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Author: Krajnak, Kristine M.

Source: Environmental Health Insights, 8(s1)

Published By: SAGE Publishing

URL: <https://doi.org/10.1177/EHI.S15263>

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Supplementary Issue: Occupational Health and Industrial Hygiene

Potential Contribution of Work-Related Psychosocial Stress to the Development of Cardiovascular Disease and Type II Diabetes: A Brief Review

Kristine M. Krajinak

Engineering and Controls Technology Branch, Health Effects Laboratory Division, National Institute for Occupational Safety and Health, Morgantown, WV, USA.

ABSTRACT: Two of the major causes of death worldwide are cardiovascular disease and Type II diabetes. Although death due to these diseases is assessed separately, the physiological process that is attributed to the development of cardiovascular disease can be linked to the development of Type II diabetes and the impact that this disease has on the cardiovascular system. Physiological, genetic, and personal factors contribute to the development of both these disorders. It has also been hypothesized that work-related stress may contribute to the development of Type II diabetes and cardiovascular disease. This review summarizes some of the studies examining the role of work-related stress on the development of these chronic disorders. Because women may be more susceptible to the physiological effects of work-related stress, the papers cited in this review focus on studies that examined the difference in responses of men or women to work-related stress or on studies that focused on the effects of stress on women alone. Based on the papers summarized, it is concluded that (1) work-related stress may directly contribute to the development of cardiovascular disease by inducing increases in blood pressure and changes in heart rate that have negative consequences on functioning of the cardiovascular system; (2) workers reporting increased levels of stress may display an increased risk of Type II diabetes because they adopt poor health habits (ie, increased level of smoking, inactivity etc), which in turn contribute to the development of cardiovascular problems; and (3) women in high demand and low-control occupations report an increased level of stress at work, and thus may be at a greater risk of negative health consequences.

KEYWORDS: review, stress, sex differences

SUPPLEMENT: Occupational Health and Industrial Hygiene

CITATION: Krajinak. Potential Contribution of Work-Related Psychosocial Stress to the Development of Cardiovascular Disease and Type II Diabetes: A Brief Review. *Environmental Health Insights* 2014;8(S1) 41–45 doi: 10.4137/EHI.S15263.

RECEIVED: September 16, 2014. **RESUBMITTED:** October 14, 2014. **ACCEPTED FOR PUBLICATION:** October 16, 2014.

ACADEMIC EDITOR: Timothy Kelley, Editor in Chief

TYPE: Review

FUNDING: Author discloses no funding sources.

COMPETING INTERESTS: Author discloses no potential conflicts of interest.

DISCLAIMER: The findings and conclusions in this report are those of the author and do not necessarily represent the views of the National Institute for Occupational Safety and Health.

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CORRESPONDENCE: Ksk1@cdc.gov

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Introduction

Cardiovascular disease and Type II diabetes are two diseases that fall into the top 10 causes of death worldwide.¹ According to the World Health Organization, cardiovascular dysfunction resulting in heart attacks, hypertension, and stroke can be classified as cardiovascular disease.¹ Type II diabetes is characterized by insulin insensitivity, increases in circulating glucose levels, and increases in circulating inflammatory factors.² Although cardiovascular disease and Type II diabetes can occur independently in individuals, many people

diagnosed with Type II diabetes will develop cardiovascular disease if their diabetes is left untreated. Thus, reducing the prevalence of Type II diabetes is likely to result in a reduction in the prevalence of cardiovascular disease (<http://www.nhlbi.nih.gov/health/health-topics/topics/dhd/>).

The etiology of both these diseases is complex, and work-related factors may contribute to, or increase, the risk of their development. Work-related stress is one factor that has been implicated in increasing the risk of developing these diseases.³ However, the studies examining the association between



work-related stress and the risk of developing Type II diabetes and heart disease are inconclusive. Some studies suggest that there may be a direct association between stress and disease development, whereas other studies suggest that work-related stress serves as a risk for adopting poor health behaviors.⁴ Although both men and women experience work-related stress, studies have suggested that women may be more susceptible to the effects of work-related stress. The goal of this review was to summarize the results of studies that have examined the effects of work-related stress on the cardiovascular system. The studies that were chosen focus on the effects of stress in women, or take into account the worker's sex as a factor when determining if work-related stress contributes to the development of Type II diabetes and cardiovascular disease. This review provides additional information regarding women because cardiovascular disease is the primary cause of death in women, and recent studies suggest that the symptoms and etiology of heart disease may be different in women than in men.⁵

Women in the Workforce

In 2008, the International Labor Organization issued a report describing worldwide trends of women in the workplace.⁶ According to this report, there was a significant increase in the number of women entering the workforce worldwide over the last decade. However, when all women of working age were considered (ie, 15–55 years of age), the number of women entering the workforce still lagged behind the number of men. In the United States, approximately 47% of the workforce comprised women. According to the US Bureau of Labor Statistics (2011), women are primarily employed in the following positions: professional occupations (eg, physicians, lawyers, and architects; 57% of the employees are women and 43% are men); sales and office positions (women 61.9% and men 38.1%); and service-related occupations (eg, restaurant work, automotive repair, teachers, etc; women 56.6% and men 43.4%). Although female workers are predominantly found in the positions listed above, women are working in virtually every sector of the workforce. Thus, understanding how various work-related factors, such as stress, affect women is important for maintaining a healthy workforce.

Stress and Work

Occupational stress can be defined as a negative physiological and psychological response to work-related conditions. The National Institute for Occupational Safety and Health reported that one quarter of the workers in the US say that their jobs are the number one source of stress in their lives.⁷ The conditions that induce stress may be psychological (ie, perceived stress due to work organization or personal factors), physical (ie, heavy work load, long working hours, and/or shift work), or a combination of both.⁸ To understand how work-related stress is correlated with the development of disease, personal reports of stress and the results of psychological

tests measuring stress are usually collected in addition to physiological or biological markers. Self-reports and biological measures of stress, along with other health-related factors are then used to determine the potential contribution of stress to the development of disease.

A number of different self-report scales have been used to assess psychological stress, including the Job Control Questionnaire (JCQ⁸). This questionnaire assesses work as high or low work demand, and high or low control over working conditions, resulting in four different levels of work-related stress. Women who report being stressed at work tend to report their highest levels of stress when in positions where there are high job demands, but they have a low level of control over how they perform their job. For example, in a literature review of eight studies from three countries, Toivanen⁹ found that high job demand and low control were associated with an increased risk of developing cardiovascular disease and stroke in both men and women. However, the incidence of stress-related stroke tended to be higher in women than in men. In another study, a smart phone app was used to measure heart rate in 40 healthy female managers (25–45 years of age) in various public and private sectors of employment in Sweden. Subjects provided subjective ratings of their level of stress at work. Subjects were asked to report their level of stress when heart rate was high. They were also asked to report stress levels at random times during the day. In both cases, increases in stress were associated with increases in heart rate. Women who reported chronic work-related stress showed greater increases in heart rate during these acute measurements than women who ranked low on ratings of long-term stress. Because repetitive or maintained increases in heart rate in response to stress can be associated with increases in blood pressure, it was concluded that women in the higher stress category may be at a greater risk of developing cardiovascular disease.¹⁰ Analyses of the effects of workplace stress were also performed on data collected from 89 middle-aged male and female workers in the Belgian Job Stress Project. Stress was assessed using the JCQ. Cardiovascular function was measured at work, at home, and while subjects were asleep, using ambulatory blood pressure. Ambulatory blood pressure levels were higher when all subjects were at work than when they were at home. Workers with the highest job strain scores had higher blood pressure levels at home and at work than workers with lower job strain scores. Because increases in blood pressure are often indicative of metabolic disorder (a condition that precedes the development of Type II diabetes and is associated with pre-clinical increases in circulating glucose), or impending cardiovascular disease, it was concluded that the workers displaying chronically elevated blood pressure may be at a greater risk of developing a cardiovascular health-related disorder.¹¹ Finally, in a pair of studies using data collected as part of the WHO Monitoring of Trends and Determinants in Cardiovascular disease project, data from men and women (25–64 years of age) were analyzed to determine the association between job stress (assessed using

the JCQ) and the risk of developing Type II diabetes or cardiovascular disease.^{12,13} The cohort included three independent cross-sectional and population-based surveys collected between 1984 and 1995. Data were collected from 6725 men and 6702 women. Increases in job stress were associated with an increased risk of developing diabetes and coronary heart disease in men and women even after being adjusted for other risk factors such as smoking, physical activity, and cholesterol. Stress was also associated with an increase in a number of pro-inflammatory factors. These inflammatory factors can be used as indicators of impending disease or to diagnose diabetes or cardiovascular disease.

Other studies suggest that job-related stress may not directly increase the risk of developing coronary heart disease and/or Type II diabetes, but instead indirectly increase the risk of developing these diseases by contributing to increases in unhealthy behaviors. In the Buffalo Cardio-metabolic Occupational Police Stress (BCOPS) study, the association between workplace stress and the risk of developing metabolic syndrome was assessed in 710 police officers from Buffalo, New York, between 2004 and 2007. The Spielberger police stress survey was used to obtain subjective ratings of perceived stress on a scale from 0 to 100 (0 is no stress; 100 is very stressful). Both men and women rated physical and psychologically threatening events as most stressful. However, the ratings were higher in women. In addition, women reported a higher mean rating for a lack of support. In contrast, males rated administrative and organizational events as more stressful. Although both sexes reported specific classes of events as stressful, there was only an association between the symptoms of metabolic disorder and stress levels in women. This may be because of the perception of the lack of support, or the fact that there are more male than female police officers. Women police officers also were more likely to smoke than males in this study. It is possible that the increased stress levels perceived by the female officers, and the increase in smoking, contributed to the development of metabolic disorders in women.¹⁴ In another study using a cohort of civil servants, the model for predicting the risk of developing cardiovascular disease in the Framingham risk score was reanalyzed, adding the results of a questionnaire assessing job demand, decision latitude, and social support (ie, job strain). Although job strain was associated with an increased risk of developing coronary heart disease, other factors such as socioeconomic status, C-reactive protein (a marker of cardiovascular dysfunction), and carotid-intima media thickness were better predictors for developing the disease.¹⁵ Other studies performed by the Individual Participant Data Meta-Analysis of Working populations consortium followed the development of hypertension and cardiovascular disease in European men and women between 1984 and 2003. These studies found that job strain did increase the risk of developing diabetes and cardiovascular disease in both men and women. Job strain was also associated with an increase in smoking, a decrease in physical activity, and an increase in

obesity. These additional indices of health were also associated with an increased risk of developing coronary heart disease and Type II diabetes.^{4,15,16} In a study examining the effects between job strain and lifestyle on subjective ratings of personal health in workers within various government departments and high-tech enterprises in China, job strain was associated with poor health habits, lower health ratings, and feelings of lack of control only in government workers.¹⁷

Mitigating the Effects of Work-Related Stress

There are a number of factors that help alleviate the effects of work-related stress in women. The development of social support groups has been shown to have a positive impact and reduce perceived stress in women.¹⁸ Providing more control over the working environment has also been shown to reduce perceived workplace stress in women. When women are offered more control and allowed to make more decisions, perceived stress levels are reduced.^{19,20} Women also tend to benefit from peer groups within the workplace setting. In healthcare providers, the ability to talk with peers going through similar circumstances reduced perceived levels of stress.²¹ There are also interventions that may help both men and women cope with work-related stress. For example, participating in outside activities and hobbies can help reduce psychological effects of stress. In Sweden, workers participating in a group gardening program reported an improvement in burnout, feelings of fatigue, and self-rated productivity.²² A statement issued by the American Heart Society also reviewed the literature and supported a study that showed that owning a pet, especially a dog, increased exercise and reduced hypertension and other measures of cardiovascular disease in participants.²³ The implementation and participation in wellness programs also helps reduce stress and improves overall health of workers. In nurses, increased physical activity and improving sleep were associated with a reduced risk of cardio-metabolic dysfunction.²⁴ A review of worksite health and wellness programs in the U.S.¹⁸ showed that participation in worksite wellness programs resulted in weight loss and improvement in indices of cardiovascular dysfunction, such as high blood glucose and cholesterol levels. A study assessing stress and sleep deficiency in registered nurses found that maintaining good sleep and exercise patterns positively influenced modifiable 10-year cardiometabolic risk, defined as maintaining body weight, healthy levels of cholesterol, and systolic blood pressure within a normal range, and thereby reducing the risk of developing a cardiovascular disorder.²⁴ In workers occupying lower paying jobs, improved access to healthcare and education regarding healthy habits and stress can help reduce the risk of developing chronic diseases.

Biomarkers for Measuring Stress

Many of the studies mentioned above have also used physiological markers to assess stress and determine its effects on health. Biomarkers may be good candidates to use as more objective indicators of stress. Salivary cortisol is a traditional



marker of stress. However, to use cortisol as a marker, samples need to be collected at the same time during the day, and food intake prior to sample collection needs to be controlled.²⁵ For example, a study looking at the relationship between stress, fatigue, sleep, and waking cortisol showed that disrupted sleep patterns and stress were associated with a disruption in waking cortisol pattern.²⁶ In contrast, a study of primarily female teachers in Malaysia from seven secondary schools used the JCQ to assess stress levels and measured cortisol and immunoglobulin A (IgA). IgA is a salivary and serum biomarker that changes in response to psychosocial stress. Reductions in IgA are often indicative of a reduction in functioning of the immune system.²⁷ Teachers in the 31–40 years bracket and who were involved in educating handicapped children, and those without supervisory support showed higher stress and lower IgA levels.²⁷ Teachers with 5 to 10 years of experience vs teachers with less than 5 years displayed higher job strain scores. However, there was no correlation between job strain and cortisol levels in any of these groups.²⁸ The differences in these two studies may have had to do with the timing of the cortisol measure and the fact that the stress induced by the sleep disruption in the police study may have been more severe. Takaki et al.^{29,30} showed an association between stress levels and activation of the vascular endothelial nitric oxide (NO) system by measuring circulating nitrate/nitrite (NO_x) concentrations. Stress induced changes in this system in women, but not in men. Thus, it may be possible to use circulating NO_x levels as a marker to assess stress-induced cardiovascular disease in women. Changes in pro-inflammatory markers and work-related stress levels are also associated with an increased risk of cardiovascular disease. However, as with the markers of NO activity, additional studies are needed to show that these markers are reliable and specifically induced by stress or some stress-related behavior. Finally, in a study using the BCOPS cohort,³¹ the association among work-related stress, carotid intima media thickness (assessed by ultrasound), and the presence of symptoms of metabolic syndrome was assessed in male and female police officers. This study demonstrated that carotid media intima thickness was positively associated with the symptoms of metabolic syndrome and an increased level of stress in women, but not men. Although there are a number of factors that may underlie the different responses of the carotid intima media thickness to metabolic syndrome in males and females, this study demonstrates that thickness of the carotid may be a potential indicator of impending cardiovascular dysfunction in females and may potentially be used to assess the effects of work-related stress on the cardiovascular system.

Confounding Factors when Assessing Stress

The inconsistent results regarding the effects of work-related stress on the development of Type II diabetes and cardiovascular disease may be the result of a number of different factors. For example, data were collected from workers performing different tasks, and, therefore, the challenges

and potential stressors each group of workers experienced may be different. Furthermore, some studies examined the short-term effects of stress while others examined the effects of work-related stress prospectively over long periods of time. The tools or questionnaires used to assess stress levels were different across studies. This may be because cultural aspects influence responses to job stress. The JCQ has been validated and it appears to be predictive of work-related stress in European and Asian cohorts, but not in cohorts from the United States.⁸ Race can also act as a confounding factor. In South African teachers, stress-related activation of the L-arginine/NO system in the vascular endothelial cells of black teachers was more prevalent than in white teachers. The increase in activity in the NO system was characterized by higher NO_x , L-arginine, and perceived stress levels in black than in white teachers.³²

Conclusions

This brief review summarizes some of the findings regarding the association between work-related psychosocial stress and the effects it may have on the development of cardiovascular disease and Type II diabetes. This review is in no way exhaustive; most of the studies reviewed focus on jobs that are traditionally considered white collar positions. Additional studies examining the effects of physical stress, stress in workers in other sectors and industries, and how stress in the workplace may exacerbate stress or problems at home that contribute to the development of cardiovascular disease and Type II diabetes are needed. However, based on the current data, it appears that work-related stress may indirectly influence the risk of developing cardiovascular disease by increasing unhealthy behaviors that increase the risk of developing Type II diabetes. Studies suggest that social factors, such as developing support groups, and wellness programs may reduce the risk of developing negative health effects or habits associated with the development of the negative health effects, and thereby reduce the incidence of heart disease and Type II diabetes in these workers.

The reviewed studies also examined the effects of sex on the development of these chronic diseases; cardiovascular disease is now the number one cause of death in most women, and the symptoms and possibly the etiology of the disease may be different in men and women. The studies above suggest that work-related stress can contribute to the development of these chronic diseases in women. There are many other factors in addition to work-related stress to increase the risk of developing chronic disease. These include, but are not limited to, ethnicity of workers, stress related to home and family life, and exposure to other workplace and environmental factors that can negatively impact cardiovascular function. Future research examining how these various factors contribute to the development of these diseases in women and men is important for developing approaches that can be used to reduce the incidence of these diseases.

Author Contributions

KMK conducted the review of the literature and wrote the manuscript. The author reviewed and approved the final manuscript.

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