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Review

Psychophysiological biomarkers of workplace stressors

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ABSTRACT

Workplace stressors are associated with greater coronary heart disease risk, although there is debate over the psychophysiological consequences of work stress. This study builds on recent reviews and examines the literature linking work stress with sympatho-adrenal biomarkers (plasma catecholamines and heart rate variability) and HPA axis biomarkers – the post-morning profile of cortisol.
Methods: Relevant studies using appropriate search terms were searched using the bibliographic databases *PubMed*, *Embase*, *Biosys* and *Toxline*. Four studies on plasma catecholamines, 10 studies on heart rate variability, and 16 studies on post-morning cortisol were reviewed.
Results: In the majority of studies that examined the association of HRV and work stress, greater reports of work stress is associated with lower heart rate variability. The findings for plasma catecholamines and cortisol secretion are less clear cut and suffer from poorer quality of studies in general.
Conclusion: There is evidence that work stress is related to elevated stress responses in terms of sympatho-adrenal and HPA axis biomarkers.

Contents

1. Psychophysiological biomarkers of workplace stressors and health

Exposure to workplace stressors (or “work stress”) increases the risk of heart disease. A recent systematic review concluded that there was moderate evidence that adverse psychosocial working

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conditions are a risk factor for ischaemic heart disease among men (Eller et al., 2009). A meta-analysis estimated that there was an average 50% excess risk for CHD among employees with work stress (Kivimaki et al., 2006). The mechanisms leading from exposure to workplace stressors to CHD are hypothesised to be indirect effects through unhealthy behaviours (such as smoking, unhealthy dietary patterns, lack of exercise), as well as direct effects on neuroendocrine stress responses (Chandola et al., 2008). Activation of these pathways can be quantified using psychophysiological stress biomarkers. However, there is some debate on whether such daily life stressors are associated with elevated neuroendocrine stress responses (Gersten, 2008), especially as many studies report no significant associations and a few report a decreased stress response with work stress.

2. Neuroendocrine pathways linking stress to disease

Stressful stimuli serve to activate neural, neuroendocrine and endocrine pathways. Short term biological responses to stressful stimuli can be adaptive; for example, an increase in the capacity of the blood to clot under stress can serve to reduce blood loss in case of injury. However extreme, frequent or chronic activations of such mechanisms may be detrimental to health. These include changes in the function of two main axes of the stress response: (i) the sympatho-adrenal axis, which includes activation of the sympathetic nervous system leading to changes in peripheral adrenaline and noradrenaline levels; (ii) the hypothalamic-pituitary function, leading to changes in a wide variety of endocrine factors including cortisol and prolactin.

2.1. Sympatho-adrenal biomarkers

Activation of the sympathetic nervous system can be assessed by measurement of peripheral adrenaline or noradrenaline levels (catecholamines), however these are short acting and short lived molecules and researchers have tended to examine these using integrated methods for example in urine collections, or examine change in these factors in response to an acute stress. Researchers have also examined factors that may reflect the autonomic system function more generally and assess sympathetic or parasympathetic activity. These include measures such as heart rate or heart rate variability, which reflect the balance between sympathetic and parasympathetic activities. Heart rate variability is a measure widely used as a marker of autonomic influences on the heart. This is assessed by power spectral analysis and typical measures include total and low frequency power (relative sympathetic predominance) as well as high frequency power (vagal tone).

2.2. Hypothalamic-pituitary-adrenal axis biomarkers

A primary axis activated upon stress is the hypothalamic-pituitary-adrenal (HPA) axis. Stressful stimuli serve to activate HPA function to cause an increase in peripheral cortisol. Cortisol can effect physiological changes that encompass most of the main organ systems, and help to provide the energetic resources needed to face acute stressors. Cortisol also helps to modulate and contains other components of the physiological stress response (Sapolsky, 2000). Increasingly, HPA-axis researchers are focusing on the marked diurnal rhythm in the release of cortisol, with various elements of this rhythm viewed as essential indicators of HPA-axis functioning. The diurnal cortisol rhythm is typically characterised by high levels upon waking, a substantial (50–60%) increase in cortisol concentration following awakening, peaking at about 30–45 min after awakening (called the cortisol awakening response or CAR), and a subsequent decline over the remainder of the day, reaching a low point or nadir around midnight (Kirschbaum and Hellhammer, 1989). Healthy HPA-axis function is thought to require the presence of strong diurnal patterning. It has been suggested that deviations from the typical diurnal cycle of cortisol may provide valuable information regarding environmental influences on the HPA axis and the role of the HPA axis in disease processes (Carney et al., 2001).

Additional less well considered neuroendocrine pathways that are altered upon stress include increases in prolactin and decreases in testosterone. Additionally, activation of the HPA axis leads to decreases in activity in the hypothalamic-pituitary-growth hormone pathway and in the reproductive pathways leading to changes in reproductive hormones in men and women.

3. Defining workplace stressors (“work stress”)

There are three main validated models of work stress. The demands/control/support model (Karasek and Theorell, 1990) measures three factors: psychological job demands, decision latitude (or job control) and social support at work. Job strain, a measure of workplace stress, can be derived from the demands/control/support model and posits that people working in jobs that are simultaneously characterised by high demands and low control are at risk of stress-related ill health and disease. Iso-strain, a related measure of workplace stress, hypothesises that people experiencing job strain and who are simultaneously socially isolated (experience low work social support) carry even higher risk for disease.

The theoretical approach of the effort–reward imbalance (ERI) model is focused on the notion of social reciprocity where efforts are equalized by respective rewards (Siegrist, 1998). Failed reciprocity resulting from a violation of this norm elicits strong negative emotions and sustained stress. Related to effort–reward imbalance, overcommitment at work is an additional work place stressor, which may lead to conditions of high effort/low reward.

Organisational justice refers to the extent to which employees perceive workplace procedures, interactions and outcomes to be fair in nature (Elovainio et al., 2002). There are two main components. Relational justice refers to the extent supervisors consider their employees’ viewpoint, are able to suppress personal biases, and take steps to deal with subordinates in a fair and truthful manner. Procedural justice involves the fairness of formal decision-making procedures.

4. Recent reviews linking workplace stressors to neuroendocrine responses

There have been two recent reviews on workplace stressors and neuroendocrine responses. One focussed on physiological changes in blood and urine (Hansen et al., 2009) while another focussed on the cortisol awakening response (Chida and Steptoe, 2009). The Hansen et al. (2009) review found 11 studies that linked adverse psychosocial working conditions with urinary catecholamines, while a further four studies showed no association. The review did not find any evidence for an association between work stress and lower levels catecholamines. This review also did not report any studies on work stress and plasma catecholamines.

The Hansen et al. review also concluded that there are no consistent associations between cortisol in serum or urine and the psychosocial working environment. In contrast, the Chida and Steptoe (2009) review concluded there is a positive association between work stress and the cortisol awakening response. The reasons for this discrepancy may partly lie in the nature of the studies reviewed (predominantly urinary cortisol samples for the Hansen et al. review, while the Chida and Steptoe review included saliva samples), and also in the inclusion of differing sampling