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ORIGINAL ARTICLE

Is effort–reward imbalance at work associated with different domains of health functioning? Baseline results from the French CONSTANCES study

Johannes Siegrist[1] · Morten Wahrendorf[2] · Marcel Goldberg[3,4] · Marie Zins[3,4] · Hanno Hoven[2]

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Abstract

Purpose Despite its importance a comprehensive assessment of health functioning has rarely been included in epidemiological investigations of work-related health outcomes. In this study, we analyzed associations of a health-adverse psychosocial work environment with a comprehensive set of subjective and objective measures of health functioning that cover the three domains of affective, cognitive, and physical functioning.

Methods Baseline data from the French CONSTANCES cohort study were used with a sample of 24,327 employed men and women aged 45–60. Psychosocial work environment was measured by the short version of the effort–reward imbalance (ERI) questionnaire. Measures of health functioning were depressive symptoms, semantic fluency, verbal memory, walking speed, standing balance and lung function.

Results First, we replicated main psychometric properties of the ERI questionnaire in the French cohort. Second, ERI scales revealed consistent associations with depressive symptoms, but less consistent links to cognitive and physical function. Among men, we observed an association of stressful work with reduced lung function.

Conclusions This study demonstrated consistent associations of stressful work in terms of effort–reward imbalance with affective functioning in a large sample of male and female employees. Relationships with physical functioning were less consistent and restricted to men, and cognitive functioning was only marginally associated with stressful work. We also established the psychometric properties of the French short version of the ERI questionnaire, thus offering a tool for guiding and harmonizing further research in this field.

Keywords Effort–reward imbalance · Health functioning · Psychometric properties · CONSTANCES cohort · Gender differences

Introduction

Measures of health functioning indicate to what extent an illness or impairment influences a person's everyday life, including his or her work ability (WHO 2001). These measures reflect the personal experience of people, thus complementing the perspective of professional medicine based on the international classification of clinically relevant diseases. Information on health functioning is of interest to occupational health research as it has been shown to predict risks of disability (Chatterji et al. 2015), early retirement (Harkonmäki et al. 2006; Rice et al. 2011), and to contribute to a substantial proportion of health care costs (Goetzel et al. 2004; Nagata et al. 2018). Reduced health functioning was also studied as an outcome of exposure to a variety of adverse working conditions in epidemiological studies (Aldabe et al.

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✉ Hanno Hoven
Hanno.hoven@med.uni-duesseldorf.de

1 Senior Professorship on Work Stress Research, Medical Faculty, University of Düsseldorf, Düsseldorf, Germany

2 Institute of Medical Sociology, Centre for Health and Society, Medical Faculty, University of Düsseldorf, Düsseldorf, Germany

3 INSERM UMS 11, Paris, France

4 Paris Descartes University, Paris, France

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2011; Descatha et al. 2016; Reinhardt et al. 2013). Nevertheless, in their majority, prospective epidemiological investigations are interested in predicting disease risk in terms of the International Classification of Diseases (ICD) rather than the International Classification of Functioning, Disability and Health (ICF) or other measures of health functioning. This also holds true for prospective studies of health outcomes that are attributable to stressful psychosocial work environments. For instance, for the two most widely studied theoretical concepts of stressful work, the job strain model (Karasek and Theorell 1990) and the effort–reward imbalance model (Siegrist et al. 2004) reports indicate elevated relative risks of coronary heart disease (Theorell et al. 2016; Dragano et al. 2017; Kivimäki and Steptoe 2018), stroke (Tsutsumi et al. 2009; Fransson et al. 2015), major depression (Rugulies et al. 2017; Theorell et al. 2015), and type 2 diabetes or metabolic syndrome (Chandola et al. 2006; Kumari et al. 2004), among others. While several cohort studies used health functioning as the main outcome, its measurement was usually restricted to the SF-36 or SF-12 questionnaire (Kuper et al. 2002; Stansfeld et al. 1998; Ware et al. 1994; Wahrendorf et al. 2012; Ware 2002).

In this study using baseline data from a large cohort of employed men and women we set out to analyze associations of a health-adverse psychosocial work environment with a comprehensive set of mainly objective measures of health functioning that cover the three domains of affective, cognitive, and physical functioning. Our choice of measuring a health-adverse psychosocial work environment in terms of the effort–reward imbalance (ERI) model was based on the following arguments. First, distinct from other concepts of stressful work, the ERI model with its focus on failed reciprocity of 'give' and 'take' in the work contract captures relevant and widely prevalent features of critical working conditions in times of economic globalization and rapid technological change, such as work pressure, rising competition and job insecurity, unfair pay and lack of recognition at work (Siegrist and Wahrendorf 2016). Second, with its explicit distinction between extrinsic and intrinsic components, this is one of the few models that meet a basic requirement of research on psychosocial work environments, i.e., the combined information on situational exposures and characteristics of the working person's coping behavior (Siegrist and Li 2016). Third, in its short version, the validated questionnaire measuring the model offers a time-saving assessment tool for large-scale cohort studies that has already demonstrated robust psychometric properties in several epidemiological investigations in other countries and languages and, thus, has been incorporated in the current study (Leineweber et al. 2010; Li et al. 2012, 2017; Kurioka et al. 2014; Magnavita et al. 2012). Concerning health functioning, we preferred objective rather than widely used self-report measures of SF-36 or SF-12 (Ware et al. 1994; Ware 2002) as objective measures are free from reporting bias and may reflect higher external validity. Importantly, we aimed at covering the three relevant dimensions of cognitive, affective, and physical health functioning which are not fully represented in the SF-36 or SF-12 measurement (see "Methods").

This contribution has two aims. First, we assessed the psychometric properties of the French short version of the ERI questionnaire. While the original ERI questionnaire has been validated in French language (Niedhammer et al. 2000, 2004), this is the first French application of the short version and, thus, requires a psychometric analysis. We test its construct validity by performing confirmatory factor analysis (see "Methods"). As a second aim, we tested associations of the model's single components 'effort', 'reward' (extrinsic) and 'over-commitment' (intrinsic), and additionally of a combined measure quantifying the balance/imbalance between effort and reward, with six indicators representing the three domains of health functioning. These analyses were calculated separately for men and women as a substantial body of evidence indicates that the consistency and strength of associations of psychosocial working conditions with health differ between men and women (McMunn 2018). Moreover, in the specific case of ERI, gender role-differences may become obvious, disadvantaging women by a higher imbalance between effort and reward (e.g., lower pay) (Magnavita 2013). The general hypothesis of this study maintained that stressful work is associated with reduced health functioning.

Methods

Data

We used data from the French CONSTANCES project. CONSTANCES is a general prospective population-based cohort with a special focus on occupational and environmental epidemiology (Goldberg et al. 2017). Baseline data collection started in 2012 to include up to 200,000 adults aged 18–69 years who are covered by the General Health Insurance Fund (CNAMTS) in France (Zins and Goldberg 2015). This health insurance includes about 85 percent of the French population, mainly salaried workers, professionally active or retired, and their participants are recruited from 22 social security health screening centers (HSCs) across the country in different regions of France. Using a random sampling strategy stratified according to unequal inclusion probabilities, participants were invited, with a response rate of 7.3% (Goldberg et al. 2017). The stratification according to unequal response probabilities was based on information from a previous survey comparing participation rates in health screenings (Institut de

Veille Sanitaire 2005). The sampling base was defined by all persons aged 18–69 years covered by CNAMTS in the catchment areas of the CONSTANCES HSCs. Baseline data collection included self-administered questionnaires and health examinations. Quality standards were met by trained study nurses and application of Standard Operations Procedures, among others (Ruiz et al. 2016). The study was approved by bodies regulating ethical data collection in France [Comité Consultatif pour le Traitement des Informations Relatives à la Santé (CCTIRS); Commission Nationale Informatique et Liberté (CNIL)], and all participants signed an informed consent.

Study population and inclusion criteria

In this study, we included the subsample of men and women aged 45 to 60 years from the CONSTANCES baseline cohort. Conceptually, the restriction to this age group was justified by the fact that, by the age of 45, most participants worked for a number of years and had an extended time of exposure to the psychosocial working conditions with potential impact on health functioning. The measures of health functioning selected for this analysis were shown to increase by age, with a substantial raise during early old age (Kuh et al. 2014; Mura et al. 2016; Shkuratova et al. 2004; Vineis et al. 2017). Operationally, this restriction was due to the fact that data collection of objective assessments of health functioning was restricted to persons aged 45 and beyond within the protocol of the CONSTANCES study (Goldberg et al. 2017).

The total sample of this age group within CONSTANCES, at the time of current data collection and with available data on the ERI questionnaire, was $n = 34{,}611$. Of these, 27,988 were employed at the time of data collection, and of these, 24,327 men and women had work contracts that did meet the strict participation criteria (excluding self-employed persons and employers). Thus, the sample of the current analysis contained 24,327 employed men ($n = 11{,}611$) and women ($n = 12{,}716$).

Measures

In CONSTANCES, sociodemographic data and extended data on current and past working and employment conditions were collected, complemented by a variety of health measures derived from biomedical screening and from self-report data (Zins and Goldberg 2015). Here, we analyzed psychosocial stress at work, as measured by the short version of the effort-reward imbalance questionnaire, and its association with measures of the three core dimensions of physical, cognitive, and affective health functioning.

Health functioning

Affective functioning was measured by a self-administrated questionnaire with the twenty item Centre for Epidemiologic Studies Depression Scale (CES-D) (Radloff 1977), with a sum score ranging from 0 to 60. We considered sex-specific thresholds for elevated depressive symptoms (women 20, men 16), as validated against clinical diagnoses for the French population (Morin et al. 2011). The use of CES-D as a measure of mental health was justified by the observation that mental health scales of SF-36 and SF-12 essentially reflect depressive mood and were even proposed as a proxy (but less validated) indicator of clinical depression (Vilagut et al. 2013). Physical functioning was measured by three indicators. First, a walking speed test was applied, assessing the time taken to walk a distance of 3 m in normal speed (Graham et al. 2008). Values were calculated in terms of cm/sec in our analyses. Second, a test of standing balance (the so-called “flamingo” test) was applied where participants are asked to raise one leg up to 30 s from a standing position (Lin et al. 2004). The third indicator concerns lung function, where ‘forced expiratory volume’ (FEV) in 1 s is determined by a standard handheld Vitalograph spirometer in a sitting position. The highest value out of three measurements was included (Miller et al. 2005). To assess cognitive functioning, the following two tests were selected from a larger test battery. In the ‘verbal memory’ part of the free and cued selective reminding test (FCSRT) (Grober et al. 1997), participants are asked to memorize a list of 16 words, and thereafter, to recall words based on free and cued recall (repeated three times). Here we restrict the analysis to the free recall score, given its significance in predicting dementia (Grober et al. 2010). In the ‘semantic fluency’ test as many animals as possible have to be named within 60 s (Borkowski et al. 1967). Reference values of these tests for the CONSTANCES population have been published (Mura et al. 2016). These tests were selected based on their wide use in epidemiologic studies and their ability to predict health risks.

Effort–reward imbalance at work

Work stress was measured by the French version of the short Effort–Reward Imbalance (ERI) Questionnaire (Leineweber et al. 2010), answered as part of the baseline CONSTANCES questionnaire. It contains three unidimensional scales. The first two scales assess the model’s extrinsic components, ‘effort’ (three items) and ‘reward’ (seven items), composed by the sub-components ‘job security’ (two items), ‘money and career’ (three items), and ‘esteem’ (two items). The third scale, ‘over-commitment’ (six items), assesses the model’s intrinsic component in terms of a motivational pattern of excessive work-related engagement. As three distinct sub-components of the construct 'reward' have been defined, these three dimensions are assumed to load on a latent factor 'reward', and this assumption is tested by a second-order factor analysis. All items are answered on a Likert scale with four response options ('strongly disagree', 'disagree', 'agree', 'strongly agree'). Items are derived from the original version composed by 23 items (Siegrist et al. 2004), and they should reflect those core aspects of participants' current job experience that are relatively frequent, thus being applicable to a variety of different occupational groups. Sum scores of ratings are calculated for each scale (effort range 3–12; reward range 7–28; over-commitment range 6–24). Taking reverse coding of single items into account higher scores reflect high effort, low reward, and high over-commitment.

In addition to single scales, the construction of a ratio of the two extrinsic scales 'effort' and 'reward' has been proposed by the authors of the questionnaire (Siegrist et al. 2004). This algorithm correcting for unequal number of items is of theoretical interest as it quantifies the imbalance between effort and reward at individual level. According to the theory of affective processing (Ledoux 1989), unfavourable trade-offs between costs and gains in routinized everyday working life often bypass conscious appraisal despite their arousal of stressful negative emotions. An investigator-based algorithm quantifying this mismatch is assumed to represent a proxy measure, capturing a relevant part of negative emotions experienced by participants. We dichotomized the information by defining scores in the upper tertile of the scale 'effort' and 'over-commitment' and scores in the lower tertile of the scale 'reward' as indicating 'high stress', as opposed to the remaining group characterized as 'low stress'. This procedure was also applied to the 'effort–reward ratio', and was based on recent convincing information that distribution-derived scale and ratio scores in the upper tertile or quartile are optimal predictors of health outcomes in cohort studies (e.g., Rugulies et al. 2017).

Sociodemographic data

Besides sex and age, we additionally include occupational position and education. Education was measured by the International Standard Classification of Education (ISCED), recoded into three categories (levels 0–2, levels 3 and 4, and levels 5–8). Occupational position is categorized into five groups by adopting the French national classification of socioeconomic categories (Nomenclature des Professions et Catégories Socioprofessionelles). These groups are (1) "executive, higher intellectual professions", (2) "intermediate professions", (3) "clerk", (4) "manual workers", and (5) "other professions".

Statistical analysis

Following descriptive analyses, we calculated multilevel regression analyses of ERI scales with individuals nested in examination centers. In case of dichotomous indicators of health functioning we estimated Prevalence Ratios based on multilevel Poisson regressions instead of estimating Odds Ratios because they are easier to interpret and because Odds Ratios overestimate Prevalence Ratios, specifically in case of high prevalence (Barros and Hirakata 2003). For continuous health measures we used multilevel linear regressions (Rabe-Hesketh and Skrondal 2008). For the regression analyses, we log-transformed walking speed to decrease skewness and standardized all continuous health measures to improve their comparability. To test our hypothesis of associations of ERI with health functioning three models were calculated. First, unadjusted estimates of prevalence ratios or unstandardized coefficients for the single components of ERI (effort, reward, and over-commitment) and also the effort–reward imbalance were calculated, with 95% confidence intervals and p-values. In a second model, these effects were adjusted for age, age-squared, and occupational position as these variables act as potential confounders. In the final model, based on model 2, the two extrinsic components 'effort', and 'reward' were entered together with the 'effort–reward ratio', and thus all predicting variables were mutually adjusted. This latter model was calculated to analyze whether and to what extent data on the balance/imbalance of effort and reward offer an explanation in addition to the one provided by single components. According to the theoretical model, this is an important aspect.

For the CES-D scale and also for each component of the ERI scale, we replace missing values by the mean of the remaining items, in case information was available on more than three items (in case of the effort component with only three items, we replaced missing values if information was available on at least two items). The proportion of missing data after mean replacements is rather small as indicated in Table 1, and not associated with key variables of our study. We therefore did not apply imputation strategies beyond those described above. The confirmatory factor analysis, finally, is based on the sample of respondents with full information on all ERI items ($n = 21{,}132$).

For the psychometric analysis of the scales of the ERI questionnaire we calculated mean and standard deviation of each item and each scale. Based on item-scale and inter-scale correlations scale reliability was determined (Cronbach's alpha). To test the dimensional structure of the theoretical model, we performed confirmatory factor analysis, where we compared different specifications and used a weighted least square estimator with standard errors derived from a bootstrapping procedure with 2500 iterations (Acock 2013). More specifically we estimated 2 models, a first-order model

Table 1 Sample description: observations (no.) and percentage (col.%) or mean and standard deviation (SD), by sex; $n=24,327$

Categories or range	Men		Women	
	No.	Col.% or mean (SD)	No.	Col.% or mean (SD)
Age				
45–60	11,611	52.1 (4.3)	12,716	52.1 (4.4)
Occupational position [0.5% missing ($n=113$)]				
Higher Prof.	4725	40.9	3445	27.2
Intermediate Prof.	3113	26.9	4241	33.5
Employees	1175	10.2	4322	34.1
Manual workers	2411	20.9	532	4.2
Other positions	130	1.1	120	0.9
Effort [2.3% missing ($n=557$)]				
Low	8495	74.7	8752	70.6
High	2875	25.3	3648	29.4
Reward [2.5% missing ($n=604$)]				
High	7455	65.6	7731	62.6
Low	3915	34.4	4622	37.4
Over-commitment [2.0% missing ($n=488$)]				
Low	8958	78.6	8961	72.0
High	2436	21.4	3484	28.0
Effort–reward imbalance [3.1% missing ($n=754$)]				
No	7963	70.4	7911	64.5
Yes	3354	29.6	4345	35.5
Depressive symptoms				
Not elevated	9251	84.0	9696	81.5
Elevated	1759	16.0	2202	18.5
Standing balance				
Not failed	8377	95.1	8960	92.8
Failed	436	4.9	700	7.2
Walking speed (cm/s)				
26–300	8046	129.9 (26.2)	8851	126.1 (26.8)
Lung function (FEV)				
1.0–6.7	8722	3.7 (0.6)	9372	2.7 (0.5)
Verbal memory				
0–48	8749	32.2 (5.3)	9671	34.8 (4.7)
Semantic fluency				
0–55	8883	24.0 (6.1)	18,639	24.0 (6.0)

with all 16 items loading on effort, reward, and over-commitment, and a second-order model that reflects the theoretical structure of the ERI model more accurately. In this second model, the 'reward' factor is represented by the three sub-components 'esteem', 'job security' and 'job promotion prospects'. We describe the fit improvement from model 1 to model 2 in the text and provide data on the standardized factor loadings and fit indices for model 2 (Fig. 1). In addition to Chi square tests, we assess the following fit indices: the Root Mean Squared Error of Approximation (RMSEA), the Standard Root Mean Squared Residual (SRMR), the Comparative Fit Index (CFI), and the Tucker-Lewis Index (TLI) (Hu and Bentler 1998).

We used Stata 14.2 for the statistical analyses. Ethical approval for this study was obtained from the Institutional Review Board of the National Institute for Medical Research-INSERM (no. 01-011).

Results

A sample description is given in Table 1. There are slightly more women than men in this working population, and age is equally distributed across gender. Concerning occupational position, slightly more men are situated in the upper two categories, but men also are more often manual workers

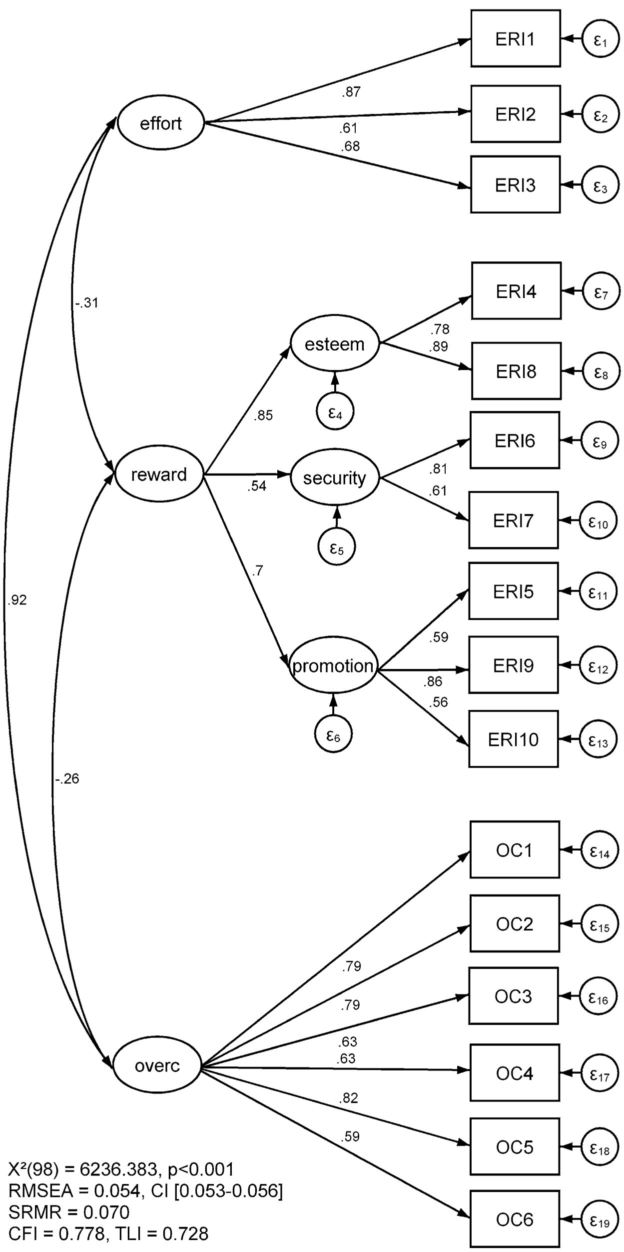

Fig. 1 Confirmatory factor model of the Effort–Reward Imbalance scale, standardized coefficients, $n = 21{,}132$

than women. More women than men are in the category of employees. Work stress is somewhat more pronounced among women, specifically the intrinsic component and the effort–reward ratio. Gender differences in the measures of health functioning hardly exist. However, women score lower than men on standing balance and lung function, but higher on verbal memory.

The findings related to the assessment of main psychometric properties of the scale, are given in Fig. 1 and in Supplementary Table 1. In model 1 (not shown), factor loadings range from 0.42 to 0.86, and fit indices for model 1 suggest a non-satisfactory model fit (RMSEA 0.070, SRMR 0.086, CFI 0.622, TLI 0.550). In model 2, where the theoretical assumption of the ERI model has been incorporated ('reward' defined by the three sub-components 'esteem', 'job security', and 'promotion prospects'), the factor loadings were clearly improved (now ranging from 0.56 to 0.89). The model fit measures also improved, and this second-order model reasonably fits the data, as indicated by satisfactory values of RMSEA (0.054) and SRMR (0.070). However, alternative model fit indices (CFI 0.778, TLI 0.728), while performing better, do not indicate a satisfactory model fit.

Supplementary Table 1 displays the mean, standard deviation, and item-rest correlation coefficients (Nunnally and Bernstein 1994) of the items of the three ERI scales. In addition the prevalence of missing data is given. Item-rest correlations vary between 0.36 and 0.80 and are all above the threshold of 0.30 (Nunnally and Bernstein 1994). For the three scales, overall Cronbach's alpha is given, ranging from 0.78 for effort and 0.76 for reward to 0.83 for over-commitment.

The results on the second research aim of whether components of the ERI model measuring work stress are associated with different domains of health functioning are displayed in Tables 2 and 3. Results are given separately for men (Table 2) and women (Table 3). Among men, affective functioning is strongly and consistently related to work stress. As suggested by the model, the effort–reward ratio is significantly associated with depressive symptoms after adjusting for single scales (model 3) For the indicators of physical health functioning, less consistent findings are obvious, except for lung function where several associations in model 2 are significant. With regard to walking speed there was a tendency that low reward was associated with lower walking speed (model 3), but standing balance was not related to stressful work. The cognitive domain of health functioning is only partially related to work stress. Verbal memory is less pronounced among those with low reward (model 3) and those scoring high on over-commitment (model 2). For over-commitment the same holds true for semantic fluency (model 2), while there is a non-significant association of the ratio with semantic fluency. Among women, affective functioning is related to work stress with similar significance and consistency as observed among men. Overall, the relationship of work stress with physical functioning is weak among women, with the exception of standing balance, where the associations of low reward in model 2 and of the ratio in model 3 are significant. Similarly, cognitive function does not seem to be associated with stressful work among women, with the exception of a significant association of high effort with lower verbal memory (model 3).

Taken together, affective functioning is consistently related to all components of the ERI model, both among men and women. While selective support of an association

Table 2 Association between effort–reward imbalance and health functioning for men: prevalence ratios risks (PR; for depressive symptoms and standing balance) or unstandardized coefficients (b), confidence intervals and *p*-values

	Model 1		*p* value	Model 2		*p* value	Model 3		*p* value
	PR/*b*	CI (95%)		PR/*b*	CI (95%)		PR/*b*	CI (95%)	
Depressive symptoms									
Effort									
Low (Ref.)									
High	1.80	(1.69, 1.91)	< 0.001	1.96	(1.83, 2.09)	< 0.001	1.28	(1.17, 1.40)	< 0.001
Reward									
High (Ref.)									
Low	2.77	(2.52, 3.05)	< 0.001	2.64	(2.41, 2.90)	< 0.001	1.93	(1.73, 2.15)	< 0.001
Over-commitment									
Low (Ref.)									
High	2.59	(2.42, 2.78)	< 0.001	2.84	(2.63, 3.07)	< 0.001			
Effort–reward imbalance									
No (Ref.)									
Yes	2.75	(2.61, 2.90)	< 0.001	2.73	(2.58, 2.88)	< 0.001	1.68	(1.53, 1.84)	< 0.001
Standing balance									
Effort									
Low (Ref.)									
High	1.08	(0.88, 1.32)	0.456	1.28	(1.04, 1.57)	0.020	1.25	(0.95, 1.64)	0.111
Reward									
High (Ref.)									
Low	1.34	(1.13, 1.58)	0.001	1.14	(0.95, 1.37)	0.151	1.10	(0.85, 1.41)	0.473
Over-commitment									
Low (Ref.)									
High	1.12	(0.90, 1.40)	0.313	1.29	(1.02, 1.62)	0.034			
Effort–reward imbalance									
No (Ref.)									
Yes	1.17	(1.02, 1.34)	0.028	1.19	(1.03, 1.38)	0.021	1.00	(0.77, 1.30)	0.999
Walking speed									
Effort									
Low (Ref.)									
High	0.01	(− 0.04, 0.06)	0.662	− 0.03	(− 0.08, 0.01)	0.174	− 0.04	(− 0.10, 0.02)	0.149
Reward									
High (Ref.)									
Low	− 0.09	(− 0.13, − 0.05)	< 0.001	− 0.04	(− 0.09, − 0.00)	0.048	− 0.05	(− 0.11, − 0.00)	0.043
Over-commitment									
Low (Ref.)									
High	0.00	(− 0.04, 0.05)	0.853	− 0.03	(− 0.08, 0.01)	0.173			
Effort–reward imbalance									
No (Ref.)									
Yes	− 0.03	(− 0.07, 0.02)	0.227	− 0.02	(− 0.07, 0.02)	0.313	0.03	(− 0.03, 0.10)	0.351
Lung function									
Effort									
Low (Ref.)									
High	− 0.01	(− 0.05, 0.02)	0.468	− 0.04	(− 0.08, − 0.01)	0.014	− 0.06	(− 0.10, − 0.01)	0.011
Reward									
High (Ref.)									
Low	− 0.09	(− 0.13, − 0.06)	< 0.001	− 0.05	(− 0.08, − 0.02)	0.001	− 0.06	(− 0.10, − 0.02)	0.001
Over-commitment									
Low (Ref.)									

Table 2 (continued)

	Model 1		*p* value	Model 2		*p* value	Model 3		*p* value
	PR/*b*	CI (95%)		PR/*b*	CI (95%)		PR/*b*	CI (95%)	
High	−0.02	(−0.06, 0.02)	0.294	−0.03	(−0.07, 0.00)	0.087			
Effort–reward imbalance									
No (Ref.)									
Yes	−0.05	(−0.09, −0.02)	0.005	−0.03	−0.06, 0.00	0.073	0.04	(−0.01, 0.08)	0.147
Verbal memory									
Effort									
Low (Ref.)									
High	0.07	(0.02, 0.12)	0.005	−0.00	(−0.05, 0.04)	0.874	0.01	(−0.05, 0.07)	0.688
Reward									
High (Ref.)									
Low	−0.16	(−0.21, −0.12)	<0.001	−0.08	(−0.12, −0.03)	0.001	−0.07	(−0.12, −0.02)	0.010
Over-commitment									
Low (Ref.)									
High	−0.01	(−0.06, 0.04)	0.683	−0.08	(−0.13, −0.03)	0.002			
Effort–reward imbalance									
No (Ref.)									
Yes	−0.05	(−0.10, −0.00)	0.032	−0.04	(−0.09, 0.00)	0.051	−0.01	(−0.08, 0.05)	0.696
Semantic fluency									
Effort									
Low (Ref.)									
High	0.08	(0.03, 0.13)	0.001	0.00	(−0.04, 0.05)	0.851	0.04	(−0.02, 0.10)	0.229
Reward									
High (Ref.)									
Low	−0.11	(−0.16, −0.07)	<0.001	−0.02	(−0.06, 0.03)	0.472	0.01	(−0.04, 0.06)	0.740
Over-commitment									
Low (Ref.)									
High	−0.00	(−0.05, 0.05)	0.913	−0.07	(−0.12, −0.02)	0.006			
Effort–reward imbalance									
No (Ref.)									
Yes	−0.04	(−0.09, 0.00)	0.072	−0.03	(−0.08, 0.01)	0.148	−0.06	(−0.13, 0.01)	0.086

Models are based on multilevel regressions (individuals nested in health examination centres). Model 1 is unadjusted, model 2 is adjusted for age, age-squared and occupational position, and model 3 is additionally adjusted for each component of the ERI model (effort, reward, and effort–reward imbalance). In case of lung function model 2 and model 3 are additionally adjusted for height

of physical functioning with stressful work was observed among men, specifically with regard to lung function, associations were largely absent among women. Concerning cognitive functioning, fewer relationships were observed than in the other two domains of health functioning.

Discussion

This study analyzed associations between reports of a stressful psychosocial work environment in terms of the effort–reward imbalance model and indicators of affective, physical, and cognitive health functioning in a large cohort of employees aged 45–60. Main findings demonstrate consistent associations of stressful work with reduced affective functioning, both among men and women. Associations with physical functioning are by far less consistent and almost restricted to men. Importantly, single model components, but not the ratio, were related to reduced lung functioning. Compared to affective and physical functioning, the two indicators of cognitive functioning, verbal memory and semantic fluency, were only marginally associated with stressful work, most clearly in case of over-commitment among men. Taken together, apart from affective functioning, our hypothesis was only weakly supported by the findings, and more so among men. Each one of the single model components contributed to these associations, but after mutually adjusting for all components an additional

Table 3 Association between effort–reward imbalance and health functioning for women: relative risks (PR; for depressive symptoms and standing balance) or unstandardized coefficients (b), confidence intervals and *p*-values

	Model 1		*p* value	Model 2		*p* value	Model 3		*p* value
	PR/*b*	CI (95%)		PR/*b*	CI (95%)		PR/*b*	CI (95%)	
Depressive symptoms									
Effort									
Low (Ref.)									
High	1.66	(1.49, 1.84)	< 0.001	1.77	(1.60, 1.97)	< 0.001	1.27	(1.11, 1.46)	< 0.001
Reward									
High (Ref.)									
Low	2.44	(2.29, 2.59)	< 0.001	2.34	(2.19, 2.51)	< 0.001	1.86	(1.71, 2.03)	< 0.001
Over-commitment									
Low (ref.)									
High	2.24	(2.07, 2.43)	< 0.001	2.49	(2.28, 2.71)	< 0.001			
Effort–reward imbalance									
No (Ref.)									
Yes	2.26	(2.10, 2.43)	< 0.001	2.28	(2.12, 2.45)	< 0.001	1.40	(1.26, 1.56)	< 0.001
Standing balance									
Effort									
Low (Ref.)									
High	0.93	(0.80, 1.10)	0.411	1.03	(0.88, 1.22)	0.683	0.85	(0.69, 1.05)	0.135
Reward									
High (Ref.)									
Low	1.36	(1.24, 1.48)	< 0.001	1.25	(1.13, 1.40)	< 0.001	1.10	(0.96, 1.25)	0.159
Over-commitment									
Low (Ref.)									
High	0.97	(0.84, 1.11)	0.638	1.08	(0.94, 1.24)	0.285			
Effort–reward imbalance									
No (Ref.)									
Yes	1.24	(1.10, 1.39)	< 0.001	1.27	(1.13, 1.43)	< 0.001	1.32	(1.08, 1.60)	0.005
Walking speed									
Effort									
Low (Ref.)									
High	− 0.01	(− 0.05, 0.04)	0.716	− 0.03	(− 0.08, 0.01)	0.151	− 0.05	(− 0.10, 0.01)	0.114
Reward									
High (Ref.)									
Low	− 0.06	(− 0.10, − 0.02)	0.007	− 0.04	(− 0.08, 0.00)	0.065	− 0.05	(− 0.10, 0.00)	0.059
Over-commitment									
Low (Ref.)									
High	− 0.00	(− 0.05, 0.04)	0.904	− 0.03	(− 0.08, 0.01)	0.161			
Effort–reward imbalance									
No (Ref.)									
Yes	− 0.02	(− 0.06, 0.02)	0.399	− 0.02	(− 0.07, 0.02)	0.266	0.03	(− 0.03, 0.10)	0.351
Lung function									
Effort									
Low (Ref.)									
High	− 0.01	(− 0.03, 0.02)	0.539	− 0.01	(− 0.03, 0.01)	0.299	− 0.00	(− 0.03, 0.02)	0.742
Reward									
High (Ref.)									
Low	− 0.01	(− 0.04, 0.01)	0.311	− 0.01	(− 0.03, 0.01)	0.428	− 0.00	(− 0.03, 0.02)	0.778
Over-commitment									
Low (Ref.)									

Table 3 (continued)

	Model 1		p value	Model 2		p value	Model 3		p value
	PR/b	CI (95%)		PR/b	CI (95%)		PR/b	CI (95%)	
High	−0.01	(−0.03, 0.02)	0.573	−0.02	(−0.04, 0.00)	0.099			
Effort–reward imbalance									
No (Ref.)									
Yes	−0.01	(−0.03, 0.02)	0.493	−0.01	(−0.03, 0.01)	0.230	−0.01	(−0.04, 0.02)	0.635
Verbal memory									
Effort									
Low (Ref.)									
High	0.02	(−0.02, 0.06)	0.287	−0.03	(−0.07, 0.01)	0.134	−0.05	(−0.10, −0.00)	0.046
Reward									
High (Ref.)									
Low	−0.06	(−0.10, −0.02)	0.002	−0.01	(−0.05, 0.03)	0.577	−0.03	(−0.07, 0.02)	0.253
Over-commitment									
Low (Ref.)									
High	0.06	(0.02, 0.10)	0.003	−0.00	(−0.04, 0.04)	0.978			
Effort–reward imbalance									
No (Ref.)									
Yes	0.00	(−0.04, 0.04)	0.941	−0.00	(−0.04, 0.03)	0.849	0.04	(−0.02, 0.10)	0.156
Semantic fluency									
Effort									
Low (Ref.)									
High	0.03	(−0.01, 0.08)	0.133	−0.03	(−0.07, 0.01)	0.129	−0.03	(−0.09, 0.02)	0.250
Reward									
High (Ref.)									
Low	−0.08	(−0.12, −0.04)	0.000	−0.02	(−0.06, 0.02)	0.440	−0.01	(−0.06, 0.04)	0.636
Over-commitment									
Low (Ref.)									
High	0.08	(0.03, 0.12)	0.000	−0.00	(−0.04, 0.04)	0.920			
Effort–reward imbalance									
No (Ref.)									
Yes	−0.01	(−0.05, 0.03)	0.556	−0.02	(−0.06, 0.02)	0.256	0.00	(−0.06, 0.06)	0.943

Models are based on multilevel regressions (individuals nested in health examination centres). Model 1 is unadjusted, model 2 is adjusted for age, age squared and occupational position, and model 3 is additionally adjusted for each component of the ERI model (effort, reward and effort–reward imbalance). In case of lung function, models 2 and 3 are additionally adjusted for height

explanatory contribution of the effort–reward ratio was restricted to only three associations.

The observed link of failed reciprocity at work with reduced affective functioning in terms of elevated depressive symptoms corroborates previous findings from a number of mostly prospective studies (Godin et al. 2005; Juvani et al. 2014; Li et al. 2013; Rugulies et al. 2017; Stansfeld et al. 1999; Wege et al. 2018). To our knowledge, one investigation only explored associations of this work stress model with cognitive functioning. In a longitudinal study, changes of cognitive function in terms of perceptual speed and verbal memory over 6 years were analyzed in relation to level of stressful work reported at study onset (Riedel et al. 2017). A combination of high effort and low reward was associated with positive changes of both indicators, and these associations were also observed for the reward component. It is of interest to note that high reward at work was related to an improvement of verbal memory in the longitudinal study, and that our cross-sectional findings demonstrate that low reward at work goes along with lower scores on verbal memory. A study based on the demand control model (Karasek and Theorell 1990) found associations of semantic fluency and psychomotor speed, the latter being measured by the Digit Symbol Substitution Test (DSST), with high strain and passive strain, and low control, respectively (Sabbath et al. 2016). In an additional sensitivity analysis, we used data on DSST in CONSTANCES to analyze the robustness of our findings, and we observed an association with low reward.

The combination of high effort and low reward was significant for men only (results not shown). Concerning physical functioning, several previous publications used the SF-12 measure of physical functioning in relation to the ERI model and, similar to this report, observed weaker associations of physical compared to mental health functioning (Kuper et al. 2002; Li et al. 2017). However, our study is one of the first to assess physical functioning by objective tests, such as lung function, walking speed, and standing balance in relation to psychosocial stress at work. Importantly, an earlier investigation based on CONSTANCES data observed a similar association of work stress in terms of ERI with lung function among men, but not among women (Magnusson Hanson et al. 2017), whereas a further study reported no significant relationship (Loerbroks et al. 2017).

As a relevant aim of this report, we assessed psychometric properties of the short version of the effort–reward imbalance (ERI) questionnaire within the French CONSTANCES cohort study. Results on the internal consistency of the scales and on their factorial validity are in line with those reported in previous studies of working populations in other countries and languages (Kurioka et al. 2014; Leineweber et al. 2010; Li et al. 2012, 2017; Magnavita et al. 2012). We also replicated the finding that the model fit improved when extending the test of a first-order model to a second-order model that reflects the theoretical construct more appropriately. When conducting confirmatory factor analysis, appropriate statistical models were applied in view of the fact that not all scale items were normally distributed. A form of weighted least squares estimator was applied, with standard errors derived from a bootstrapping procedure with 2500 iterations (Acock 2013). The model fit was evaluated by calculating several fit indices, where RMSEA and SRMR, but not CFI revealed satisfactory values. The relatively low level of this latter index calls for further exploration. Taken together, the short French version of the ERI questionnaire meets major criteria of a psychometrically valid instrument to assess distinct extrinsic and intrinsic aspects of self-reported psychosocial stress at work.

Our study has several strengths and limitations. Strengths include, first, a large sample of employed men and women in midlife and early old age from different regions in France, covering a variety of occupational groups. Second, the CONSTANCES study provides a comprehensive assessment of sociodemographic, occupational and biomedical data meeting high quality standards of data collection. Furthermore, it contains a range of subjective, self-report information and of objectively assessed data, and most of these measures had been validated in previous investigations. Third, with its focus on main domains of health functioning, this report extends previous research on associations of psychosocial stress at work with health that was more often concerned with clinical disease outcomes than with measures of health functioning. Studying health functioning instead of clinical disease has the advantage of mirroring the personal experience of people, their assessment of wellbeing and functioning in everyday life including working life. As self-evaluations determine a range of people's behavioral decisions this information is relevant to occupational research and practice. Fourth, with this contribution, we provide the first psychometric validation of the French short version of the ERI questionnaire, and we demonstrate that each one of the single model components contributes towards explaining health functioning. Even more so, when mutually adjusting for all model components, the explanatory power of our summary measure, the effort–reward ratio, continues to contribute in some, but not all analyses. This may indicate that findings based exclusively on the ratio, without adjusting for the effects of single components, may run the risk of being overestimated.

However, our study also reveals a number of limitations. First, as the data are taken from the baseline wave of the CONSTANCES cohort our analyses are restricted to a cross-sectional design. Thus, the direction of observed effects cannot be determined, and we cannot exclude reverse causation in the observed associations. Second, despite its size the study sample does not represent the whole structure of professions and occupations in France as it excludes self-employed persons and farmers. To what extent this may have produced a specific sample bias, e.g., in terms of socioeconomic position or health condition, is not known. Similarly, albeit the participation rate was comparable to similar cohorts (e.g., UK Biobank) higher rates would have been desirable. To analyze the potential selection effect due to voluntary participation, a 'control cohort' of 400,000 non-participants was drawn to compare the sociodemographic and health-related composition between the two groups. According to preliminary results minor selective discordance does not threaten the generalizability of results within the above mentioned restrictions (Goldberg et al. 2017). Moreover, if the study documents a robust association, the potential lack of representativeness of sample characteristics does not invalidate its broad applicability (Rothman et al. 2013). Thus, the low response rate may not affect the reported associations between work stress and health. Third, as we restricted the age range to 45–60 years, we cannot exclude a healthy worker effect, such that healthier employees at younger age have a higher probability of 'surviving' into an older age cohort. Furthermore, observed differences between men and women would require a more intense inquiry, specifically with regard to gender roles. Finally, the range of independent and dependent variables in this study was limited. We focused the analysis on one theoretical model of stressful work, effort–reward imbalance, without presenting additional sensitivity analyses (see Wege et al. (2018)), and we introduced a restricted number of indicators of health functioning, where the study protocol did not allow us to use an equal number of indicators for each dimension of health functioning.

In conclusion, this study demonstrates consistent associations of stressful work in terms of effort–reward imbalance with affective functioning in a large sample of male and female employees. Relationships with physical functioning were less consistent and restricted to men, and cognitive functioning was only marginally associated with stressful work. We also established the psychometric properties of the French short version of the ERI questionnaire, thus offering a tool for guiding and harmonizing further research in this field.

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Compliance with ethical standards

Conflict of interest The authors declare no conflict of interest.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Ethical considerations CONSTANCES has obtained authorization from the French National Data Protection Authority ("Commission nationale de l'informatique et des libertés") and was approved by the National Council for Statistical Information, the National Medical Council, and the Institutional Review Board of the National Institute for Medical Research17 INSERM.

Informed consent Informed consent was obtained from all individual participants included in the study. The analyses were carried out in accordance with the relevant guidelines and regulations.

Data availability The data that support the findings of this study are not publicly available due to legal restrictions, but applications for data access can be submitted in the context of calls for proposals. For more information about how to make use of the CONSTANCES cohort, see http://www.constances.fr/index_EN.php.

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