low				-1.37	0.84	0.10
Middle				-1.36	0.78	0.082
High				REF	REF	REF
Smoking status						
Current smoker				-0.83	0.94	0.37
Former smoker				0.29	0.49	0.55
Never				REF	REF	REF

Table 11: *Association of effort–reward imbalance trajectories across four phases with BMI.*
Model 1: No adjustments. Model 2: adjusted for demographic variables.
All models were adjusted for baseline SBP, baseline SBP, baseline LDL cholesterol, baseline HDL cholesterol, baseline TC, baseline TG_S, baseline Glucose.

Discussion

Result of our study showed that the mean effort-reward imbalance score increased over four phases suggests a more dynamic process over the time. Over-commitment, by contrast declined throughout surveys. ERI will encompass workers' subjective appraisal and could be expected to change. Clustering workers into a set of latent classes based on ERI scores, results of latent growth trajectory model showed that workers could classified in two classes. Class 1 (11.5% workers) had intercept 1.13 on ERI scores and class 2 (88.5% workers) had intercept 0.39. On the other hand, workers in class 1 at baseline had job stress worse than class 2. Although, trajectory of class 1 was declining and class 2 was increasing over time, but workers in class 1 had higher ERI scores than class 2 overall. Therefore, in terms of job stress workers in class 1 was worse than class 2. We evaluated the longitudinal associations between ERI and CVD risk factors which our GEE analyses revealed SBP, HDL cholesterol and TG_S significantly were associated with ERI trajectory classes. Other risk factors of CVD with ERI trajectory classes were not related significantly. The high-declining-ERI-trajectory class (class with higher job stress) had higher SBP and TG_S compared to the low-increasing trajectory class. However, high-declining-ERI-trajectory class had lower HDL cholesterol compared with low-increasing trajectory class. After adjusting for baseline scores and socio-demographic factors, the results of our study did not change. Information on other potentially relevant factors, such as physical activity, dietary intake was limited in the study and therefore it was not possible to adjust for them in the analyses.

Some studies have also shown the relationship between stress and traditional risk factors such as diabetes [24-26], hypertension [27,28], dyslipidemia [29,30] and BMI [31,32]. One study reported that, chronic stress was constantly associated with prevalence of CHD and stroke and main CVD risk factors including diabetes, hypertension and smoking [33]. These findings agree with theoretical models suggesting that it is protracted exposure to stress over time that is most harmful to health [34]. Many of these biological effects may rise as a functional adaptation to extreme hypothalamic pituitary adrenal and sympathetic nervous system stimulation that can be considered as a result of sustained allosteric burden [35]. Chronic stressor stated that predicted a 22% and 26% excess risk of CHD and stroke, respectively, in fully controlled models [33]. A latest review and meta-analysis assessing effects of perceived stress recognized a modest rise in incident CHD (OR = 1.27, 95% CI 1.12, 1.45) across six articles that primarily evaluated European or Asian populations [36]. In one multi-cohort study, persons with one of the two work stressors (effort-reward imbalance and job strain) had a 16% excess hazard ratio of incident coronary heart disease in comparison with those free of these stressors; in persons with both work stressors, this excess hazard ratio was 41%. Thus, effort-reward imbalance and job strain at work might be connected with biologic changes that are introduced as risk factors for coronary heart disease, such as elevated fibrinogen and atherogenic blood lipids, raised blood pressure, reduced heart rate variability, raised inflammatory markers and dysregulation of the hypothalamic-pituitary-adrenal axis [19]. Of the five earlier studies that examined association between effort-reward imbalance with BP risk factor [37-41], four detected a deleterious effect of ERI. It is also remarkable that all of these studies has examined the effects of repeated ERI exposure on BP. Our findings seem, therefore, in line with those of previous studies. Although one longitudinal study was reported no association in men between repeated ERI exposure and BP [42]. This discrepancy could be due to an underestimation of the true effect in that study. Over-commitment was referred to impatience, irritability and an incapability to withdraw from work responsibilities. However, as proposed by Siegrist, this coping pattern can be considered a psychological risk factor on its own, even in the absence of imbalance at work [6]. In our study, over-commitment was associated with higher TG_S mean in workers. However, there was not an association between over-commitment and others risk factors. Five previous studies evaluated the relationship between over-commitment and ambulatory BP or coronary heart disease (CHD) [43-45]. Peter., *et al*. reported a higher risk of heart attack (1.68 (95% CI = 1.07 - 2.62)) among overcommitted women [44]. Steptoe., *et al*. mentioned higher systolic BP mean in overcommitted men (+6.4 mm Hg) [45]. Maina., *et al*. reported higher (but non significant) ambulatory BP regression coefficients in overcommitted workers (-1.5 mm Hg in systolic BP and -1.1 mm Hg in diastolic BP) [43]. Vrijkotte., *et al*. and Irie., *et al*. observed no effect among male samples [37,41]. In the present analyses, we utilized all available data for CVD risk factors from each participant by using an estimation method (full information maximum likelihood) that allows for missing data. By using GGM as an analytical strategy, we were able to assess the nature of the relationships between the change trajectories of ERI scores and CVD risk factors, which is not possible when traditional variable-based methods are employed. The current study has several strengths. There was a high participation rate, a prospective design, repeated measures of ERI and good consideration of potential confounders. Another strength is the use of the psychometrically validated original version of the effort-reward imbalance questionnaire. Therefore, results could be interpreted precisely as longitudinal design for measuring ERI and CVD risk factor, allows conclusions regarding temporality or causality. This study also has some limitations. The selection bias might have been introduced in our study through the exclusion of subjects treated for hypertension, diabetics and CVD. Even if these exclusions might have led to a healthier cohort, they helped to avoid a misclassification bias due to artificially lowered BP measurements. Furthermore, previous studies exploring the association between ERI and BP have also chosen to exclude participants under medication for hypertension [41,45]. One other limitations might help to explain the absence of an association between ERI and over-commitment with DBP, LDL cholesterol, TC, glucose and BMI. The true associations may have been underestimated due to a selection bias in refusals, missing values, lose to follow-up. One can discuss that another limitation is that effort, reward and over-commitment were assessed using a self-report questionnaire. In theory, self-administered data leads to more reporting bias than objective data. According to Siegrist, however, the individual's judgment is the reason of most of the adverse effects of psychosocial work factors on health [46]. Finally, only daytime and clinical-type BP was measured. However, Boggia., *et al*. reported that daytime BP predicts the 10-year incidence of deadly and non-deadly cardiovascular endpoints just as well as night-time BP does [47]. However, due to the specific sample characteristics (inclusion of only male, white and blue collar workers), careful replication of the study in different samples, other welfare systems and other regions and cultures are needed for generalization of the results. I spite of these limitations our findings are in line with recent evidence of adverse health effects of ERI on CVD risk factors.

Conclusion

The present observational cohort study results suggest that preventive measures and policies that address the imbalance between high efforts and low rewards might reduce disease incidence. Further research is required to evaluate the benefits and harms of monitoring stressful work environments in a systematic and regular way at the company level and application of measures to decrease any adverse impact of detected ERI. Examples of such interventions include securing fair wage and promotion opportunities, developing a culture of recognition and supportive leadership, decreasing excessive workload and working hours and improving control and autonomy at work. To enable sustainability, these measures may need to be reinforced by active labor market policies at the national and international levels. Future registered cluster-randomized trials and natural experiments evaluating the additional value of such workplace intervention strategies compared with usual coronary heart disease prevention that highlights conventional risk factors modification (smoking cessation, healthy diet, physical activity, antihypertensive treatment and statin therapy) would be particularly informative.

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