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PSYCHOLOGICAL ASPECTS OF CARDIOVASCULAR DISEASES (A STEPTOE, SECTION EDITOR)

Psychosocial Stressors at Work and Ambulatory Blood Pressure

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Abstract

Purpose of Review Psychosocial stressors at work from the demand-latitude and effort-reward imbalance models are adverse exposures affecting about 20–25% of workers in industrialized countries. This review aims to summarize evidence on the effect of these stressors on blood pressure (BP).

Recent Findings Three systematic reviews have recently documented the effect of these psychosocial stressors at work on BP. Among exposed workers, statistically significant BP increases ranging from 1.5 to 11 mmHg have been observed in prospective studies using ambulatory BP (ABP). Recent studies using ABP have shown a deleterious effect of these psychosocial stressors at work on masked hypertension as well as on blood pressure control in pharmacologically treated patients.

Summary Evidence on the effect of these psychosocial stressors on BP supports the relevance to tackle these upstream factors for primary prevention and to reduce the burden of poor BP control. There is a need for increased public health and clinical awareness of the occupational etiology of high BP, hypertension, and poor BP control.

Keywords Psychosocial stressors at work · Job strain · Effort-reward imbalance · Ambulatory blood pressure · Masked hypertension · Hypertension control

Introduction

Workplaces have faced many in depth transformations in the last decades, mainly characterized by work intensification and job insecurity [1]. In parallel, national surveys showed high levels of stress among workers. For example, a 2011 Canadian survey reported that 25% of workers are highly stressed, 60% of them identifying work as their main source of stress [2]. Stress is a broad concept with many definitions used for research, public health, and clinical purposes. The National Institute of Occupational Safety and Health (NIOSH) in the USA defines work stress as "the harmful physical and emotional responses that occur when the requirements of the job do not match the capabilities, resources, or needs of the worker" [3]. According to NIOSH's definition, working conditions play a primary role in causing work stress. Exposure to stressful working conditions (work stressors) can have a direct influence on worker safety and health [3, 4].

Epidemiological studies have documented the effect of work stressors on cardiovascular diseases [5] as well as on

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other health outcomes including mental health problems [6] and musculoskeletal disorders [7]. These studies examined critical dimensions of the work environment (psychosocial stressors at work) for which an effect on worker's health is empirically demonstrated. Using these critical dimensions have many advantages including reducing the complexity of the psychosocial environment to relevant components in terms of health risks. Besides the potential for generalization, it allows for a quantitative estimation of exposure prevalence, allowing for screening, surveillance, and facilitating primary prevention measures in workplaces [8] .

Two theoretical models have mainly been used: the demand-control model and the effort-reward imbalance model. In industrialized countries, the proportions of working men and women exposed to these psychosocial stressors at work have been found to be about 20–25% [9]. According to a Canadian survey conducted in 2015, this prevalence is comparable to that of smoking and obesity (around 20–25% in working age groups) [10], two major BP risk factors. The demand-control model suggests that workers simultaneously experiencing high psychological demands and low job control, i.e., job strain, are more likely to develop stress related health problems [11]. Psychological demands refer to an excessive work load, very hard or very fast work, task interruption, intense concentration, and conflicting demands. Job control is a combination of skill discretion and decision authority. Skill discretion refers to the degree to which a worker can develop skills, learn new things, and use creativity at work. Decision authority refers to the extent to which one can take part in decisions, make decisions, and have a say on the job and how the work is accomplished. An extension of this model includes a third component, *low social support*, defined as a lack of help and cooperation from supervisors and coworkers. Low social support may act directly or amplify the effect of job strain [12]. The effort-reward imbalance (ERI) model proposes that efforts at work (e.g., constant time pressure, many interruptions and disturbances, lot of responsibility, pressure to work overtime) should be rewarded in various ways: income (financial reward), respect and esteem (socioemotional reward), and career promotion and job security (status-related reward) [13]. Workers are in a state of detrimental imbalance, e.g., lack of reciprocity, when high efforts are accompanied by low reward, causing a state of emotional distress which can lead to adverse health outcomes.

Psychosocial Stressors at Work, Blood Pressure, and the Cardiovascular Continuum

Prospective studies have documented the effect of psychosocial stressors at work at different phases of the cardiovascular continuum. The cardiovascular continuum is framed as a chain of events, initiated with risk factors and progressing to subclinical organ damage then cardiovascular events up to the development of end-stage organ diseases [14]. Evidence supports the adverse effect of psychosocial stressors at work on CVD outcomes measured at various stages of this pathogenic process, including high BP [15–17], CVD incidence [5], and CVD recurrence [18]. Interventions aimed at reducing high BP and hypertension prevalence, e.g., interventions in the early stages, could interrupt or mitigate the continuum and confer protection against CVD events [14]. Psychosocial stressors at work, being frequent and modifiable, could be relevant targets to achieve population-based reduction of high BP and hypertension.

Research on psychosocial stressors at work and BP has led to many primary studies on the topic, informative systematic reviews, and meta-analyses as well as new research development. The current review aims at summarizing key points from available reviews and highlights some new research direction on the topic.

Ambulatory Blood Pressure and Masked Hypertension

Blood pressure is characterized by its high variability. A simple measure or some measures obtained in specific context such as a visit in the medical office (casual or clinic BP) do not take into account BP fluctuations throughout the day. Therefore, clinic BP (CBP) is a relatively poor marker of the true pressure exerted on target organs. The introduction of ambulatory BP (ABP) monitoring has helped overcome this limitation, collecting BP measurement by a simple yet rigorous method every 15 to 30 min during the day. In addition, ABP measurements are more precise, therefore leading to increased study power when such measurements are used as the outcome. Previous studies reported a better correlation between ABP and target organ damage (left ventricular hypertrophy, left ventricular function, microalbuminuria, retinopathy, cerebral dysfunction) when compared to clinic BP [19–21]. ABP measurements are also better predictors of CVD events [22, 23]. For example, a recent multi-center national cohort, including 63,910 adults, showed that ABP is a stronger predictor of all-cause and cardiovascular mortality when compared to CBP [24•].

ABP combined with traditional CBP has refined the classification of hypertension. Masked hypertension refers to the condition defined by normal CBP (less than 140 and less than 90 mmHg) combined with elevated ABP (at least 135 or at least 85 mmHg) [25, 26]. In contrast, sustained hypertension is defined as BP levels in hypertensive range according to both measurement methods. There is a growing interest in masked hypertension since the condition has been associated with a similar [22, 27, 28] or even higher [24•] cardiovascular risk when compared to sustained hypertension.

Psychosocial Stressors at Work and Blood Pressure: Evidence from Recent Systematic Reviews and Meta-Analyses

Landsbergis et al. reviewed the effect of job strain on ABP [15]. Meta-estimates showed that workers exposed to job strain had higher work systolic (3.43 mmHg; 95% CI = 2.02–4.84) and diastolic (2.07 mmHg; 95% CI = 1.17–2.97) ABP, when compared to unexposed workers. A majority of studies from which these meta-estimates were derived have controlled for hypertension risk factors, including age, body mass index, race, work physical activity, and alcohol use. Interestingly, job strain was associated with all form of ABP (work, home, and sleep) among men while the only significant association among women was for work systolic BP. By the time the review was conducted, only three prospective studies had examined the effect of job strain on ABP. Therefore, meta-estimates were restricted to cross-sectional studies while prospective studies, summarized in a narrative review, all provided support for an effect of job strain on ABP [29–31]. Landsbergis' review had many strengths, including being the first to draw attention to the effect of job strain on ABP using a quantitative meta-analysis, allowing for the estimation of an overall effect size. The reported effects are of important public health significance. Indeed, at the population level, a 2-mmHg lower systolic BP mean could result in approximately 10% lower stroke mortality and 7% lower mortality from ischemic heart diseases or other vascular causes in middle age [32]. Furthermore, methodological characteristics of included studies argue in favor of an underestimation of the true effect of psychosocial stressors at work on BP. For example, only job strain was considered, likely leading to an underestimation of the total effect of work stressors on BP. Moreover, few studies considered cumulative exposure which could also lead to an underestimation.

Indeed, measuring psychosocial stressors at work at multiple times makes it possible to consider changes in exposure and to identify chronically exposed subjects, who may be at increased high BP risk. Prospective studies that were not included in Landsbergis' review (focusing on ERI or being more recently published) have examined the effect of cumulative job strain and/or ERI exposure on ABP changes and have added support to the adverse effect of cumulative exposure on ABP changes and hypertension. In a sample of 1595 white-collar workers (629 men and 966 women), Gilbert-Ouimet et al. showed that chronic ERI exposure led to higher systolic and diastolic ABP increases in women < 45 years old and a higher hypertension incidence in women ≥ 45 years [33]. Results from an extended 5-year follow-up of this study unfolded an adverse effect of ERI exposure onset on women's BP increases [34]. ABP changes and hypertension incidence were also higher in men who were chronically exposed to an active job (e.g., high psychological demands and high job control). These studies support the underestimation of the true burden of high BP that could be attributable to psychosocial stressors at work when considering high job strain as the sole stressor faced by workers.

A second review by Gilbert-Ouimet et al. examined the effect of psychosocial stressors at work from both job strain and ERI models on BP [16]. Overall, approximately half of the studies reported a significant adverse effect. However, the adverse effect of psychosocial stressors at work was more consistent in studies of higher methodological quality. Indeed, five out of six studies using a prospective design and ABP measures reported such effect. In these studies, BP differences between exposed and unexposed workers ranged from + 1.9 to 11.0 mmHg (systolic) and from + 1.5 to 7.0 mmHg (diastolic). The vast majority of included studies adjusted for at least one potential confounder although there was heterogeneity in the number and nature of included factors. Potential confounders were sociodemographic, socioeconomic, lifestyle risk factors, biological risk factors, and other factors such as posture, stress outside work, and length of time in the current job. Gilbert-Ouimet's review also reported a more consistent effect among men. Two possible hypotheses were put forward to explain gender differences. First, women having different occupational trajectories may have less continuous exposure to psychosocial stressors at work. Second, the burden of large family responsibilities could reduce the additional impact of psychosocial stressors at work [16]. One should bear in mind that gender differences were not systematically examined in studies on work stressors and BP. Therefore, additional research should be conducted on the impact of these stressors on women's BP to clarify gender differences.

Finally, Babu et al. conducted a meta-analysis on the association between job strain and hypertension [17]. This meta-analysis included three case-control and six prospective studies and excluded studies with a cross-sectional design. The pooled OR of hypertension was 1.3 (95% CI 1.13–1.48), adding crucial evidence in order to enhance clinical awareness about the effect of psychosocial stressors at work on cardiovascular health. Babu et al. review also points toward the need to consider the methodological quality of studies. Indeed, all studies reported information on confounding and have controlled for major risk factors. However, the risk of bias assessment showed a potential for selection bias and measurement errors. Methodological quality was therefore explicitly examined and results showed an effect of higher magnitude in cohort studies of higher quality (pooled OR 1.49, 95% CI 1.25–1.77) when comparted to those of lower methodological quality (pooled OR 0.86, 95% CI 0.49–1.52). There was also high heterogeneity in instruments used to assess job strain, hypertension definition (treated hypertension, hypertension assessed with CBP or ABP), and studied populations.

To sum this up, systematic reviews, along with more recent findings, support the adverse effect of psychosocial stressors at work from the job strain and ERI models on BP and hypertension. More consistent effects were observed in studies of higher methodological qualities, such as those using ABP measurements and a prospective design. Table 1 presents selected results from the three recent systematic reviews discussed above.

On the Importance of Considering a Broader Range of Psychosocial Stressors at Work

Job strain and ERI cover different aspects of the psychosocial environment at work. The demand-control model focuses on task-level characteristics, while the ERI model focuses on broader socioeconomic conditions, such as salaries, promotion prospects, and job stability. Evidence suggests that both job strain and ERI have their own independent effect on coronary heart disease [35••, 36]. This independent effect was also observed in studies on BP. In one study conducted among men only, workers exposed to psychosocial stressors from both models had twice the hypertension prevalence than that of unexposed workers (OR 2.03, 95% CI 1.18–3.49) while no association was observed for men exposed to stressors from a single model. Another study showed the independent effect of ERI exposure on ABP means after controlling for the effect of job strain, in both men and women [37]. Therefore, considering psychosocial stressors at work from both models is desirable. The effect of other dimensions of the psychosocial environment at work on cardiovascular health has also been documented, including organizational injustice [38••], shift work [39], and long working hours [40••]. However, studies on the effect of these specific stressors on ABP are limited [41, 42]. These additional and potentially complementary dimensions of work stress may be included in future prospective studies on ABP.

New Research Directions

Psychosocial Stressors at Work and Masked Hypertension

Masked hypertension is characterized by high ambulatory BP in the face of normal office BP [43] and is strongly associated with CVD risk [24•]. The prevalence of masked hypertension could be up to 30% [27]. Many factors have been associated with this clinical condition including sociodemographic and lifestyle-related risk factors such as alcohol and cigarette smoking [27, 44, 45]. The work environment may also play a role in masked hypertension etiology. Adverse psychosocial exposures at work could lead to selective BP increases outside the medical office that remained underdetected by traditional CBP. Two cross-sectional studies conducted by our group among 2300 white-collar workers showed that masked hypertension prevalence was higher in those exposed to psychosocial stressors at work [46, 47]. The first focused on the effect of psychosocial stressors at work from the demand-control model and reported a higher prevalence of masked hypertension among men exposed to an active job situation (OR 2.07, 95% CI 1.30–3.31) while no association was observed in women. The second reported an effect of ERI exposure (OR 1.53, 95% CI 1.16–2.02) and high efforts at work (OR 1.61, 95% CI 1.13–1.29) on the prevalence of masked hypertension in both men and women. Moreover, the effect of psychosocial stressors at work from both models was investigated in a cross-sectional study conducted in the USA, among 164 hospital and home care employees [48]. The effect of job strain (OR 1.82, 95% CI 0.66–5.05) and the effect of ERI (OR 2.05, 95% CI 0.73–5.74) did not reach statistical significance which could partly be explained by limited study power. However, there was an association between the combined exposure to job strain and ERI and masked hypertension (OR 2.97, 95%

Table 1 Selected results from systematic reviews on the effect of psychosocial stressors at work and blood pressure

	Exposure	Outcome	Effect measures type	Effect measures (BP difference between exposed and unexposed workers or OR (odds ratio))
Landsbergis et al.	Job strain	ABP means	Meta estimates from cross-sectional studies using work ABP (N = 22 studies)	Systolic + 3.43 mmHg; 95% CI = 2.02–4.84 Diastolic + 2.07 mmHg; 95% CI = 1.17–2.97
Gilbert-Ouimet et al.	Job strain, effort-reward imbalance	ABP means	Range of effect in studies with a prospective design and ABP (N = 5/6 studies reporting a significant effect)	Systolic + 1.9 to + 11.0 mmHg Diastolic+ 1.5 to + 7.0 mmHg
Babu et al.	Job strain	Hypertension	Meta-estimates from cohort studies of higher methodological quality (N = 3 studies)	Hypertension: OR = 1.49 (95% CI 1.25–1.77)

CI 1.02–8.60). Interestingly, shift work was also strongly associated with masked hypertension suggesting that additional work-related risk factors should be considered in future efforts to document the occupational etiology of the condition.

The effect of psychosocial stressors at work on masked hypertension incidence, assessed among initially normotensive individuals, is unknown. Evidence of this effect would strengthen the relevance of these stressors for primary prevention of masked hypertension and for screening of at risk individuals. Psychosocial stressors at work might also affect masked hypertension persistence over time. In a prospective study of 232 untreated participants [49], 1 out of 5 participants with baseline masked hypertension still had the condition after 5 years. Risk factors, such as work stressors, could contribute to postpone the detection and subsequent management of masked hypertension, but no evidence is yet available on this topic.

Psychosocial Stressors at Work and Uncontrolled Hypertension in Treated Workers

The prevalence of uncontrolled hypertension among pharmacologically treated patients is high. According to national surveys in Canada and in the USA, one to two adults out of five receiving a pharmacologic treatment for hypertension have uncontrolled hypertension (BP values higher than the recommended targets) [50, 51]. Mezuk et al. found no effect of job strain on BP control in a US sample of aging working men [52]. However, some study features could have led to an underestimation of the effect, including the use of CBP measurements and the fact that the study was conducted among older male workers (mean age over 60 years). A more recent study by Trudel et al. using ABP found a deleterious effect of ERI exposure on the prevalence of uncontrolled hypertension among 473 white-collar workers treated for hypertension [53••]. Treated workers in the highest tertile of effort-reward imbalance at work had a 45% higher prevalence of uncontrolled hypertension (prevalence ratio (PR) = 1.45, 95% confidence interval (CI) 1.16, 1.81) compared to treated workers in the lowest tertile. This study had noteworthy methodological strengths including a high participation rate, the use of ABP to assess uncontrolled hypertension, and the inclusion of a large set of potential confounders. Two pathways might explain the association between psychosocial stressors at work and uncontrolled hypertension among treated individuals: 1—a direct effect of exposure on BP increases and 2—an intermediate effect through treatment adherence. The presence of such an intermediate effect is supported by a study showing an association between adverse psychosocial factors and non-adherence to cardiovascular health recommendations [54]. Whether one or both of these mechanisms are involved, findings suggest that tackling upstream factors such as psychosocial stressors at work could have a beneficial effect on BP control among treated hypertensive patients. An ongoing study conducted by our research team is examining the effect of the other model, the demand-control model. The preliminary results show a deleterious effect on uncontrolled hypertension (manuscript in preparation).

Mechanisms

The repeated exposure to psychosocial stressors at work can lead to an increase in the neuroendocrine activity of the sympathetic nervous system (catecholamines) and the hypothalamic-pituitary-adrenal axis (glucocorticoids). Moreover, the sympathetic nervous system is one of the pathways activating the renin-angiotensin system. Therefore, in conjunction with other risk factors, exposure to psychosocial stressors at work can trigger vasoconstriction, endothelial dysfunction, cellular proliferation, and inflammation that promote arterial stiffness, hypertension, atherosclerosis, and, subsequently, cardiovascular events [55–57].

Lifestyle-related risk factors including body mass index (BMI), physical activity, smoking, and alcohol could act through indirect pathways [58–60]. Studies have shown associations between job strain and other BP risk factors including diabetes, smoking, physical inactivity, and obesity [61]. The effect of weight gain was more frequently examined. Previous prospective studies showed greater weight gain in exposed workers with higher BMI at baseline. [62–64]. More recently, Trudel et al. have measured the indirect effect of ERI on ABP through weight gain and found a modest effect among initially overweight women [65]. Evidence on indirect pathways linking work stressors and ABP is scarce and suggests subgroup-specific effects. Moreover, most studies showing an effect of work stressors and ABP have adjusted (controlled for) the effect of lifestyle-related risk factors, therefore pointing toward an important role of direct bio-physiological mechanisms.

Public Health and Clinical Perspectives

Public Health Perspective

Addressing psychosocial stressors at work for which an adverse effect on BP is demonstrated is a promising avenue. Previous intervention studies showed that it is possible to conduct high quality workplace intervention [66]. Indeed, evidence showed that the prevalence of psychosocial stressors at work can be reduced [67, 68] and supports the beneficial effect of such interventions on targeted health outcomes such as reductions in symptoms related to mental health and illness absenteeism [69–71]. Workplaces can be supported by health policies in their efforts to tackle psychosocial stressors at work, and there are interesting national initiatives toward that goal [66]. However, little is known on the effect of workplace

Table 2 Items from a screening tool to assess psychosocial stressors in workplaces

In general, in my workplace	Targeted psychosocial stressor at work[1]
Work overload is often present	Psychological demands
Employees are not involved in decision-making	Job control
Superiors are rarely available	Social support/supervisors
There is little collaboration between colleagues	Social support/colleagues
Employment security is poor	Reward
Efforts deployed by employees are not acknowledged	Reward

Screening tool developed by the Institut National de Santé Publique du Québec (INSPQ). (Adapted with permission from Chénard C et al.: https://www.inspq.qc.ca/sites/default/files/publications/2373_risques_psychosociaux_travail_mesurables_modifiables.pdf) [75]

[1] Psychosocial stressors included in demand-control-support and effort-reward imbalance models

interventions in lowering BP. In order to fill the current knowledge gap, there is a need for additional interventions relying on strict quality criteria such as the use of validated instruments to measure psychosocial stressors at work and the assessment of ABP.

Clinical Perspective

Lifestyle modifications are recommended in most national guidelines for the prevention and management of hypertension [72–74]. "Stress" is sometimes mentioned in those guidelines, despite the lack of a clear definition of the concept. More likely conceived in common knowledge as a physiological response to a stressor rather than a root cause of this response (stressor per se), recommendations to reduce stress mostly involve cognitive behavioral and relaxation techniques. Available etiological evidence argues in favor of improved awareness among healthcare professionals, including physicians, on psychosocial stressors at work and their adverse effect on BP. However, the assessment of these work stressors in clinical practice is challenging for many reasons, including the difficult shift from a population-based approach to an individual-centered approach of prevention and management of high BP. Nonetheless, initiating a discussion on psychosocial stressors at work could contribute to improve patient's empowerment and help putting words on factors which would have remained unidentified otherwise. Another potential clinical utility could be the identification of at-risk patients that might benefit the most from ABP monitoring whether it be to "unmask" hypertension or to improve BP control. Table 2 presents selected items, derived from a brief screening tool recently developed by the Institut National de Santé Publique du Québec (INSPQ) [75]. It targets psychosocial stressors at work encompassed in validated models and for which an effect on BP is empirically supported. Such brief screening tools could contribute to efforts toward improved awareness and knowledge on these precise and modifiable stressors in clinical settings.

Conclusion

Psychosocial stressors at work are frequent, precise, and modifiable risk factors. Among exposed workers, BP increases ranging from 1.5 to 11 mmHg have been observed in prospective studies using ABP [16]. Recent studies focusing on the effect of psychosocial stressors at work on masked hypertension and uncontrolled hypertension have shown a higher prevalence of these adverse outcomes among exposed workers. In the face of accumulating evidence on the adverse effect of work stressors on ABP, future research should determine whether workplace interventions reducing psychosocial stressors at work are effective primary prevention strategies to improve BP and to reduce the critical burden of hypertension at the population level. There is also a need for an improved clinical awareness on these work stressors as risk factors involved in the etiology of high BP. Tackling these upstream factors could contribute to improve the prevention and management of hypertension, including masked hypertension and uncontrolled hypertension.

Compliance with Ethical Standards

Conflict of Interest Xavier Trudel, Chantal Brisson, Mahée Gilbert-Ouimet, and Alain Milot declare that they have no conflict of interest.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

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