Review

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Adverse effects of psychosocial work factors on blood pressure: systematic review of studies on demand–control–support and effort–reward imbalance models

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Objectives A growing body of research has investigated the adverse effects of psychosocial work factors on blood pressure (BP) elevation. There is now a clear need for an up-to-date, critical synthesis of reliable findings on this topic. This systematic review aimed to evaluate the adverse effects of psychosocial work factors of both the demand–control–support (DCS) and effort–reward imbalance (ERI) models on BP among men and women, according to the methodological quality of the studies.

Methods To be eligible, studies had to: (i) evaluate at least one psychosocial work factor, (ii) evaluate BP or hypertension, (iii) comprise ≥100 workers, (iv) be written in English or French, and (v) be published in a peer-reviewed journal.

Result A total of 74 studies were included. Of these, 64 examined the DCS model, and 12 looked at the ERI model, with 2 studies considering both models. Approximately half the studies observed a significant adverse effect of psychosocial work factors on BP. A more consistent effect was observed, however, among men than women. For job strain, a more consistent effect was also observed in studies of higher methodological quality, ie, studies using a prospective design and ambulatory BP measures.

Conclusions A more consistent adverse effect of psychosocial work factors was observed among men than women and in studies of higher methodological quality. These findings contribute to the current effort of primary prevention of cardiovascular disease by documenting the psychosocial etiology of elevated BP, a major cardiovascular risk factor.

Key terms cardiovascular risk factor; hypertension; job control; Karasek; overcommitment; psychological demand; Siegrist; workplace stressor.

Cardiovascular diseases (CVD) are the leading cause of death worldwide (1). In Canada, these diseases account for one third of male and female deaths (2) and are the most costly group of health problems in terms of hospitalization (3). High blood pressure (BP) is a major risk factor for CVD (4). Indeed, it accounts for an estimated 54% of all strokes and 47% of all ischemic heart disease events globally (5). Among adults, almost one American in five (6) and one Canadian in five (7) has high BP. The risk of cardiovascular mortality grows linearly with BP from 115/75 mm Hg among adults aged 40–69 years-old with no CVD. At the population level, even a mean systolic BP that was 2 mm Hg lower would lead to a reduction in middle-age mortality from coronary heart disease and stroke of approximately 7% and 10%, respectively (8, 9). Over recent decades, a growing number of studies have investigated the adverse effects of psychosocial factors, including those of the workplace (ie, work stress), on BP elevation.

Two well-defined and internationally recognized theo-

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retical models have been used to assess the adverse effects of psychosocial work factors on BP: the demand–control–support (DCS) (10) and the effort–reward-imbalance (ERI) (11) models. The DCS model suggests that workers simultaneously experiencing high psychological demands and low job control are more likely to develop stress-related health problems (10). Psychological demands mainly refer to an excessive workload, very hard or overly fast work, and conflicting demands. Job control is a combination of skill discretion (eg, learning new things, opportunities to develop skills, creativity, a variety of activities, non-repetitive work) and decision authority (eg, taking part in decisions affecting oneself, making one's own decisions, having a say on the job, and freedom as to how the work is accomplished) (10). Johnson et al (12) introduced poor social support as a third component of the demand–control model. This component refers to a lack of help and cooperation from supervisors and coworkers. The ERI model proposes that extrinsic efforts (eg, pressure to work overtime, increasingly demanding work, constant time pressure, repeated interruptions) should be rewarded in various ways, namely: financially (income), socially (respect, esteem), and organizationally (job security, promotion prospects) (11). Workers are in a state of detrimental imbalance when high extrinsic efforts are accompanied by low reward and thus more susceptible to health problems. A third component, overcommitment, is a personal coping style that presents as being unable to withdraw from work obligations, being impatient and irritable, and having a high need for approval (13). Overcommitment may act either directly or as a modifier (ie, amplifier) of the ERI effect (13).

Two main biological pathways have been suggested to explain how psychosocial work factors contribute to BP elevation. Firstly, CVD results from a chain of events linking risk factors to cardiovascular events, which is summarized in Dzau's CVD "continuum" (14, 15). First, asymptomatic damage occurs from interactions between genetic and environmental risk factors (14, 15). This damage then amplifies over time to trigger cardiovascular events. For example, BP elevation could successively lead to hypertension, arterial stiffness, and stroke or ischemic heart disease. Several epidemiological studies have demonstrated that psychosocial stressors might contribute to the incidence of CVD. Even though possible mechanisms are not clearly defined (16), based on experimental studies, one can reasonably assume that the deleterious effects of psychosocial stressors arise from the cumulative impact of multiple and prolonged exposures. These studies have provided evidence that the sympathetic nervous system, a primary mediator of the stress response, is one of the major pathways activating the renin-angiotensin system (17, 18). Stress can therefore stimulate the secretion of renin and increase plasma levels of angiotensin II, which has a significant effect on blood vessel walls. Indeed, angiotensin II plays a crucial role in the development of CVD by causing vasoconstriction, endothelial dysfunction, cellular proliferation, and inflammation that promotes atherosclerosis (19–22). In conjunction with sympathetic activation and hypothalamo-pituitary-adrenal axis stimulation, activation of the renin–angiotensin system can lead to hypertension and cardiovascular events (17, 18). Secondly, psychosocial work factors could act more indirectly on BP through known risk factors or risk behaviors (eg, obesity, smoking, lack of physical exercise, or excessive alcohol consumption) (22–25).

Six systematic reviews have been conducted to investigate the adverse effect of psychosocial work factors on CVD (26–30, 31). These reviews concluded that these psychosocial factors play an important role in the etiology of CVD. Five reviews also reported that adverse effects were more consistently observed among men than women (26–30). A possible explanation for these gender differences is the fact that on average, CVD occur ten years later among women (32). Therefore, work-related CVD might occur at the end of or after the work period among women, leading to low statistical power to detect an effect in some studies. However, such a limitation might be of lesser importance in studies on BP, since BP elevations tend to occur earlier in life than CVD. It is also worth adding that large studies conducted in the US and Europe observed a consistently higher proportion of women exposed to adverse psychosocial work factors than men (33). High job strain and ERI are therefore a frequent psychosocial exposure among women.

Two recent literature reviews (34, 35) have presented evidence that adverse psychosocial work factors may also be a risk factor for BP elevation. Based on 22 cross-sectional studies, Landsbergis et al (35) presented higher pooled BP means of +3.43 mmHg (systolic) and +2.07 mm Hg (diastolic) among workers exposed to high job strain as compared to non-exposed workers. However, 13 of 22 studies observed no significant effects (35), thereby indicating inconsistencies. These two literature reviews were limited by the fact that they: (i) took a narrative approach (non-systematic) (34), (ii) did not systematically evaluate ERI (34, 35), and (iii) did not systematically investigate the effects on hypertension (34, 35). Therefore, no previous systematic review has investigated the adverse effects of both the DCS and ERI factors on BP level and hypertension. There is thus a need to investigate the consistency of effects according to gender and the methodological quality of studies.

The general objective of this systematic review was to evaluate the effects that the psychosocial work factors of both the DCS and ERI models had on BP among men and women. The period under study was 1979 (year of the first publication presenting the demand–control

model) (10) to 4 November 2011. The following specific objectives were assessed: (i) Do workers exposed to psychosocial work factors of the DCS and ERI models have higher BP than unexposed workers? (ii) Are there gender differences in the effects of these psychosocial work factors on BP? (iii) Do studies of higher methodological quality, particularly studies with a prospective design and ambulatory BP measures, present more consistent adverse effects than studies of lesser methodological quality?

Methods

Search strategy

We conducted a systematic review to evaluate the association between adverse psychosocial work factors and BP among men and women. All relevant citations were collected and analyzed with a predefined strategy. Relevant citations were extracted from PubMed, Embase, Web of Science, and PsycInfo databases from 1979 to January 2011. Keywords and MeSH terms were combined to generate lists of publications. The databases were searched with a combination of three types of search strings (the complete search strategy is available on request) with terms related to: (i) the work setting: job, work, occupation, occupations, workplace, worker, employee; (ii) psychosocial factors: psychosocial factors, psychosocial work factors, psychosocial work-related factors, job stress, job-related stress, work stress, work-related stress, psychosocial, psychosocial stress, psychological demand, job demand, demand, job control, job control, job strain, iso-strain, social support, reward, effort–reward imbalance, effort reward, Karasek, Siegrist, psychosocial environment; (iii) BP: BP, hypertension, ambulatory BP, BP monitoring, cardiovascular responses, cardiovascular risk factors, systolic BP, and diastolic BP.

For practical reasons, publications had to be available in English or French. For scientific reasons, such as improved credibility and relevance, publications had to be available in peer-review journals. In the first step, a first reviewer selected studies on the basis of the title. In the second step, the abstracts of all the selected titles were sorted for a more detailed evaluation. Two independent reviewers read the abstracts and categorized them as relevant, not relevant, and possibly relevant. The same two reviewers fully reviewed, synthesized, and approved the relevant and possibly relevant publications. The quality and integrity of this review were optimized by following the validated PRISMA (preferred reporting items for systematic reviews and meta-analyses) recommendations (36).

Selection criteria

The selected populations had to include populations of >100 workers at baseline. Workers had to be exposed to psychosocial work factors of the DCS and/or ERI models. The comparison groups had to be composed of workers unexposed to the corresponding psychosocial work factors. The cut-offs between exposed and unexposed workers were generally determined by the median score of the study population or by the median score observed in a reference population (eg, the working population of a given country). To be included, a study must also have assessed these psychosocial work factors at the individual level. Articles based on imputed job title exposure score were therefore excluded since they are more vulnerable to misclassification (28, 29, 37).

The outcome had to be defined by (i) BP level (ie, mean or coefficient) or (ii) hypertension incidence or prevalence. Studies using office BP or ambulatory measurements were included. Office hypertension was generally defined as systolic or diastolic BP mean ≥140 mm Hg and ≥90 mm Hg, respectively. Ambulatory hypertension was generally defined as systolic or diastolic BP mean ≥135 mm Hg and ≥85 mm Hg, respectively (38). However, some studies used higher cut-offs to define hypertension (see tables A–C, available at www.sjweh.fi/data_repository.php). Studies on gestational hypertension were excluded.

Cross-sectional, prospective, and case–control studies were included. Narrative reviews and duplicates were excluded. Multiple publications based on the same study population were retained if the analyses were conducted for different exposures or outcomes.

Analysis

An effect was defined as being a statistically significant difference in BP between workers exposed to psychosocial work factors and those unexposed. Effect measures [differences in mean, beta coefficients, correlation coefficients, risk ratios (RR), and odds ratios OR)] and their P-value or 95% confidence interval (95% CI) were presented for each study, when available. Effects were presented for combinations of psychosocial work factors and for each factor taken separately. Results were also synthesized according to study design (cross-sectional, prospective, case–control), type of BP measures (office, ambulatory), and outcome (BP level, hypertension).

Results

Overview of included studies

The literature search provided 2913 citations, 161 of

which were selected as potentially relevant (figure 1). After a complete review of the full articles, 87 studies were excluded because they: (i) did not measure the psychosocial work factors of the DCS and/or ERI models (N=39) (39–77), (ii) did not individually assess exposure to psychosocial factors (N=3) (78–80), (iii) comprised a population of high school students (not a working population) (N=1) (81), (iv) included <100 participants (N=13) (82–93); (v) were not written in English or French (N=4) (94–97), (vi) were not published in a peer-reviewed publication (N=16) (11, 98–112), (vii) did not measure BP (N=8) (70, 113–119), or (viii) did not distinctly evaluate exposure to psychosocial work factors (N=3) (120–122). Because these last studies evaluated interaction with multiple exposures, it was not possible to isolate the impact of the psychosocial factors that were of interest in our review (120–122). A total of 74 studies were ultimately included (23, 34, 44, 123–192).

The 74 studies were published between 1982–2011; 57 were cross-sectional, 15 prospective cohorts, and 2 case–control studies. Among the prospective studies, the follow-up durations ranged from 6 weeks to 12 years. Office and ambulatory BP measures were used in 45 and 28 studies, respectively. There were 64 studies on the DCS model (tables A and B) and 12 studies on the ERI model (table C), two studies considered both models (151, 155). Studies were conducted in 18 countries and included various working populations aged ≥15 years (representative samples of the general working population, white-collar workers, bus drivers, nurses, teachers, patrol officers, etc.; tables A–C).

Except for five studies on the DCS model (152, 160, 172, 173, 179), the studies included in this review controlled for at least one potential confounder. Potential confounders were sociodemographic (age, gender, ethnicity), socioeconomic (education, income, occupation), lifestyle risk factors (smoking, alcohol or caffeine consumption, physical activity, stressful situations, personality traits), biological risk factors (body mass index, waist circumference, known history of CVD, diabetes, medication for hypertension, menopausal status, estrogen medication, pregnancy history, sodium intake, cholesterol), and other factors (marital status, number of children, posture, stress outside work, having eaten a meal, length of time in the current job, and social support at work and outside work).

Studies on DCS model

Tables 1 and 2 summarize the results of the studies on the DCS model according to methodological characteristics and gender, while tables A and B (www.sjweh.fi/data_repository.php) detail the characteristics and results of these studies.

Overall, 21/40 studies observed a significant deleterious effect of job strain on BP level and 7/19 studies observed such an effect on hypertension (table 1). Significant deleterious effects were also observed for high psychological demands in 7/25 studies on BP level and 2/7 studies on hypertension, and for low social support in 1/9 studies on BP level. As well, a significant effect was observed for high job control (protective effect) in 9/25 studies on BP level and 3/6 studies on hypertension. However, no significant effects were observed in the three studies on iso-strain.

Of the 40 cross-sectional studies on job strain (table A, figures 2–4), 16 observed a significant deleterious effect, namely: (i) differences in systolic and diastolic BP means ranging respectively from +2–+10.2 mm Hg (129, 133, 147, 150–152, 169, 170, 172, 181) and from +2–+17.97 mm Hg (1333, 147, 151, 152, 169, 170, 172, 181); (ii) OR ranging from 1.18–2.9 (132, 177, 181); (iii) beta coefficients of systolic and diastolic BP of 4.53 (175) and 0.23 (178) respectively; and (iv) P-values <0.05 for the association between job strain and mean systolic BP (44, 139) (table 1). Two studies reported a significant protective effect of job strain on hypertension (131, 138, 157): OR for hypertension of 0.61 (157) and 0.63 (systolic hypertension) (131).

Of the 12 prospective studies on job strain (table B, figures 2–4), 9 observed a significant deleterious effect, namely: (i) differences in systolic and diastolic BP means ranging respectively from +1.2–+7.7 mm Hg (142, 155, 161, 180, 182) and from +0.8–+7 mm Hg (161, 182); (ii) a hypertension OR of 1.27 after being exposed to job strain at baseline and an OR of 2.06 for a change from low to high job strain during an 8-year follow-up (154); (iii) an RR for a systolic BP increase in the highest quintile of 1.33 among men (142); (iv) a beta coefficient of systolic BP of 0.19 (166); and (v) a P-value of <0.01 for the association between job strain and mean systolic BP (176) (tables 2 and A). Contrary to what was expected, one study observed a significant protective effect of job strain on BP (138).

The two case–control studies observed that job strain had a significant deleterious effect on hypertension (table 1) (163, 167). The OR for hypertension were 2.6 and 2.7, respectively. One of these studies also presented differences in mean BP (systolic: +6.8 mm Hg, diastolic: +2.6 mm Hg) (167). It is also worth noting that one case–control study evaluated the effect of low social support at work and observed no effect among either men or women (163).

Gender. A majority of the 40 cross-sectional studies on job strain presented results separately for men and women; 19 presented results solely for men, and 15 presented results solely for women (table 2, figures 2–4). A higher proportion of studies observed a deleterious effect among men (BP level: 6/18 studies, hypertension: 2/5 studies) than women (BP level: 1/10 studies, hyper-

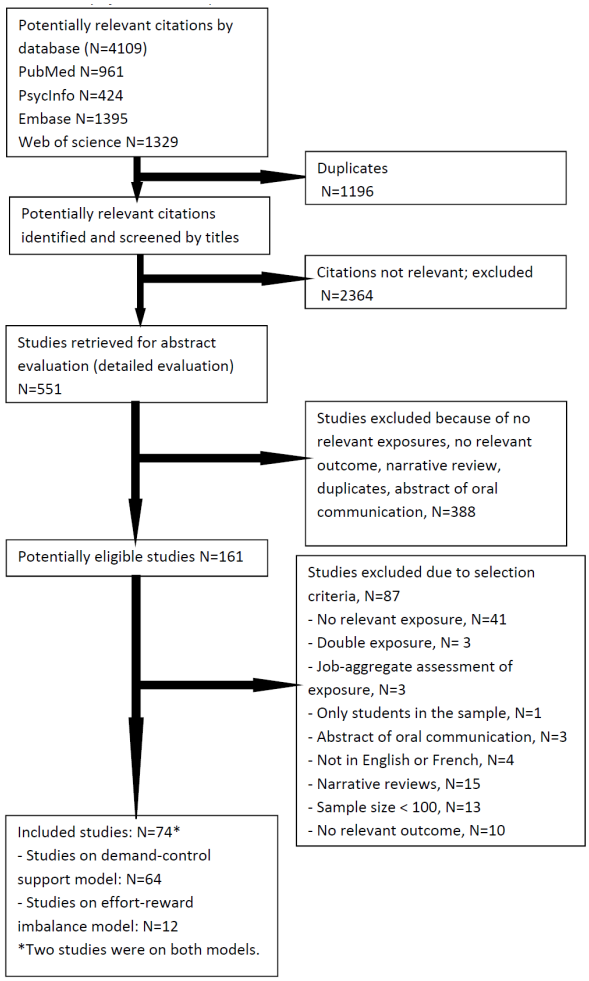

Figure 1. Summary of the selection process.

tension: 0/7 studies) (table 2, figures 2–4). Two studies on hypertension reported a significant deleterious effect among men [OR 1.18 (177) and 2.9 (181)], while none (0/7 studies) observed such an effect among women.

In addition, a slightly higher proportion of cross-sectional studies observed a deleterious effect of high psychological demands (4/11 studies) and high job control (6/10 studies) among men compared to women (demands: 2/11 studies, control: 5/11 studies) (table A).

Of the 12 prospective studies on job strain, 5 presented separate results for men and 4 presented separate results for women (table 2, figures 2–4). In studies on BP level, a higher proportion observed a deleterious effect among men (5/5 studies) compared to women (2/4 studies) (table 2). Moreover, the only study on hypertension reported a deleterious effect among men versus no effect among women (145) (table 2).

The effects of high psychological demands and low job control that were observed in prospective studies were not consistent among either men (demands: 2/7 studies, control: 2/7 studies) or women (demands: 2/5 studies, control: 3/5 studies) (table 2). In addition, the only study that evaluated the effect of low social support observed a deleterious effect among women but not men (133) (table 2).

Study design. For job strain, a higher proportion of prospective studies yielded a deleterious effect on BP mean level as compared to cross-sectional studies (significant effect in 7/9 studies as compared to 13/30 studies) (table B). However, a prospective design did not lead to a more consistent effect in studies on hypertension (significant effect in 2/5 prospective studies as compared to 3/12 in cross-sectional studies).

Type of BP measures. Office and ambulatory BP measures were used in respectively 39 and 27 studies on job strain (table 1). Overall, a higher proportion of studies using ambulatory BP measures (13/20 studies) observed an adverse effect of job strain than did studies using office measures (12/35 studies) (table 1). This observation mostly applies for cross-sectional studies. Indeed, among cross-sectional studies, 9/15 studies using ambulatory BP measures observed a significantly deleterious effect as compared to 7/27 studies using office BP measures (table 1). However, in prospective studies on BP level, ambulatory BP measures (4/5 studies) did not lead to a more consistent deleterious effect than office measures (3/4 studies), which could be due to the small number of studies (table B). Only one prospective study on hypertension used ambulatory BP measures.

Among studies evaluating the separate effects of the demand–control–support factors, the use of ambulatory or office BP measures led to inconsistent findings for high psychological demands (ambulatory BP: 3/9 studies, office BP: 2/9 studies) and high job control (ambulatory BP: 4/9 studies, office BP: 2/9 studies) (table 1). Moreover, only 1/12 studies on the separate effect of low social support observed a significant deleterious effect (table 1).

Studies on ERI model

Tables 3 and 4 summarize the results of the studies on the model according to methodological characteristics and gender, while table C details the characteristics and results of these studies.

In studies on ERI, 4/7 studies observed a significantly deleterious effect of ERI on BP level and 5/6 studies observed such an effect on hypertension (table 3). A significant deleterious effect of overcommitment on BP level was also observed in 2/4 studies (table 3).

Of the 11 cross-sectional studies of the ERI model, 7 studies observed a significant deleterious effect (table C, figures 5–6), namely: (i) differences in systolic and diastolic BP means ranged respectively from +1.86–

Table 1. Number of studies reporting a statistically significant deleterious effect / total number of studies having these methodological characteristics (reference number) reporting a deleterious effect of the demand–control–support factors on blood pressure according to study designs (cross-sectional, prospective or case–control), blood pressure (BP) measurements (office or ambulatory), and outcome (hypertension or BP level).

	Cross-sectional studies (N=50) [a]		Prospective studies (N=14)		Case-control studies (N= 2)		Total
	Office BP (N=29/50)	Ambulatory BP (N= 21/50)	Office BP (N=9/14)	Ambulatory BP (N=5/14)	Office BP (N=1/1)	Ambulatory BP (N=1/1)	
Job strain (N=52)							
Hypertension	1[b] (177) / 10 (33, 123, 124, 131, 134, 135, 147, 149, 157, 177)	2 (132, 181) / 2 (132, 181)	2 [c] (142, 154) / 4 (23, 142, 148, 154)	0 / 1 (137)	1 (163) /1 (163)	1 (167) / 1 (167)	7 / 19
BP level	6 [d] (129, 139, 147, 152, 172, 178) / 17 (129, 136, 138, 139,145–147, 152, 158, 160, 171–173, 178, 193, 214)	7 (44, 133, 150, 151, 169, 175, 181) / 13 (44, 125, 126, 128, 135, 150,151, 153, 156, 169, 170,175, 181)	3 (142, 161, 180) / 4 (142, 148, 161, 180)	4 (155, 166, 176, 182) / 5 (137, 155, 166, 176, 182)	0 /0	1 (167) / 1 (167)	21 / 40

[a] Studies on both BP level and hypertension (137, 147, 158, 162, 167).
[b] Two studies also reported a significant protective effect of job strain (131, 157).
[c] The estimated risk ratios (RRs) for blood pressure increases in the highest quintile for each job strain group (142).
[d] One study also reported a significant protective effect of job strain (138).

Table 2. Number of studies reporting a statistically significant deleterious effect / total number of studies having these methodological characteristics (reference number) reporting a deleterious effect of job strain on blood pressure (BP) according to gender, study designs (cross-sectional, prospective or case–control), BP measurements (office or ambulatory) and outcome (hypertension or BP level).

	Cross-sectional studies (N=26)		Prospective studies (N=6)		Total
	Office BP (N=18/26)	Ambulatory BP (N= 8/26)	Office BP (N=3/6)	Ambulatory BP (N=3/6)	
Women					
Hypertension	0 / 6 (131, 134, 135, 149, 157, 177)	0 / 0	0 / 1 (142)	0 /0	0 / 7
BP level	1 (138)/ 7 (129, 138, 152, 171, 178, 193, 214)	1 (150) / 3 (126, 150, 156)	1 (180) / 3 (142, 161, 180)	1 (166) / 1 (166)	4 / 14
Men					
Hypertension	1 (177) / 4 (134, 147, 157, 177)	1 (181) / 1 (181)	1 (142) / 1 (142)	0 / 0	3 / 6
BP level	5 (129, 147, 152, 172, 178) / 11 (129, 138, 145–147, 152, 160, 171, 172, 178, 193)	2 (151, 181) / 6 (125, 126, 128, 151, 156, 181)	3 (142, 161, 180) / 3 (142, 161, 180)	2 (155, 182) / 2 (155, 182)	12 / 22

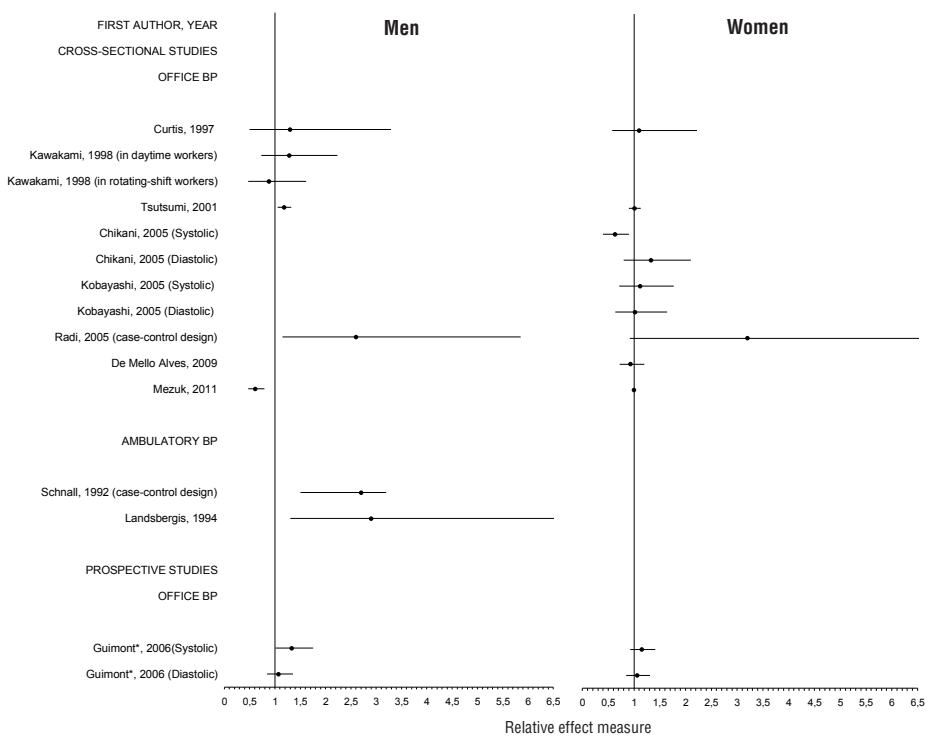

Figure 2. Relative risk of hypertention observed among studies on job strain by gender. [BP=blood pressure.]

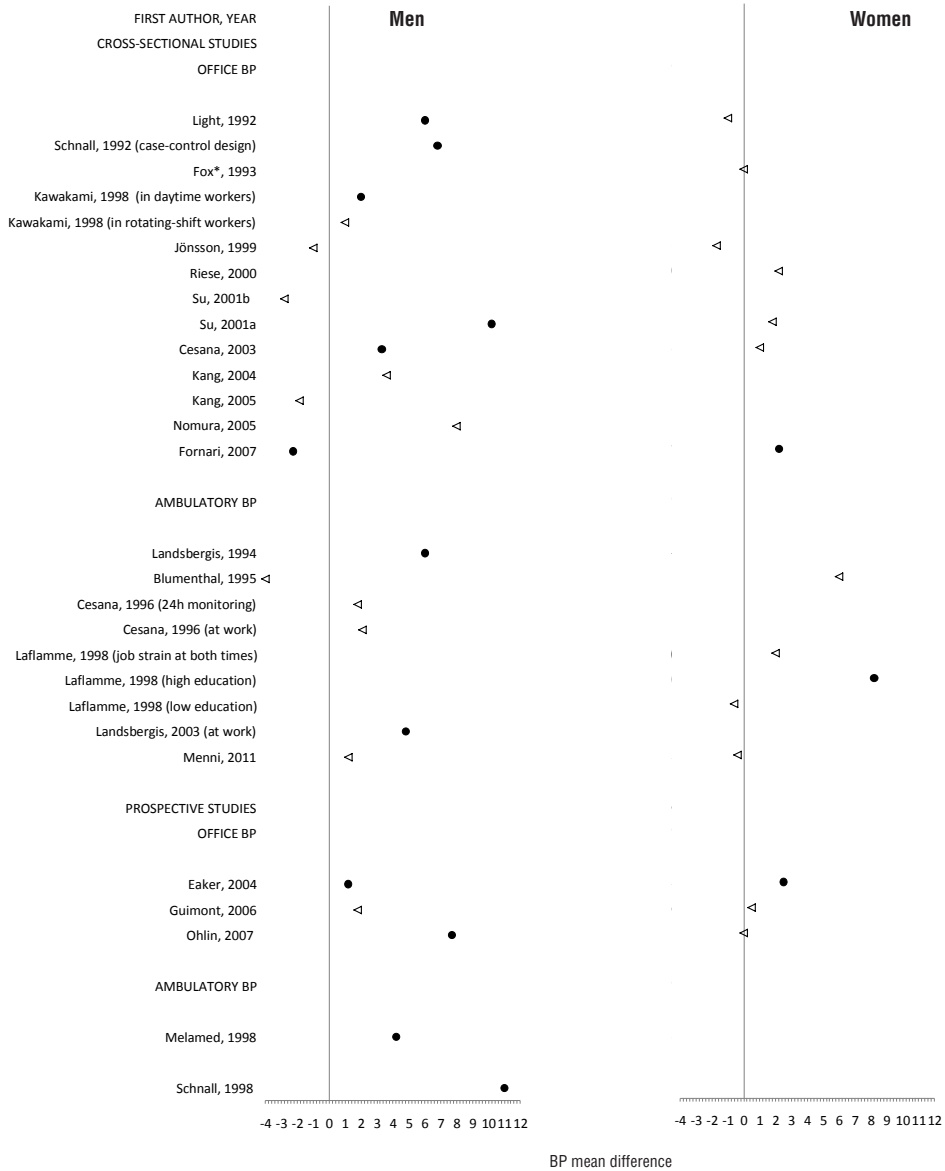

Figure 3. Systolic blood pressure (BP) mean differences observed among studies on job strain by gender. A dot designates a statistically significant result (P<0.05) while a triangle designates a non-significant result. * This difference was stated as statistically significant but no effect measure was presented.

+4.52 mm Hg and +1.31–+4.17 mm Hg (153, 188, 189) and (ii) hypertension OR ranged from 1.62–5.77 (184, 185, 186, 190). In addition, two cross-sectional studies evaluated the separate effect of effort and reward (153, 190). None of these studies observed significant results (table C).

A significant deleterious effect of overcommitment was observed in one out of three cross-sectional studies (194). This study observed a higher ambulatory systolic BP mean among men (+6.4 mm Hg) but no effects among women (194). It is also worth mentioning that no cross-sectional studies presented results for the potential modifying effect of overcommitment on the association between ERI and BP.

Only one prospective study evaluated the effect of ERI on BP (191). This study used ambulatory BP measures. Among men, no association was observed. Among women, age had a modifying effect. Women <45 years old exposed to ERI at both times (over a 3-year follow-up) had significantly higher BP means at follow-up than those unexposed (systolic: +1.86 mm Hg, diastolic: +1.48 mm Hg) (table C, figure 6). Among women ≥45 years old, the cumulative incidence of hypertension was 2.78 times higher among those exposed to ERI at both times (table C and figure 6). In this study, no modifying effects were observed for overcommitment. However, men and women in the higher tertile of overcommitment also had higher BP means than those in the lower tertile (men: systolic +1.66 mm Hg, diastolic non-significant; and women: systolic: +1.28 mm Hg, diastolic +1.02 mm Hg) (table C).

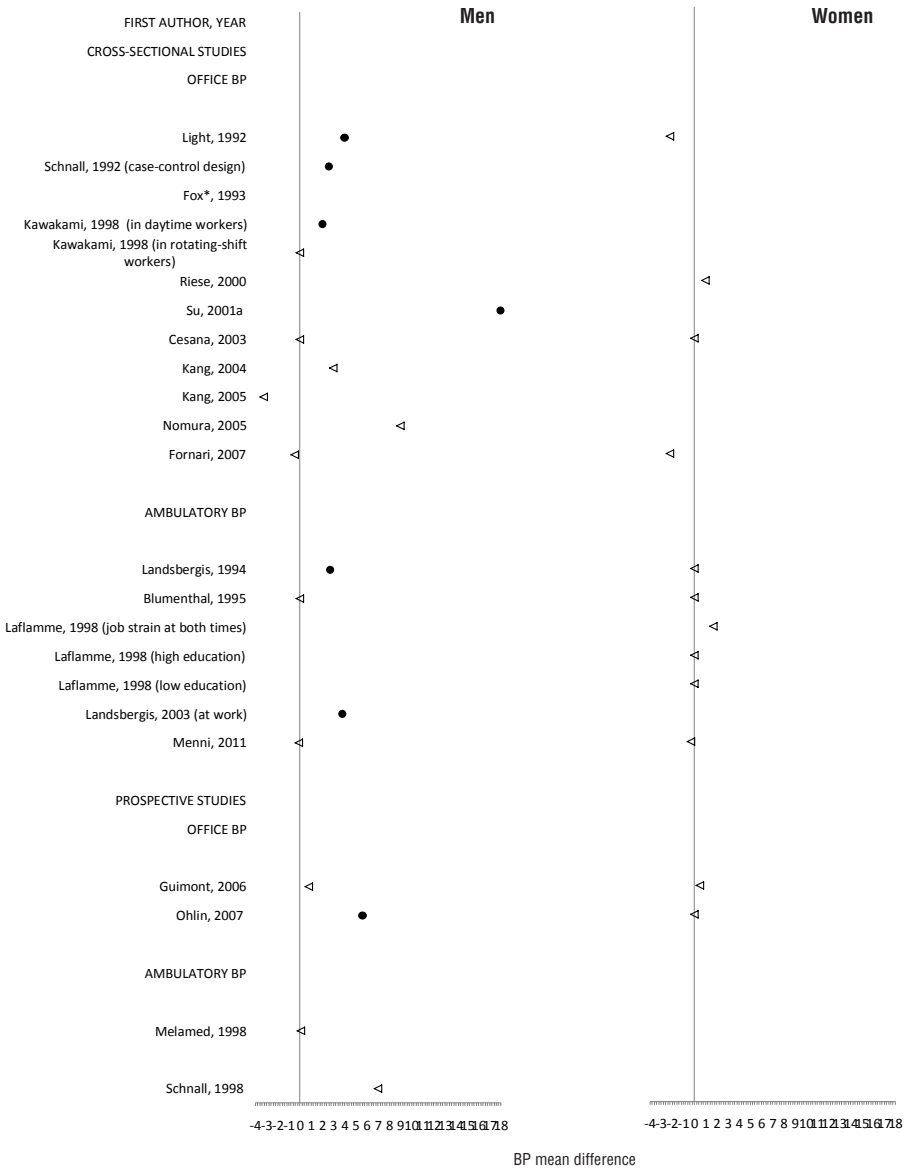

Figure 4. Diastolic blood pressure (BP) mean differences observed among studies on job strain by gender. A dot designates a statistically significant result (P<0.05) while a triangle designates a non-significant result. * This difference was stated as statistically significant but no effect measure was presented.

Gender. Of the 11 cross-sectional studies on ERI, 6 presented results separately for men and women (table C, figures 5–6). The deleterious effect of ERI was more consistent among men (5/6 studies) than women (1/6 studies) (table C, figures 5–6).

Methodological characteristics. For the ERI model, there were 11 cross-sectional studies and only 1 prospective study (table 3). More prospective studies are needed to compare results according to study designs.

A higher proportion of studies using ambulatory BP measures (3/4 studies) observed an adverse effect of ERI as compared to studies using office measures (5/8 studies, table 3). However, this comparison should be interpreted cautiously due to the small number of cross-sectional (N=3) and prospective (N=1) studies using ambulatory BP measures.

Discussion

Of the 74 studies on the adverse effects of psychosocial work factors on BP, 64 looked at the DCS model and 12 at the ERI model, with two studies considering both models (152, 156). For both models, a more consistent adverse effect has been observed for men compared to women. In studies on job strain, those of higher methodological quality (ie, studies using a prospective design and/or ambulatory BP measures) observed a more consistent effect than those of lesser quality.

Gender

In line with the results of the current review, previous reviews on BP (35) and CVD (26–30, 35) also observed

Table 3. Number of studies reporting a statistically significant deleterious effect / total number of studies having these methodological characteristics (reference number) reporting a deleterious effect of the effort-reward imbalance (ERI) factors on blood pressure (BP) according to study designs (cross-sectional, prospective, or case-control), BP measurements (office or ambulatory), and outcome (hypertension or BP level).

	Cross-sectional studies (N=11)		Prospective study (N=1)		Total
	Office BP (N=8/11)	Ambulatory BP (N=3/11)	Office BP (N=0/1)	Ambulatory BP (N=1/1)	
ERI (N=12)					
Hypertension	4 (184–186, 190) / 5 (149, 184–186, 190)	0 / 0	0 / 0	1 (191) / 1 (191)	5 / 6
BP level	1 (189) / 3 (183, 187, 189)	2 (153, 188) / 3 (153, 188, 194)	0 / 0	1 (191) / 1 (191)	4 / 7

a more consistent adverse effect of psychosocial work factors among men than women (26–30, 35). However, a recent meta-analysis of coronary heart disease European cohort studies, including 197 473 workers, observed a similar effect in both genders (31). Gender differences may be due to the fact that BP elevations tend to arise later in women's lives than men's. Indeed, until age 45, a lower percentage of women have high BP (195). Therefore, among women, age might modify the effect of psychosocial work factors on BP, leading to a stronger effect in older than younger women. Supporting this hypothesis, Gilbert-Ouimet et al (191) observed an adverse effect of ERI on hypertension among women aged ≥45 years old, while no such effect was observed among younger women. It is thus possible that studies observing no significant adverse effect (in particular studies on hypertension) would have observed such effect after stratifying on age. However, since only two studies stratified their results on women's age (both having observed an adverse effect) (130, 191), it would be important to further evaluate this potential modifying effect.

Gender differences could also be explained by women having different occupational trajectories than men (more often characterized by absences or reduced hours of paid work due to family responsibilities), resulting in less continuous exposure to psychosocial work factors. In addition, it is also possible that being exposed to adverse psychosocial work factors might only add a little adverse impact to that already encountered by experiencing the burden of large family responsibilities. As pointed out by Messing et al (196), multiple roles and complex exposures make it difficult to pin down risks for working women. In the current review, only three studies have taken family responsibilities into account (135, 142, 159). Future studies would benefit from evaluating the potential modifying or confounding effect of family responsibilities. Marital cohesion would also be of interest since previous studies have observed that a lack of it amplified (ie, modified) the adverse effect of psychosocial work factors on BP (176, 197).

Gender differences in the experience of stress (198) may also lead to differential self-reported exposures to psychosocial work factors (26). In line with this, two studies that used both self-reports and external observations to assess psychosocial work factors noted that women tended to overestimate their self-reported job control, while no such phenomenon was observed among men (78, 199). For women, this may lead to an underestimation of the prevalence of high job strain. Such non-differential misclassification could dilute the adverse effect of high job strain on BP among women.

Another potential explanation for gender differences might lie in the effect of social support at work among women. As shown for the association between job strain and depression (200), high social support at work may moderate the adverse effects of job strain among women. None of the studies included in the current review evaluated the potential modifying effect of social support on the association between psychosocial work factors and BP according to gender. It is thus possible that studies showing no significant adverse effect among women would have observed such an effect after stratifying on social support. It is also worth noting that only one study (130) evaluated the separate effect of social support. This study observed an adverse effect among women but no effect among men. More studies evaluating the separate and modifying effects of social support at work according to gender are needed.

Finally, the gender differences observed in the current review rely partly on a comparison of studies comprising solely men or women. A potential limitation of comparing such studies is that gender differences might result from inter-study differences (eg, differences in design, BP measurements, and definition of psychosocial exposures) instead of true gender differences. We therefore conducted a complementary analysis to verify this hypothesis by comparing only studies including *both* men and women. For job strain, a higher proportion of studies observed a deleterious effect among men (7/15 studies) than women (1/15 studies) (tables A and B, figures 2–4), which is in line with the findings of the overall analysis. For ERI, only three studies including both men and women presented results according to gender (188, 193, 194). A deleterious effect was observed among men and women in 2/3 and 1/3 of the studies, respectively (table C, figures 5–6). More studies on ERI that include both men and women are needed. These additional studies would allow a comparison of the consistency of the effect of ERI according to gender.

Table 4. Number of studies reporting a statistically significant deleterious effect / total number of studies having these methodological characteristics (reference number) reporting a deleterious effect of effort-reward imbalance (ERI) on blood pressure (BP) according to gender, study designs (cross-sectional, prospective or case-control), BP measurements (office or ambulatory) and outcome (hypertension or BP level).

	Cross-sectional studies (N=11)		Prospective study (N=1)		Total
	Office BP (N=8/11)	Ambulatory BP (N=3/11)	Office BP (N=0/1)	Ambulatory BP (N=1/1)	
Women					
Hypertension	0 / 3 (149, 185, 190)	0 / 0	0/0	1 (191) / 1 (191)	1 / 4
BP level	1 (189) / 2 (183, 189)	0 / 0	0/0	1 (191) / 1 (191)	2 / 3
Men					
Hypertension	4 (184–186, 190) / 4 (184–186, 190)	0 / 0	0/0	0 / 1 (191)	4 / 5
BP level	0 / 0	1 (188) / 1 (188)	0/0	0 / 1 (191)	1 / 2

Methodological characteristics

Study design. A prospective design is more appropriate than a cross-sectional one, especially for studies on hypertension. Indeed, cardiovascular alterations such as hypertension could take years to develop. A prospective design has a considerable advantage in that it allows for a time lag between exposure and outcome measurements, circumventing an eventual reverse causation bias.

In this review, studies used different study designs to evaluate the effect of psychosocial work factors on BP. For job strain, a higher proportion of prospective studies (7/9 studies) yielded a deleterious effect on BP mean level compared to cross-sectional studies (13/30 studies) (table B). However, the prospective design did not lead to a more consistent effect in studies on hypertension (significant effect in 2/5 prospective studies compared to 3/12 in cross-sectional studies). This may be due to the low number of prospective studies on hypertension (N=5) and their predominant use of office BP measures (4/5 studies) (table 1). More studies combining a prospective design and ambulatory BP measures are needed to evaluate the role of job strain in the etiology of hypertension.

For the ERI model, there was only one prospective study (191), which emphasizes the need for more studies using this design.

Types of BP measures. A higher proportion of studies using ambulatory BP measures showed an adverse effect of job strain (13/20 studies) and ERI (3/4 studies) as compared to studies using office measures (12/35 and 5/8 studies, respectively) (tables 1 and 3). Ambulatory BP measures are known to sidestep the observer error (the so-called "white-coat effect"). They also provide better precision by capturing the BP fluctuations related to daily life and make it possible to capture "masked" hypertension, defined as elevated daytime ambulatory BP (≥135/85 mmHg) in the face of normal office BP (<140/90 mm Hg). The prevalence of masked hypertension has been estimated to be between 8–30% in the general population (201–204). Several population-based studies and prospective clinical trials have provided clear evidence of the superiority of ambulatory over office BP measures in predicting cardiovascular risks (152, 205–208).

Besides comparing clinical to ambulatory BP measures, a distinction can be made according to the moment of BP collection (ie, during work, at home, over 24 hours, and during sleep). We performed a complementary analysis of studies that measured BP during and outside work (N=10) (44, 127, 128, 133, 137, 139, 151, 169, 175, 181) (tables A and B). Most of these studies were cross-sectional (N=9) and used ambulatory BP measures (N=9) (tables A and B). All the studies (except reference 44) presenting significant results found a deleterious effect in both BP at work and: (i) at home (133, 139, 151, 181), (ii) over 24 hours (133, 175), and (iii) during sleep (133). The effect magnitudes were comparable for all periods. This suggests that the deleterious effect of psychosocial work factors not only contributed to inflate daytime BP but also persist after work. It is likewise noteworthy that most studies included in this review (N=64/74) only measured daytime BP. Boggia et al (205) showed that daytime BP predicts the 10-year incidence of fatal and non-fatal strokes, cardiac, and coronary events just as well as nighttime BP. Indeed, hazard ratios for the combination of these cardiovascular events were 1.33 and 1.25 for systolic and diastolic daytime BP, respectively, compared to 1.31 and 1.28 for nighttime BP (in continuous analyses).

Limitations

Methodological choices. As Belkic et al (29) emphasize, publication bias and heterogeneity are major reasons for skepticism towards meta-analyses of non-experimental studies (29, 210, 211). There is also an increasing need for qualitative approaches and the identification of the best way of evaluating effects (29). The current review does not provide meta-analytical estimates since the available data did not meet the criteria for homogeneity in methods used to assess job strain and ERI, confounders, outcome measures, and biases potentially affecting internal validity. Our review however provides an in-depth analysis of several potential explanations for data inconsistencies (ie, gender, study design, types of BP measures, instruments for measuring psychosocial factors, categorization of exposure to psychosocial fac-

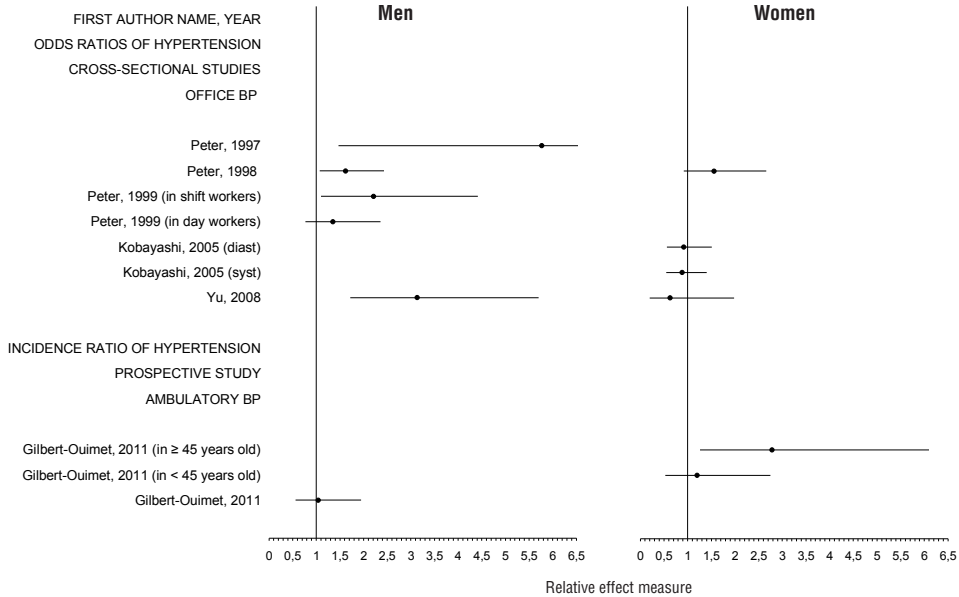

Figure 5. Relative risk of hypertension observed among studies on effort-reward imbalance by gender. [BP=blood pressure; syst=systolic; diast=diastolic]

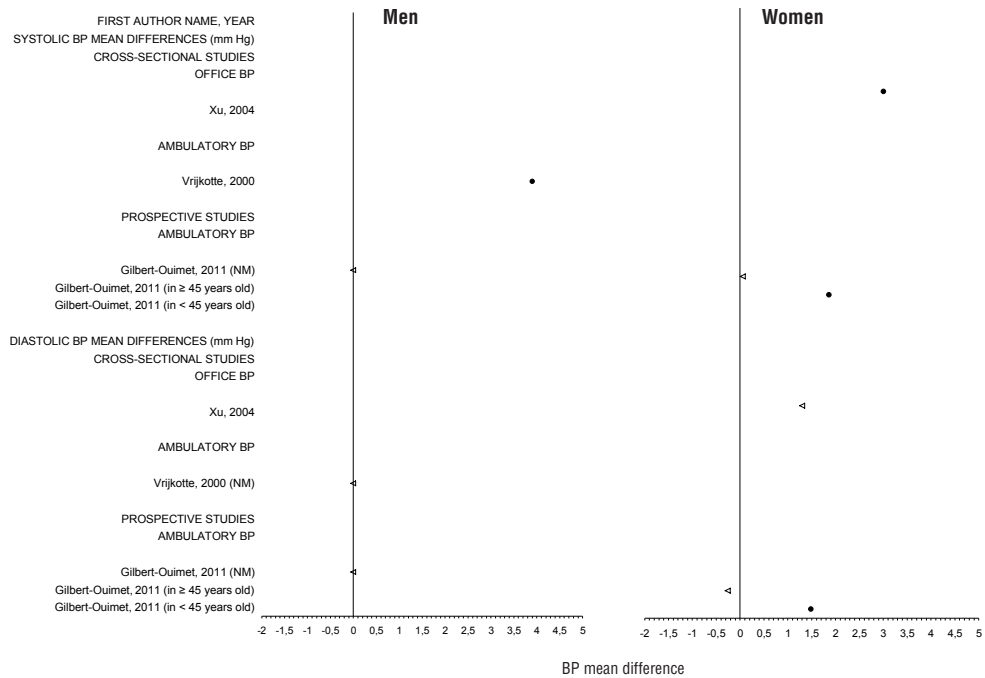

Figure 6. Systolic and diastolic blood pressure (BP) mean differences and beta coefficients observed among studies on effort-reward imbalance by gender. A dot designates a statistically significant result (P<0.05) while a triangle designates a non-significant result. [NM=effect not mentioned].

tors, control for potentially confounding factors, and participation rate). Such analysis allowed the identification of "optimal" methods to consistently observe the deleterious effect of psychosocial work factors on BP, namely the use of a prospective design and ambulatory BP measures.

However, the calculation of a meta-analytical estimate based on a sub-sample of studies with comparable methodological characteristics would partly circumvent the pitfalls of heterogeneity. The only subsample comprising a sufficient number of studies (N>5) of higher methodological quality (ie, studies having either a prospective design or ambulatory BP measures) would be the cross-sectional studies evaluating the association between job strain and mean level of ambulatory BP. However, Landsbergis et al (198) already calculated such an estimate in a very recent meta-analysis. Indeed, based on 22 cross-sectional studies, they presented higher pooled ambulatory BP means of +3.43 mmHg (systolic) and +2.07 mm Hg (diastolic) among workers exposed to high job strain compared to non-exposed workers (35).

Also, it is worth mentioning we could have missed potentially relevant papers in the first step of data selection when we selected citations on the basis of their titles rather than reviewing abstracts, which would have minimized the chance of introducing such bias. However, the references of all included studies and prior literature reviews have been thoroughly consulted and no additional studies were added. Even though it cannot be ruled out, a potential bias resulting from this data selection step seems unlikely.

In line with previous literature reviews on psychosocial work factors and cardiovascular health (26, 27, 29, 30), we evaluated the consistency of the effects on the basis of statistical significance. However, gainful but non-significant effects have also been observed in studies on job strain (N=13) (tables A and B) (no such effects have however been observed in studies on ERI, table C). Only three of these studies (N=3) had a sample size <200 (N=100–175, table A), which suggests that statistical power is unlikely to explain why results were not significant. It is also noteworthy that most of these studies were cross-sectional (12/13 studies) and used clinical BP measures (9/13 studies), which supports the hypothesis that poorer methodological quality leads to lower effect consistency.

Publication bias. A potential publication bias might have been introduced due to the inclusion of articles written only in English or French. To document this potential bias, a sensitivity analysis including articles written in other languages was conducted. This complementary search led to the identification of four potentially relevant articles written in Chinese, Italian, Persian, and Spanish (94–97). The potential relevance of these articles was based on the titles and abstracts, which were written in English. Three articles were on the DCS model (94, 96, 97) and two were on the ERI model (95, 97). One article included both models. Based on the abstracts, only one study (96) observed significant results. This cross-sectional study looked at the DCS model and used ambulatory BP measures. However, since it included only 30 men, it would not have been eligible for the current review (studies had to include ≥100 workers). Thus, this sensitivity analysis revealed that three possible eligible studies with negative results were omitted. Of these, two were cross-sectional (98, 100) (the other one did not mention the study design in the abstract). The abstracts did not mention the type of BP measurement used in these studies.

Another publication bias could have arisen from the fact that statistically significant results are more likely to get published than non-significant results. Such publication bias is assumed to be present if larger studies (in which it is easier for smaller effects to be significant) report smaller effects than small studies (larger effects are needed for significant findings) (209). To investigate the presence of this bias, the test for funnel plot asymmetry is generally conducted (209). However, due the diversity of effect measures, psychosocial exposures, study designs, and outcomes used in the reviewed studies, such a test could not be performed. The current review was restricted to studies including ≥100 workers. This makes it easier to achieve satisfactory statistical power, which reduces the likelihood of a publication bias due to non-significant findings. In addition, approximately one in two reviewed studies reported non-significant results, which shows that such results are frequently published in this field. It is, however, important to point out that other non-significant results might not have been presented. As mentioned above, only one study on ERI presented an investigation of the potential modifying effect of overcommitment. This however does not definitively suggest that such analyses were not performed. Presenting non-significant modifying effects is needed to further document the psychosocial etiology of BP elevation. The magnitude of such publication bias cannot be estimated.

The potential biases of the reviewed studies are detailed below.

Selection bias. A selection bias could have been introduced in studies where participants and non-participants differed with regard to both psychosocial work factor exposure and BP (210). Studies having a low participation rate at baseline and/or follow-up are particularly vulnerable to such bias (212). In a recent literature review, Galea et al (213) reported that a participation rate of ≥75% is generally considered satisfactory in epidemiological studies. In the current review, 20 studies had participation rate(s) <75% (23, 128–130, 132, 133, 141, 148, 149, 153, 159, 162, 166, 176–178, 188, 193, 194, 214,) (tables A–C). Almost half of these (9/20 studies) documented the potential differences between participants and non-participants (23, 128, 141, 148, 149, 159, 166, 176, 214). Those suspecting a differential participation (4/9 studies): (i) observed higher cardiovascular risk factor prevalence (159) combined with lower socioeconomic status (177) or with a higher prevalence of psychosocial work factors in non-participants (23, 148), and (ii) noted that, since recruitment was by advertisements, it is possible that the study attracted predominantly "stressed" subjects as volunteers (176). These observations suggest that a selection bias due to differential participation could lead to an under- or overestimation of the true effects. It is important to mention that participation rate(s) were not reported in a third of the studies (26/76 studies, 34%) (121, 125–127, 131, 134, 136, 138, 140, 143, 146, 152, 154, 156, 157, 161, 163, 165, 168, 173, 181, 183, 185, 186, 190, 194) (tables A–C). Such a high proportion of non-reporting of participation is in line with what Mor-

ton et al (212) observed in a recent review of articles published in major epidemiology journals. They noted comparable or poorer reporting of participation rates in cross-sectional (participation rate not mentioned in 41% of studies), case–control (66%), and prospective (68%) studies. Since selection bias may threaten the internal validity of epidemiologic studies, authors should report participation rate(s) consistently.

The well-documented selection bias of the "healthy worker effect" (210) might also have been introduced in some of the included studies. This bias, which is more likely to occur in cross-sectional than prospective studies (210, 215), generally leads to an underestimation of the true effect (218). In occupational studies, a healthy worker effect can arise from: (i) a differential participation at baseline or follow-up (discussed above) and (ii) the application of selection criteria. In prospective studies on hypertension, this second mechanism could for example be introduced by excluding hypertensive workers at baseline, who are "sicker" than normotensive workers. However, creating prospective cohorts free of the outcome under study at baseline is an important methodological quality since it allows causal inferences to be made by ensuring that the exposure precedes the outcome. In keeping this rationale, most prospective studies on hypertension (4/6 studies) opted to exclude hypertensive workers at baseline (137, 142, 154, 191) (tables A–C).

It is also noteworthy that, in occupational studies, the healthy worker effect has mostly been observed in studies on cardiovascular disease, diabetes, and respiratory disorders (210, 215) due to the fact that such diseases are symptomatic. Studies on BP mean level or hypertension are less prone to such bias because: (i) BP elevations and hypertension are generally asymptomatic, and (ii) over 50% of individuals with high BP are unaware of their condition (216). Nevertheless, the healthy worker effect can occur in cross-sectional studies on hypertension and generally lead to an underestimation of the true effect (210).

Information bias. An information bias might have resulted from the fact that psychosocial work factors are notoriously difficult to measure. Indeed, psychosocial work factors are known to be more difficult to measure than standard cardiovascular risk factors such as smoking, alcohol consumption, or abdominal adiposity. More specifically, the concept of psychological demands measured by the DCS model has been criticized for not measuring emotional demands, which include becoming emotionally involved during work or having to face emotionally disturbing situations (217). Thus, the concept of psychological demands might underestimate the actual "demands" to which workers are exposed. This could lead to a non-differential information bias underestimating the true adverse effect of psychological demands (210).

Another potential information bias might have resulted from the use of different instruments to measure the psychosocial work factors of both the DCS and ERI models. Of the 64 studies on the DCS model, 53 used Karasek's Job Content Questionnaire (JCQ) (10) (tables 1 and 2). A majority of these studies observed significant effects of the DCS factors (32/53) (tables A and B). Among the studies using instruments other than the JCQ, a majority (9/11 studies) also observed significant effects (tables A and B). For the ERI model, 10/12 studies used the recommended Siegrist questionnaire (13) (table C), 7 of which observed a significant effect (table C). The two studies that used other instruments partly (191) or entirely (185) also observed significant effects. However, comparing the effect consistency observed in studies on the basis of the instrument used to measure psychosocial factors is complex since studies also differ with regard to other methodological characteristics. Uniformity in measuring psychosocial work factors is nevertheless recommended to improve interstudy comparability.

A misclassification bias might also have resulted from the fact that studies on job strain used different categorizations of exposure. Some studies (19/52 studies) categorized job strain in quadrants as recommended (10) (tables A and B). These quadrants classify workers as unexposed (low demands, low control), passive (low demands, high control), active (high demands, high control), or high strain (high demands, low control). Even though quadrants are recommended, a majority of studies (28/52 studies) used a dichotomous exposure, comparing the high strain category (as "exposed") to the combination of unexposed, passive, and active categories (as "unexposed") (tables A and B). A dichotomous job strain categorization might lead to an important misclassification bias. Such a bias would lead to a dilution of the adverse effect of high job strain. A complementary analysis showed that studies using the job strain quadrants did not yield a more consistent effect than studies using a dichotomous exposure (8/19 compared to 12/25 studies, tables A and B). As mentioned previously, such a comparison is limited by the fact that studies differ in other methodological characteristics. It is also noteworthy that three studies using the job strain quadrants observed deleterious effects in the active group (166) or in both the active and passive groups (33, 163).

In the same vein, a misclassification bias might also have resulted from the use of different scales to measure the ERI factors. A majority of studies (8/12) used an agreement scale with answers varying from "strongly agree" to "strongly disagree" (153, 183, 186–188, 190, 191, 194). The four other studies (149, 184, 185, 189) used a scale measuring both the agreement and the intensity of distress experienced. In these studies, participants who agreed to a given item had to indicate the level of

distress experienced, ranging from "very distressed" to "not at all distressed". Measuring both the employees' agreement and distress intensity may have led to a more acute exposure to ERI than measuring only the employees' agreement. In line with this hypothesis, a slightly higher proportion of studies combining both agreement and distress intensity observed a significant deleterious effect of ERI (3/4 versus 4/8 studies). In future studies, measuring psychosocial work factors with standardized instruments would favor interstudy comparability.

Another potential information bias might have arisen from the use of a single time-point exposure. Only 7 (137, 150, 151, 154, 166, 182, 191) of 64 studies evaluated the effect of job strain or ERI using more than a single time-point. Of these, 5 observed a significant adverse effect, which is a higher proportion than that observed in studies using a single time-point exposure (28/57 studies, table A). In line with this, data from the British Whitehall II study and the Quebec post-myocardial infarction cohort showed that a single time-point measurement underestimated the effect of job strain on first and recurrent coronary heart disease (28, 218). Measuring psychosocial work factors repeatedly makes it possible to take changes in exposure into account. It also makes it possible to identify chronically exposed subjects, who may have a higher cardiovascular risk than subjects exposed for a shorter period. There is too little empirical evidence to suggest an optimal number of measures or an ideal interval of time between psychosocial work factor measurements. According to experimental studies, it is however reasonable to assume that the deleterious effect of psychosocial stressors on BP elevations, particularly on hypertension, would arise from prolonged exposures (17–19, 219–221).

An additional information bias might have occurred in studies on BP level that did not take hypertension medication into account. Since hypertension medication leads to artificially lowered BP measures, not considering it might contribute to underestimating the true adverse effect of psychosocial work factors on BP level. A total of 18/59 studies on BP means (141, 145, 146, 158, 160, 162, 165, 167, 178–180, 182, 187, 189, 192, 193) did not take hypertension medication into consideration (ie, workers on medication were not excluded or not controlled for in analyses) (tables A–C). Of these 18, 10 studies observed an adverse effect of psychosocial work factors, which is, however, comparable to the overall proportion of studies observing such an effect.

It is also worth mentioning that: (i) 2 of 3 prospective studies on hypertension did not consider workers taking hypertension medication at follow-up as "hypertensive cases" (ie, as having the outcome under study) (table B); and (ii) of 14 cross-sectional studies on hypertension, 1 excluded workers taking hypertension medication and 5 controlled for the consumption of such medication (table A). Since workers taking hypertensive medication have the outcome under study, not considering them as "cases" leads to a misclassification that might bias the estimates toward the null.

One can also argue that another misclassification bias could have been introduced by assessing psychosocial work factors using self-reported questionnaires. In theory, self-reported data tend to introduce more misclassification bias than objective data (210). However, it has been suggested that the individual's judgment may bring about most of the deleterious effects of psychosocial work factors on health (13). In addition, job title exposure score has been shown to involve more misclassification than self-reported measures due to an incomplete capture of psychosocial work exposure (generally leading to an underestimation of estimates) (28, 29, 222).

Finally, it is worth noting that some studies included populations of workers from only one or two occupations [ie, bus drivers (123), nurses (127, 139, 166), police officers (125), and teachers (127, 169, 192)] (tables A–C). In these studies, the range of variation of exposure to psychosocial work factors might have been limited due to considerable similarity in job characteristics. Little variation due to restricted working areas may lead to lower effect estimates compared to those that would have been observed in representative samples of the active working population. Also, as Landsbergis et al (153) states, a limited range of variation in exposure due to study design might reduce the statistical power available to detect main effects of psychosocial work factors.

Confounding. Confounding biases also need to be addressed. The five studies on the DCS model (152, 160, 171, 173, 179) that did not control for any cofactors are the most prone to confounding bias. Confounding might also be present in other studies due to a lack of control for cardiovascular risk factors. For example, some studies did not control for age (125, 132, 144, 146, 174) or family history of CVD (61 studies) (23, 44, 124–129, 131–141, 153, 155–159, 161–168, 171, 174, 178, 180, 181, 183, 185–189, 192–194, 214, 223, 224) (tables A–C), which constitute major risk factors for high BP. Residual confounding might also have resulted from the fact that none of the studies on job strain controlled for ERI or vice-versa. Finally, residual confounding might have been present due to psychosocial work factors of emerging models, such as organizational injustice (225) and managerial leadership (226), which have been suggested to be causally related to cardiovascular risk (28, 226). It is worth mentioning that recent studies have presented evidence of a complementary adverse effect of job strain and ERI on BP and coronary heart disease (227 and Trudel X, Brisson C, Milot A, Vézina M, Masse B. Psychosocial work environment

and ambulatory blood pressure: independent effect of demand–control and ERI models. In preparation). Similarly, a recent systematic review observed that procedural and relational injustice (ie, two components of the organizational injustice model) can be considered a different and complementary model to the DCS and ERI models. It is also possible that simultaneous exposures to psychosocial work factors would lead to an increased adverse effect on BP compared to single exposures. Such a phenomenon has been observed in job strain and ERI with regard to the risk of acute myocardial infarction among men and women of a large case–control study (N=951 cases and 1147 referents) (228).

A large majority of studies presented effect measures adjusted for lifestyle risk factors that might have acted as mediating variables (62/77 studies) in the causal pathway linking work stress and BP (28, 29). Indeed, psychosocial work factors have been associated with lifestyle, cardiovascular risk factors such as increased smoking intensity (229), reduced leisure-time physical activity (229), unhealthy diet (230), weight gain, and obesity (28, 231). Adjusting for mediating factors may result in controlling for a part of the effect under study, which contributes to an underestimation of the overall effect of psychosocial work factors on BP (210). To avoid such a limitation, five studies (23, 124, 157, 186, 187) evaluated the additional effect of adjusting for lifestyle, cardiovascular risk factors in a supplementary statistical model (ie, sequential adjustment). In all of these studies, this additional adjustment only resulted in a slight change in the effect measures presented. Studies using structural equation modeling are, however, needed to quantify the potential causal pathway linking psychosocial work factors, lifestyle risk factors, and BP.

Generalization

The results of the current study can be generalized to working populations from various countries. Indeed, participants in a large proportion of studies (N=35/78) were recruited from representative samples of the active working population. The remaining studies included workers from various but restricted working areas (ie, public employees, bus drivers, nurses, and teachers; tables A–C), which may limit the external validity of their results (153, 176).

Concluding remarks

The present review has some strengths. It gathered and summarized empirical evidence through an explicit, systematic, and objective research strategy known for minimizing bias (36). This is also the first systematic review on the effects of both the DCS and the ERI models on BP level and hypertension. This review also provides an in-depth analysis of gender differences. In addition, the systematic approach made it possible to explore five methodological characteristics as potential explanations for the data inconsistencies observed in the literature: (i) study design, (ii) types of BP measures (office versus ambulatory), (iii) instruments for measuring psychosocial factors, (iv) categorization of exposure to psychosocial factors, (v) control for potentially confounding factors, and (vi) participation rate.

In conclusion, the present review contributes to current efforts of primary prevention of CVD by providing an up-to-date, systematic synthesis of reliable findings on the psychosocial etiology of BP, a major CVD risk factor. Overall, approximately half the studies observed a significant adverse effect of psychosocial work factors on BP. However, the extensive body of research on this topic showed a more consistent effect for men than for women. In studies on job strain, a more consistent effect was also observed in studies of higher methodological quality that is studies using: (i) a prospective design and (ii) ambulatory BP measures. The numerous evidences presented in this review supports the need for workplace intervention studies to evaluate the effect that reducing psychosocial work factors has on BP among various working populations.

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