Int Arch Occup Environ Health
DOI 10.1007/s00420-016-1165-z

ORIGINAL ARTICLE

Do psychosocial job resources buffer the relation between physical work demands and coronary heart disease? A prospective study among men

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Received: 10 December 2015 / Accepted: 24 August 2016

Abstract
Purpose Increasing evidence shows the detrimental impact of high physical work demands for cardiovascular health and mortality. The aim of this study was to investigate the buffering effects of social support at work and job control in the relation between physical work demands and incidence of coronary events.
Methods The study included 14,337 middle-aged men free from coronary heart disease (CHD) at baseline. The sample consisted of a mixed occupational group recruited within 18 organizations from the manufacturing, service, and public sector. Data were collected through standardized questionnaires and clinical examinations. The incidence of clinical coronary events was monitored during a mean follow-up time of 3.15 years. Multilevel Cox proportional hazard regression modeling was used, adjusting for socio-demographic and classical coronary risk factors.
Results Social support at work buffered the impact of physical work demands on CHD risk: Only among workers with low social support at work did physical work demands significantly increase the risk for CHD incidence (fully adjusted HR 2.50: 95 % CI 1.13–5.50), while this harmful effect completely disappeared in case of high level of workplace social support (fully adjusted HR 0.40; 95 % CI 0.09–1.70). No interaction or buffering effect with job control was observed.
Conclusions The results of our study suggest that supportive relationships at work may be a useful resource for reducing the cardiovascular risk associated with physical work demands in men. Future studies are needed to confirm this moderating role of workplace social support and to unravel the underlying mechanisms.

Keywords Occupational health · Physical activity · Psychosocial · Coronary heart disease · Cardiovascular

Introduction

Over the past decade, increasing evidence has shown that high physical work demands are likely to have an adverse impact on workers' cardiovascular health (Krause 2010; Li et al. 2013). Findings from a large number of prospective cohort studies have indicated that strenuous occupational physical activities increase the risk for coronary heart disease (CHD) and mortality in men (Clays et al. 2013; Holtermann et al. 2010, 2012a; Krause et al. 2015; Kristal-Boneh et al. 2000). Evidence in women is generally more sparse and inconsistent, but a recent study showed that high physical activity at work was a risk factor for ischemic heart disease among Danish nurses (Allesøe et al. 2015). Exposure to physically strenuous work is quite prevalent for considerable groups of workers, even in modern service economies (Holtermann et al. 2012b; Krause et al. 2007). Data from the latest European Working Conditions Survey demonstrate that many jobs in Europe still involve manual labor such as carrying heavy loads, and this proportion has

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Published online: 30 August 2016

hardly changed over the last 20 years (Eurofound 2012). Moreover, exposure to posture-related physical risks remains prevalent in all sectors and is observed not only in manual workers but also in services and sales workers (Eurofound 2012). Currently available evidence thus highlights the need for taking preventive measures against premature cardiovascular morbidity and mortality in workers with high physical demands. It is particularly important to elucidate structural preventive measures at the collective workplace level for primary prevention of cardiovascular disease in this group (Krause et al. 2015).

From a theoretical perspective, the psychosocial work environment offers opportunities to counter the harmful effects of physical work demands. Within the research area of psychosocial risk factors at the workplace, the Job-Demand-Control-Support model is still one of the most widely used and influential theoretical frameworks (Johnson and Hall 1988; Karasek and Theorell 1990). The model captures both job content, mainly focusing on psychological demands, alongside job control as a work organizational measure to meet the demands, and social support from supervisors and co-workers as a major contextual factor. Workplace social support and job control are theoretically conceptualized as potential effect modifiers, i.e., buffering factors. The buffer hypothesis of the Job-Demand-Control model postulates that job control may prevent job demands from increasing disease risk, while in the extended Job-Demand-Control-Support model, the dimension of workplace social support may moderate the harmful effect of job strain (Häusser et al. 2010). Applying this to the context of physical demands, job control may provide opportunities to organize manual tasks in a way that provides sufficient recovery or rest breaks and therefore be less physiologically strenuous on the worker. Likewise, support from supervisors and co-workers may provide a context in which the physically demanding tasks are well tailored to the individual worker's physical fitness, which is shown to be of importance for its risk on CHD (Clays et al. 2014; Holtermann et al. 2010; Krause et al. 2015). Otherwise, workplace social support may more directly modify the physiological reactions to physical work demands (Gruenewald and Seeman 2010). However, empirical assessment of the potential buffering effect of job control and social support in the relation between physical work demands and CHD is lacking.

The aim of this study was to investigate the buffering effect of psychosocial job resources in the relation between physical work demands and incidence of coronary events; this was tested within a mixed occupational sample of healthy males from the BELSTRESS cohort. If psychosocial job resources are observed to play an effect modifying role, this would suggest a great potential for interventions aimed at reducing the excessive coronary risk in workers with physically strenuous work demands. We hypothesized that high levels of workplace social support and high levels of job control would lower the impact of physical work demands on CHD risk.

Methods

Study population

We used data from the BELSTRESS cohort study on job stress, cardiovascular and other health issues, and sickness absence (De Bacquer et al. 2005). Baseline data were collected between 1994 and 1998 in a sample of 21,419 respondents (24 % women) from 25 companies or public administrations across Belgium. Workers aged 35–59 years were personally invited to participate in the study, and a participation rate of 48 % was reached. All participants gave their informed consent before inclusion in the study. Data were collected through self-administered questionnaires and bio-clinical examinations. Females were not included in the prospective follow-up given the low number of CHD events expected among middle-aged women. Because of organizational reasons, relating to practical feasibility of the monitoring procedure, follow-up information was not gathered in seven of the smaller companies, resulting in 14,859 male employees included in the prospective follow-up study (De Bacquer et al. 2005). The sample consisted of a mixed occupational group. The participating organizations included nine large industrial plants, five bank and insurance companies, and four public administrations. The ethics committees of the University Hospital of Ghent and the Faculty of Medicine of the Free University of Brussels approved the BELSTRESS study protocol.

Questionnaire data

Participants reported their age, educational level, and job title. Primary school was classified as low education level, secondary school as medium education level (minimum 12 years of education completed), and high school or university as high education level. Occupations were defined according to the International Standard Classification of Occupations (ISCO) and grouped into executive, white-collar and blue-collar (ILO 1990). Participants were asked about their smoking status and alcohol consumption. Current smokers were defined as those who regularly (i.e., on a daily basis) smoke cigarettes, cigars, or pipes. The average total number of alcohol units per week was calculated. People were classified as having diabetes if they had answered positively to the question whether a physician had ever told them that they had diabetes. Participants were asked to indicate their usual level of leisure time physical activity

on a set of four response possibilities and were classified into moderate to high (engage in heavy physical activity during 20 min or more, at least once a week) or low (no or only light activity during most weeks) levels (Clays et al. 2013). The strength of the social network in private life was derived from three items regarding the number and nature of contacts with friends and family (Berkman and Syme 1979; Eng et al. 2002). A high or strong social network was defined as having regular contacts (at least once a month) with at least five close friends or family members.

Physical work demands were measured with a scale including five items from the Job Content Questionnaire (Karasek et al. 1998). The scale is composed of three items assessing physical exertion (i.e., high physical effort, lifting heavy loads, and rapid physical activity) and two items assessing isometric loads (i.e., awkward body positions and awkward positions of head or arms) and has been shown an internationally validated tool (Karasek et al. 1998). The items were scored on a four-point Likert scale from 'fully disagree' to 'fully agree'. A summary scale of physical work demands was composed of the sum score of the five items and ranged from 5 to 20. This variable was skewed to the right and therefore categorized. A minimum score of 13 was classified as high level of physical work demands, generally corresponding to an exposure to three up to five of the individual items (Clays et al. 2012, 2013). Psychosocial job resources were also assessed by means of the Job Content Questionnaire (Karasek et al. 1998), in line with the Job-Demand-Control-Support (JDCS) model (Johnson and Hall 1988; Karasek and Theorell 1990). All items were scored on a four-point Likert scale from 'fully disagree' to 'fully agree'. Job control or decision latitude was composed of the sum score (range 9–36) of two subscales: skill discretion or the level of skill and creativity required on the job (six items) and decision authority or the possibilities for workers to make decisions about their work (three items). The dimension of social support at the workplace also consisted of the sum score (range 8–32) of two subscales: supervisor support (four items) and co-worker support (four items). The Job Content Questionnaire has been shown a valid and reliable tool to measure psychosocial job stressors within the BELSTRESS cohort (Pelfrene et al. 2001). Dichotomous variables (low vs high) were created for job control and social support at work based on the median-split procedure.

Clinical examination

The clinical examination was done by centrally trained paramedics from either the occupational health service or the research center, following a standardized manual of operations. The examination took place in the medical office at the workplace during working hours. Blood pressure was calculated as the average of two successive readings with a 5-min interval obtained by sphygmomanometry in a sitting position. A non-fasting blood sample was taken and shipped to a central laboratory for determination of serum total and high-density lipoprotein (HDL) cholesterol. Body mass index (BMI) was calculated as body weight (in kg) divided by the square of the height (in m). In line with international standards defined by the World Health Organization, overweight was defined as a BMI of 25 or higher; those with a BMI of 30 or higher were classified as obese.

Follow-up of coronary heart disease

The male population was followed up until December 31, 1999 for clinical manifest coronary events, defined as the occurrence of an acute myocardial infarction, unstable angina, and hospitalization for coronary artery bypass grafting or percutaneous transluminal coronary angioplasty (De Bacquer et al. 2005). The mean follow-up time was 3.15 years, with a total of 45,210 person-years of observation. The incidence of CHD was carefully monitored in collaboration with the occupational health service according to a standardized procedure; details have been described previously (De Bacquer et al. 2005). At the analysis stage, 522 men with existing CHD at baseline were excluded, resulting in a cohort of 14,337 men free of CHD at the start with complete follow-up information.

Statistical analysis

Descriptive statistics were obtained through proportions and mean (plus standard deviation) or median (plus interquartile range) values. We compared crude cumulative incidence of coronary events between risk groups using Chi-squared test or Fisher's exact tests. Multilevel Cox proportional hazard regression modeling was used to assess the relation of physical work demands and psychosocial job resources with CHD in a predictive model for time-to-event data, while accounting for the clustering of participants within 18 organizations. Parameter estimation was conducted by the maximum likelihood method; Exp(B) with the corresponding 95 % confidence interval was produced as the estimated hazard ratio. A visual inspection of the log minus log plots was performed in order to check whether the proportional hazards assumption was met (Petrie and Sabin 2009). The analyses were adjusted for a number of well-established risk factors for CHD that were available in the data, in order to assess the independency of the main relations from classical cardiovascular risk factors (Perk et al. 2012). Age-adjusted hazard ratios were generated in the first model, while additional adjustment was performed for educational level and occupational class in the second model, and for body mass index, smoking,

alcohol consumption, leisure time physical activity, diabetes, systolic blood pressure, and total cholesterol in the final model. In a supplementary analysis, further adjustment for social network in private life was included as a control measure of psychosocial resources outside work. The interaction effect between physical work demands and both psychosocial job resource measures in relation to CHD was tested in consecutive Cox proportional hazard regression models, while entering the interaction term along with the main effects in the analysis. In case a statistically significant interaction effect was observed, additional analyses were conducted showing stratified results and results for combined exposure.

A P value at <0.05 level was considered statistically significant. All analyses were conducted in IBM SPSS Statistics version 2, except for the multilevel Cox regression models which were run in SAS version 5.1.

Results

Table 1 shows baseline socio-demographic factors, cardiovascular risk factors, as well as physical work demands and psychosocial resources at work and in private life, within the cohort of 14,337 middle-aged men free from existing CHD. Almost 44 % of the sample had a low educational level; the majority of participants were white-collar (43 %) or blue-collar (39 %) workers. In general, the coronary risk profile of the sample was in line with expectation for a male Belgian working population of that age range in the nineties, with 30 % current smokers, 3 % individuals with diabetes, and 14 % being obese (De Bacquer et al. 2005). High physical work demands were present in 15 % of the male workers.

Within this cohort, 87 new coronary events, including 20 fatal attacks, were registered during a mean follow-up of 3.15 years. These events included 44 cases of acute myocardial infarction, 28 cases of unstable angina, 9 cases of percutaneous transluminal coronary angioplasty, and 6 coronary artery bypass grafting surgical procedures.

Table 2 displays the main effects of physical work demands and psychosocial job resources on the incidence of CHD, as well as their interaction effects. We observed a significant interaction effect between physical work demands and social support at work in relation to CHD incidence in the model including age and both main effects as covariates. This interaction effect turned marginally significant after adding further adjustments in model 2 ($P = 0.08$) and model 3 ($P = 0.05$).

In the stratified analyses (presented in Table 3), social support at work buffered the impact of physical work demands on CHD risk: Only among workers with low social support at work did physical work demands significantly increase the risk for CHD incidence (fully adjusted HR 2.50: 95 % CI 1.13–5.50), while this harmful effect completely disappeared in case of high level of workplace social support (fully adjusted HR 0.40; 95 % CI 0.09–1.70). In the analysis based on four separate groups of combined exposure, men who combined high physical work demands with low levels of workplace social support

Table 1 Description of baseline socio-demographic factors, cardiovascular risk factors, physical and psychosocial risk factors at work, in 14,337 men from the BELSTRESS cohort study

Characteristics	% (*N*) or mean (SD)
Age in years: mean (SD)	45.9 (6.0)
Educational level: % (*N*)	
Low	43.5 (6188)
Medium	28.8 (4098)
High	27.7 (3950)
Occupational class: % (*N*)	
Executive	17.8 (2486)
White-collar	42.9 (5988)
Blue-collar	39.2 (5471)
Social network in private life: % (*N*)	
Low	55.4 (7808)
High	44.6 (6294)
Body mass index (kg/m^2): mean (SD)	26.4 (3.6)
Weight group: % (*N*)	
Normal weight (BMI < 25 kg/m^2)	36.6 (5241)
Overweight (25 kg/m^2 ≤ BMI < 30 kg/m^2)	49.5 (7081)
Obesity (BMI ≥ 30 kg/m^2)	13.9 (1992)
Current smoker: % (*N*)	29.5 (4192)
Weekly alcohol consumption in units: median (IQR)	10 (3–21)
Leisure time physical activity: % (*N*)	
Low	60.8 (8447)
Moderate to high	39.2 (5450)
Diabetes: % (*N*)	2.8 (392)
Systolic blood pressure (mmHg): mean (SD)	132.9 (15.3)
Diastolic blood pressure (mmHg): mean (SD)	84.5 (10.2)
Total cholesterol (mg/dl): mean (SD)	225.4 (39.8)
HDL cholesterol (mg/dl): mean (SD)	49.0 (13.3)
Physical work demands: % (*N*)	
Low	85.4 (12,035)
High	14.6 (2052)
Job control: % (*N*)	
Low	44.5 (6320)
High	55.5 (7887)
Social support at work: %(*N*)	
Low	40.7 (5608)
High	59.3 (8177)

SD standard deviation, *IQR* inter-quartile range, *BMI* body mass index

Table 2 Crude and adjusted relations of physical work demands and psychosocial job resources—and of their interaction effects—with coronary heart disease, results from multilevel Cox proportional hazards regression analyses in 14,337 men from the BELSTRESS cohort study

	Crude results			Adjusted results: model 1[a]		Adjusted results: model 2[b]		Adjusted results: model 3[c]	
	% Events	No of events (total no of subjects)	P (χ^2)	HR	95 % CI	HR	95 % CI	HR	95 % CI
Physical work demands			<0.05						
Low	0.5	66 (12,035)		1		1		1	
High	0.9	19 (2052)		1.68	1.00–2.83	1.61	0.90–2.86	1.41	0.75–2.64
Job control			0.88						
High	0.6	49 (7887)		1		1		1	
Low	0.6	38 (6320)		0.96	0.62–1.47	0.86	0.54–1.36	0.79	0.48–1.29
Social support at work			<0.05						
High	0.5	39 (8177)		1		1		1	
Low	0.8	44 (5608)		**1.76**	1.14–2.71	**1.68**	1.07–2.63	**1.94**	1.20–3.16
Interaction effect between physical work demands and job control[d]	–	–	–	0.68	0.24–1.91	0.73	0.25–2.18	0.65	0.20–2.16
Interaction effect between physical work demands and social support at work[d]	–	–	–	**3.63**	1.08–12.22	3.05	0.89–10.50	4.84	0.98–23.86

HR hazard ratio, *CI* confidence interval, significant associations at the 0.05 level are in bold

[a] Adjusted for age

[b] Adjusted for age, educational level, and occupational class

[c] Adjusted for age, educational level, occupational class, body mass index, smoking, alcohol consumption, leisure time physical activity, diabetes, systolic blood pressure, and total cholesterol

[d] Interaction analysis was also adjusted for both main effects

showed an almost three times significantly higher incidence rate compared to the group with low physical demands and high support (fully adjusted HR 3.20; 95 % CI 1.56–6.55).

Results from additional analyses showed significant interaction effects between physical work demands and both the sub-dimensions of support by co-workers (fully adjusted HR for the interaction term 3.68; 95 % CI 1.06–12.76) as well as support by supervisors (fully adjusted HR for the interaction term 5.69; 95 % CI 1.16–27.99). Results for the stratified and combined exposure analyses showed very similar patterns as for the primary analyses, with a significant buffering effect of co-worker/supervisor support on the relation between physical work demands and risk for coronary events, and the combined exposure group with high levels of physical work demands and low levels of co-worker/supervisor support having the highest CHD incidence rates (results not shown).

When considering the separate sub-dimensions of the job control scale, i.e., skill discretion and decision authority, no significant interaction effects with physical work demands were observed (results not shown).

Supplementary analyses were performed taking a measure of psychosocial resources outside work into account. Social network in private life was not related to increased risk for coronary events, nor did additional adjustment for this factor change any of the findings (results not shown).

Discussion

This study investigated whether psychosocial job resources buffer the relation between physical work demands and CHD in men. Social support at work showed a strong buffering effect in the sample of 14,337 healthy males from the BELSTRESS cohort on CHD incidence. High physical work demands significantly increased the risk for CHD incidence among workers with low social support at work, but not among workers with high social support at work.

Table 3 Crude and adjusted relations of physical work demands with coronary heart disease stratified by social support at work, and of combined exposure to physical work demands and social support at work, results from multilevel Cox proportional hazards regression analyses in 14,337 men from the BELSTRESS cohort study

	Crude results			Adjusted results: model 1[a]		Adjusted results: model 2[b]		Adjusted results: model 3[c]	
	% Events	No of events (total no of subjects)	P (χ^2)	HR	95 % CI	HR	95 % CI	HR	95 % CI
Stratified analysis: low SSW									
Physical work demands			<0.01						
Low	0.6	27 (4575)		1		1		1	
High	1.6	15 (944)		**2.86**	1.50–5.46	**2.73**	1.29–5.78	**2.50**	1.13–5.50
Stratified analysis: high SSW									
Physical work demands			0.81						
Low	0.5	35 (7021)		1		1		1	
High	0.4	4 (1028)		0.78	0.27–2.20	0.72	0.25–2.08	0.40	0.09–1.70
Combined groups			<0.001						
Low PWD and high SSW	0.5	35 (7021)		1		1		1	
High PWD and high SSW	0.4	4 (1028)		0.76	0.27–2.15	0.81	0.28–2.33	0.47	0.11–1.99
Low PWD and low SSW	0.6	27 (4575)		1.26	0.76–2.09	1.25	0.74–2.09	1.42	0.82–2.46
High PWD and low SSW	1.6	15 (944)		**3.45**	1.86–6.41	**3.08**	**1.56–6.06**	**3.20**	1.56–6.55

HR hazard ratio, *CI* confidence interval, *PWD* physical work demands, *SSW* social support at work, significant associations at the 0.05 level are in bold

[a] Adjusted for age

[b] Adjusted for age, educational level, and occupational class

[c] Adjusted for age, educational level, occupational class, body mass index, smoking, alcohol consumption, leisure time physical activity, diabetes, systolic blood pressure, and total cholesterol

Highly similar results were observed for the sub-dimensions of support from supervisors and co-workers.

Increasing evidence demonstrates the harmful impact of high physical work demands on cardiovascular disease and mortality risk in men and women (Clays et al. 2012, 2013; Holtermann et al. 2010, 2012a; Kristal-Boneh et al. 2000; Li et al. 2013; Allesøe et al. 2015), so investigation of primary preventive measures among workers with physically strenuous jobs is needed (Krause 2010; Krause et al. 2015). To the best of our knowledge, this is the first study showing social support at work as a considerable effect modifier in the association between physical work demands and CHD. Men exposed to high demands had a more than doubled risk for CHD incidence when they reported low levels of workplace social support, but no harmful effect whatsoever was observed in the group with high support. When looking at combined exposure, in the fully adjusted model, workers combining high physical demands with low social support at work had the highest CHD event rate and their risk was more than three times higher compared to men not exposed to any of both risk factors. In light of the rapidly growing—but still somewhat controversial—literature about the health risk of occupational physical activities, these findings suggest that the role of psychosocial work factors should be taken into account, which is mostly lacking in the available evidence so far (Krause 2010; Krause et al. 2015).

In behavioral medicine, it has been widely established for decades that social integration is positively associated with better health (Gruenewald and Seeman 2010). The relation of poor levels of overall social support with the onset and progression of CHD has been confirmed in a number of prospective cohort studies (Kuper et al. 2002). Social support in general may produce both direct and buffering effects on health, both of which have been empirically supported (Gruenewald and Seeman 2010). The

Job-Demands-Resources model is a theoretical framework particularly relevant for the present findings. The model focuses on the ability of job resources—including the presence of a supportive working environment—to reduce the physiological and psychological costs that are associated with one's job demands, with job demands here referring to the physically, mentally, or emotionally demanding aspects of the job (Bakker and Demerouti 2007). There is some empirical evidence in favor of the buffer hypothesis demonstrating that social support at work attenuates the impact of physical demands on burnout or exhaustion (Bakker et al. 2005). To our knowledge, no studies have tested this in relation to CHD.

Mechanisms underlying the relation between overall social support and health may be psychological, behavioral, or biological, all of which may help explain the present findings (Gruenewald and Seeman 2010). Supportive relationships with supervisors and co-workers may impact mental states and perceptions of workers and as such alleviate the influence of physical demands. Instrumental or emotional support can for instance help putting the physically strenuous work tasks in another perspective, or a supportive working environment might help the worker to cope with the physical demands, through facilitating performance and achievement of work goals, or by encouraging to use effective behavioral strategies (Bakker and Demerouti 2007). Greater workplace support may also induce a biological mechanism and as such be related to more positive patterns of physiological functioning, i.e., it may lower the cardiovascular reactivity in response to physical work load (Gruenewald and Seeman 2010).

Job control or its sub-dimensions did not buffer the effect of physical work demands on CHD in this cohort, suggesting that resources like skill utilization or job autonomy may not be effective in preventing the cardiovascular overload initiated by physically strenuous work tasks. Within job strain research, there is generally more support for the dimension of job control compared with the dimension of job demands in explaining excess risk for ischemic heart disease (Pejtersen et al. 2015). However, studies particularly investigating the moderating hypothesis from the Job-Demand-control model in relation to mental well-being overall find weak evidence for job control to actually attenuate the negative impact of psychological job demands (Häusser et al. 2010; Ibrahim and Ohtsuka 2012).

Strengths and limitations

The major strength of this study is the use of an objective clinical outcome of CHD within a prospective cohort design. Standardized and validated measures were used to operationalize exposure variables. In addition, thorough control of confounding was conducted by taking major risk factors for coronary events into account. Moreover, additional subgroup analyses (results not shown) revealed similar patterns of the interplay between physical work demands and workplace social support in relation to CHD incidence in white-collar versus blue-collar workers, which suggests independency of the findings from occupational status. A number of clinical and behavioral cardiovascular risk factors were accounted for in the fully adjusted regression models. This could induce overadjustment—leading to underestimation of findings—since these factors may also be intermediate variables partly explaining the relation between physical work demands and CHD. An important limitation of this study relates to the assessment of physical work demands, which was based on self-reports and did not include objective monitoring data. Only a single measurement of exposure variables was available, which also increases the risk of misclassification. Due to the short follow-up time, only a relatively small number of events could be modeled in the analyses. Although thorough adjustments were made for personal, socioeconomic, and classical coronary risk factors, the observed findings may still be influenced by residual confounding. Workers with high physical job demands could have a different understanding of what psychosocial job resources represent. Finally, the findings presented here have limited generalizability since no women were included in the study. Men and women are differently exposed to physical and psychosocial risk factors at work. Moreover, it was shown that, particularly in women, high physical workload tends to cluster with adverse psychosocial work conditions (Karlqvuist et al. 2003). Future research should thus examine whether the psychosocial work environment may impact the cardiovascular risk associated with high physical demands in women.

Implications and conclusions

Physically demanding tasks are still—and will remain to be—an important reality for a large number of people in paid employment. Physical demands in modern work life not only remain high, they relate to an excess of recommended metabolic levels at work, both for women and men (Karlqvuist et al. 2003). From a public health perspective, primary prevention strategies need to be developed that enable workers with high physical demands to perform their jobs in a safe way—i.e., avoiding cardiovascular overload—and to perform them at advanced ages. The results of this study suggest that supportive relationships at work may be a useful resource for reducing the cardiovascular risk associated with physical demands in men. Intervention research should further investigate whether investing in workplace social support is a promising approach to prevent cardiovascular overload and disease among

these workers. Also, field studies using ambulatory measurements to examine cardiovascular reactivity to physical work demands in different social settings are recommended. Although this study showed a clear documentation of the buffering role of workplace social support, we are not aware of other studies reporting similar findings, so more research is needed before drawing firm conclusions.

In conclusion, in a group of 14,337 healthy male workers from the BELSTRESS cohort, we investigated the buffering effects of psychosocial job resources in the relation between physical work demands and short-term incidence of coronary events. Social support at work and also the subdimensions of co-worker and supervisor support, but not job control, were observed to moderate the impact of physically demanding work on CHD. Physical work demands imposed only a significant risk for CHD incidence among workers with low level of social support at work, while this harmful effect was not observed among those with high workplace social support. Future studies are needed to confirm this moderating role of workplace social support and to unravel the underlying mechanisms.

Acknowledgments BELSTRESS was supported by grants from the Federal Office for Scientific, Technical, and Cultural Affairs (ST/02/007), and the Research Foundation—Flanders (FWO).

Compliance with ethical standards

Conflict of interest The authors declare that they have 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.

Informed consent Informed consent was obtained from all individual participants included in the study.

References

Allesøe K, Holtermann A, Aadahl M, Thomsen JF, Hundrup YA, Søgaard K (2015) High occupational physical activity and risk of ischaemic heart disease in women: the interplay with physical activity during leisure time. Eur J Prev Cardiol 22(12):1601–1608

Bakker AB, Demerouti E (2007) The job demands-resources model: state of the art. J Manag Psychol 22(3):309–328

Bakker AB, Demerouti E, Euwema MC (2005) Job resources buffer the impact of job demands on burnout. J Occup Health Psychol 10(2):170–180

Berkman LF, Syme SL (1979) Social networks, host-resistance, and mortality - 9-year follow-up-study of Alameda County residents. Am J Epidemiol 109(2):186–204

Clays E, De Bacquer D, Van Herck K, De Backer G, Kittel F, Holtermann A (2012) Occupational and leisure time physical activity in contrasting relation to ambulatory blood pressure. BMC Public Health 12:1002

Clays E, De Bacquer D, Janssens H, De Clercq B, Casini A, Braeckman L, Kittel F, De Backer G, Holtermann A (2013) The association between leisure time physical activity and coronary heart disease among men with different physical work demands: a prospective cohort study. Eur J Epidemiol 28(3):241–247

Clays E, Lidegaard M, De Bacquer D, Van Herck K, De Backer G, Kittel F, de Smet P, Holtermann A (2014) The combined relationship of occupational and leisure-time physical activity with all-cause mortality among men, accounting for physical fitness. Am J Epidemiol 179(5):559–566

De Bacquer D, Pelfrene E, Clays E, Mak R, Moreau M, de Smet P, Kornitzer M, De Backer G (2005) Perceived job stress and incidence of coronary events: three year follow-up of the BELSTRESS cohort. Am J Epidemiol 161(5):434–441

Eng PM, Rimm EB, Fitzmaurice G, Kawachi I (2002) Social ties and change in social ties in relation to subsequent total and cause-specific mortality and coronary heart disease incidence in men. Am J Epidemiol 155(8):700–709

Eurofound (2012) Fifth European Working Conditions Survey. Publications Office of the European Union, Luxembourg

Gruenewald TL, Seeman TE (2010) Social support and physical health: links and mechanisms. In: Steptoe A (ed) Handbook of behavioral medicine. Springer, New York

Häusser JA, Mojzisch A, Niesel M, Schulz-Hardt S (2010) Ten years on: a review of recent research on the Job Demand-Control(-Support) model and psychological well-being. Work Stress 24(1):1–35

Holtermann A, Mortensen OS, Burr H, Sogaard K, Gyntelberg F, Suadicani P (2010) Physical demands at work, physical fitness, and 30-year ischaemic heart disease and all-cause mortality in the Copenhagen Male Study. Scand J Work Environ Health 36(5):357–365

Holtermann A, Burr H, Hansen JV, Krause N, Sogaard K, Mortensen OS (2012a) Occupational physical activity and mortality among Danish workers. Int Arch Occup Environ Health 85(3):305–310

Holtermann A, Hansen JV, Burr H, Sogaard K, Sjogaard G (2012b) The health paradox of occupational and leisure-time physical activity. Br J Sports Med 46(4):291–295

Ibrahim RZAR, Ohtsuka K (2012) Review of the job demand-control and job demand-control-support models: elusive moderating predictor effects and cultural implications. Southeast Asia Psychol J 1:10–21

ILO (1990) International standard classification of occupations: ISCO-88. International Labour Office, Geneva

Johnson JV, Hall EM (1988) Job strain, work place social support, and cardiovascular-disease—a cross-sectional study of a random sample of the Swedish working population. Am J Public Health 78(10):1336–1342

Karasek R, Theorell T (1990) Healthy work. Stress, productivity, and the reconstruction of working life. Basic Books, New York

Karasek R, Brisson C, Kawakami N, Houtman I, Bongers P, Amick B (1998) The Job Content Questionnaire (JCQ): an instrument for internationally comparative assessments of psychosocial job characteristics. J Occup Health Psychol 3(4):322–355

Karlqvuist LK, Härenstam A, Leijon O, Schéele P, MOA Research Group (2003) Excessive physical demands in modern worklife and characteristics of work and living conditions of persons at risk. Scand J Work Environ Health 29(5):363–377

Krause N (2010) Physical activity and cardiovascular mortality-disentangling the roles of work, fitness, and leisure. Scand J Work Environ Health 36(5):349–355

Krause N, Brand RJ, Kaplan GA, Kauhanen J, Malla S, Tuomainen TP, Salonen JT (2007) Occupational physical activity, energy expenditure and 11-year progression of carotid atherosclerosis. Scand J Work Environ Health 33(6):405–424

Krause N, Brand RJ, Arah OA, Kauhanen J (2015) Occupational physical activity and 20-year incidence of acute myocardial infarction: results from the Kuopio Ischemic Heart Disease Risk Factor Study. Scand J Work Environ Health 41(2):124–139

Kristal-Boneh E, Harari G, Melamed S, Froom P (2000) Association of physical activity at work with mortality in Israeli industrial employees: the CORDIS study. J Occup Environ Med 42(2):127–135

Kuper H, Marmot M, Hemingway H (2002) Systematic review of prospective cohort studies of psychosocial factors in the etiology and prognosis of coronary heart disease. Semin Vasc Med 2(3):267–314

Li J, Loerbroks A, Angerer P (2013) Physical activity and risk of cardiovascular disease: what does the new epidemiological evidence show? Curr Opin Cardiol 28(5):575–583

Pejtersen JH, Burr H, Hannerz H, Fishta A, Hurwitz EN (2015) Update on work-related psychosocial factors and the development of ischemic heart disease: a systematic review. Cardiol Rev 23(2):94–98

Pelfrene E, Vlerick P, Mak R, de Smet P, De Backer G, Kornitzer M (2001) Scale reliability and validity of the Karasek 'job demand-control-support' model in the Belstress-study. Work Stress 15:297–313

Perk J, De Backer G, Gohlke H, Graham I, Reiner Z, Verschuren M, Albus C, Benlian P, Boysen G, Cifkova R, Deaton C, Ebrahim S, Fisher M, Germano G, Hobbs R, Hoes A, Karadeniz S, Mezzani A, Prescott E, Ryden L, Scherer M, Syvänne M, Scholte op Reimer WJ, Vrints C, Wood D, Zamorano JL, Zannad F, European Association for Cardiovascular Prevention & Rehabilitation (EACPR), ESC Committee for Practice Guidelines (CPG) (2012) European Guidelines on cardiovascular disease prevention in clinical practice (version 2012). The Fifth Joint Task Force of the European Society of Cardiology and Other Societies on Cardiovascular Disease Prevention in Clinical Practice (constituted by representatives of nine societies and by invited experts). Eur Heart J 33(13):1635–1701

Petrie A, Sabin C (2009) Medical statistics at a glance. Wiley, Oxford