Can stress cause coronary heart disease?

Coronary heart diseases have become the leading cause of death in Western society, and their development is associated with various physiological risk factors and psychosocial factors, for example stress (Brydon, Magid & Steptoe, 2006). A good understanding of how stress affects coronary heart diseases is necessary in order to try to prevent or stabilize development of cardiovascular diseases. The aim of this essay is not to fully clarify all biological processes involved in the development of these diseases as these are very complex and their understanding requires full medical training; however basic explanation will be offered in order to point out main pathways. Furthermore, psychology has limited ways in which it can influence human biology and therefore more attention will be devoted to identifying some common stressors and their connection with the development of coronary heart diseases as examples of existing links between stress and illness.

Coronary heart diseases consist of a set of conditions (e. g. myocardial infarction, left-ventricular dysfunction and dysrhythmia) resulting from the process of coronary atherosclerosis which leads to accumulation of plaque in coronary arteries. The atherosclerotic process is very complex; involving various immune, inflammatory and hemodynamic processes; and it usually takes many years to develop. Various psychosocial and behavioural variables usually come into the equation and make the understanding of the development of coronary heart diseases even harder to grasp (Krantz & McCeney, 2002)

Stress is a complex phenomena, that occurs when demands exceed our adaptive capacity and resources and this misbalance results in physiological

changes that might influence health. However, an individual's appraisal is important in determining responses to stress and assessing situations as stressful in the first place (Holmes, Krantz, Rogers, Gottdiener & and Contrada, 2006). It is important to differentiate chronic and acute stress as these have diverse characteristics and influence the development of coronary heart diseases in different ways. Chronic stress is long lasting and influences an individual over a period of time. Most commonly recognized chronic stressors include occupation (e. g. job demand, job latitude), social relationships (e. g. marital or family conflict), and the environment (e. g. high-crime neighbourhood). On the other hand acute stress involves temporary changes resulting from brief aversive events often of abrupt onset, and both unpredictable and uncontrollable (e. g. natural or man made disasters) (Holmes et al, 2006). Stress elicits measurable changes in the sympathetic nervous system and hypothalamic-pituitary-adrenal axis (HPA axis) which influence the cardiovascular system. Chronic stress has the potential to accelerate the atherosclerotic process. On the other hand, acute stress may cause myocardial infarction, left-ventricular dysfunction and dysrhythmia (Brotman, Golden & Wittstein, 2007). A more detailed description of these processes will be offered within the main body of this essay; however, a brief outline was necessary to introduce the reader to the topic and to provide a rationale for describing the effects of acute and chronic stress separately. Therefore, two main sections will form this essay; firstly the effects of chronic stress on coronary heart diseases will be described in light of current literature. According to literature it appears that chronic stress potentially has the power to influence the development of physiological risk factors, for example hypertension and obesity, but in

addition has its independent effect. Furthermore through promoting the atherosclerotic process it makes individuals more susceptible to the influence of acute stress, which might have left healthy people unaffected. However, as it will be discussed in the second section, very severe acute stress has the strength to evoke cardiovascular episodes in healthy individuals as well.

Chronic stress and coronary heart disease (CHD)

First of all it is important to briefly introduce possible mechanisms and the biological effect of stress on the human body. The main neural system that controls the activation of the stress response is located in the hypothalamus and brainstem. Corticotropin-releasing hormone from the hypothalamus activates the hypothalamic-pituitary-adrenal axis (HPA axis) which in turn stimulates the production of glucocglucocorticoids (mainly cortisol), which play an important role in stress response. Another complex system that plays an important role is the sympathetic nervous system which mediates the brain connection to the internal organs, especially the heart, through release of catecholamines (e. g. noradrenaline, adrenaline). Both systems potentially harm the coronary system through increasing blood pressure, decreasing insulin sensitivity and affecting platelet and thrombotic functions. However, these two systems also have some differences in the way they affect the cardiovascular system, for example glucocorticoids suppress resting heart rate and inflammation, whilst sympathetic activity increases the resting heart rate and inflammation response. Although it is impossible to artificially split these two systems, the body responds to chronic stress mainly through HPA axis and alteration in cortisol levels. Presence of chronic

stress is associated with higher levels of cortisol (glucocorticoid). However, in some forms of chronic stress, for example in post-traumatic stress disorder, blunted HPA axis can be present and decreased cortisol secretion is then compensated for by sympathetic hyperactivity. Therefore simple dualism of attributing cortisol to chronic stress and calecholamines to acute stress is impossible as these two systems are closely interlinked. (Brotman et al, 2007; Torres & Nowson, 2007) The effect of circulating glucocorticoids and catecholamines does not depend solely on their level, but also on receptive tissue, on the amount of local receptors and other chemical compounds that alter these hormones. Therefore just measuring levels of stress hormones as indicators of stress and possible damage is not a straight forward and completely reliable procedure. (Torres & Nowson, 2007).

The effect of chronic stress on coronary heart disease (CHD) appears to be twofold. Yet, it is impossible to prioritise one effect over the other and therefore both will be discussed as being equally important. Firstly, literature suggests that chronic stress might have an influence on physiological risk factors of coronary heart disease (Sparrenberger, Ascoli, Fonseca, Weiss, Berwanger, Fuchs, Moreira, Fuchs, 2009; Logan & Barksdale, 2008; Torres & Nowson, 2007; Kuo, Czarnecka, Kitlinska, Tilan, Kvetnansky & Zukowska, 2008) and these furthermore increase the risk of cardiovascular diseases (Bhattacharyya & Steptoe, 2007; Brotman et al, 2007; Brydon et al, 2006). Secondly, chronic psychosocial stress seems to have unique independent contribution towards the risk of development of coronary heart diseases according to current research (Rosengren, Hawken, Ôunpuu, Sliwa, Zubaid,

Almahmeed, Blackett, Sitthi-amorn, Sato & Yusuf, 2004; Price, 2004; Kuper & Marmot, 2003; Augustin, Glass, James, Schwartz, 2008).

It has been pointed out in the literature that the following physiological factors influence the long-term etiology of coronary heart disease: hypertension, hyperlipidemia, inactivity, obesity, insuline resistance, diabetes and cigarette smoking (Brotman et al, 2007; Brydon et al, 2006; Bhattacharyya & Steptoe, 2007). Association between chronic stress and some of these factors will be discussed in greater detail as an example. Sparrenberger at al, (2009) conducted a systematic review of literature investigating the connection between stress and hypertension. Authors found that within the literature there is reasonable evidence supporting the hypothesis that chronic stress, but not acute stress, presents a risk factor for sustained elevation of blood pressure. As mentioned above the possible mechanism responsible for increase in blood pressure is the release of stress hormones, mainly cortisol and catecholamines. (Brotman et al, 2007; Torres & Nowson, 2007). Hypertension, as a risk factor, is associated with arterial abnormalities, such as vessel stiffness, thickening of heart muscle and increase atherosclerotic plaques (Logan & Barksdale, 2008). Although Sparrenberger at al, (2009) based their conclusion on a systematic review of the literature the selection procedure of the articles and their quality assessment remains unclear and therefore their findings need to be understood with some caution. Similar limitations are posed on the finding of Torres & Nowson (2007) literature review, pointing out the possible link between stress and food intake. Nevertheless, there seems to be some evidence suggesting that chronic stress is associated with consumption of

hedonic and energy dense foods and therefore could lead to weight gain. So far, this relationship does not seems to be straight forward, as results of some studies suggest that stressor severity, gender and ethnic differences might play an important mediating role in this relationship and therefore this needs to be investigated further (Torres & Nowson, 2007). Another example of the effect of chronic stress on physiological risk factors is the research of Kuo et al, (2008) who concentrated on obesity. They found that chronic stress combined with a high fat and high sugar diet upregulates the sympathetic neurotransmitter, neuropeptide Y, and also leads to increase in glucocorticoids, which yet again increase the secretion of neuropeptide Y and it's receptors in fat tissue. Stimulation of these receptors leads to fat growth mainly in abdominal area which is associated with increased risk of heart diseases. In time, inflammation of fat tissue can occur, which than can lead to changes such as hyperinsulinemia and hyperlipidemia, and to metabolic syndrome, which again is associated with increased risk of heart diseases (Kuo et al, 2008). The great disadvantage of these findings is that they are based on animal studies and therefore not easily transferable to the human population. Further research with people is needed to support these findings. Moreover, it might be difficult to separate other possible influences that could increase glucocorticoids levels which were not controlled in this study but could apply in human research, for example personality types. Sher (2005) pointed out that increased cortisol levels are observed in people with type D personality (characterized by negative affectivity and avoidant or inhibited behaviour) when experiencing stress. Cortisol is a potent body chemical that increases risk of coronary heart disease. Cortisol additionally inhibits the growth hormone and gonadal axes which in turn are associated

with higher relative risk for premature cardiovascular disease. Cortisol’s inhibition of the growth hormone and gonadal axes influnces visceral fat accumulation which releases free acids into circulation and this leads to dyslipidaemia and to insulin resistance (Espel, McEwen, Seeman, Matthews, Castellazzo, Brownell, Bell & Ickovics, 2000). Consequently, careful approach is needed when conducting research with complex human beings.

Although the above physiological risk factors of coronary heart diseases are important in its etiology and stress appears to be contributing to their development, research suggests that psychosocial stress might be able to influence set off and progress of cardiovascular diseases independently. Augustin et al, (2008) found in their research that neighborhoods that had higher levels of psychosocial hazards (violent crime, abandoned buildings, etc) were associated with significantly higher odds of self-reported cardiovascular diseases. Although this study concentrated on a large sample (n= 1140) considerable limitations are posed by the fact that it is a cross-sectional study based on self-reports, and therefore, no causal attributions can be assumed. Furthermore, various coronary risk factors (e. g. hypertention, BMI index, smoking status, activity level etc.) were not controlled and this limits the credibility of the results. Nevertheless, it is an interesting finding that could inspire further research of a better quality. A better quality research is available in the area of work stress and its affect on coronary heart diseases. Kuper & Marmot (2003) analysed data from Whitehall II study and found that employees whose job role is associated with high demands and low decision latitude are at higher risk of coronary heart diseases, even if some of the other confounding risk factors (e. g.

smoking, cholesterol levels, blood pressure, exercise, alcohol consumption, BMI, employment grade and SES) are controlled. High job demands were associated with future occurrence of CHD, for both men and women, whereas low decision latitude was predictive only in men. Credibility of these results is supported by the power of the study (N= 10 308) and by the design as the Whitehall II study was prospective, allowing for some careful causal attributions. Very similar findings were identified in another study conducted by Price (2004) who also in his literature review pointed out another import aspect of job role and that is high effort – low reward misbalance that have very similar effect on occurrence of coronary heart disease as high-demand and low control misbalance. Furthermore, he pointed out that other aspects of the work environment need to be controlled when conducting research on work stress. For example, either a too hot or too cold environment can trigger changes in cardiovascular systems that can occur in healthy individuals as well. Also vibration and exposure to chemicals (e. g. Carbon disulfide, Carbon monoxide, Nitrate esters), prolonged and/or repeated, can impair coronary system. Consequently, further research is needed that would acknowledge these factors, include them and control them in study design in order to provide stronger evidence of the association between psychosocial work stress as an independent factor and cardiovascular diseases. Possibly one of the strongest research findings available in the current literature is the result of a massive international cooperation of researchers lead by Rosengren. Rosengren et al, (2004) conducted a very comprehensive international study investigating the relationship between psychosocial stress and myocardial infarction. This study was conducted on 12 461 participants with previous

myocardial infarction and 14 637 age, sex and site-matched controls free of heart diseases and all participants were recruited from 52 countries. Compared with the control group, the cases group reported significantly higher rates of stress at work, home and financial stress and also reported more stressful life events (e. g., intra-family conflict, death of spouse, violence etc). The effect of psychosocial stress was consistent across geographic regions and in different age groups and it was independent of socioeconomic status (e. g. education and income), gender and smoking. The higher risk of acute myocardial infarction in the case group was still significant after adjusting for other cardiovascular risk factors, for example hypertension, diabetes, level of physical activity, waist/hip ratio, dietary patterns, alcohol, or raised plasma lipids. Therefore, this study offers comprehensive and systematic evidence of the existing relationship between chronic psychosocial stress and heart disease independent of known physiological risk factors.

As described above there is existing evidence supporting the notion that chronic stress influences the development of cardiovascular diseases through activation of two main biological system (HPA axis and sympathetic nervous system) which potentially harm the coronary system through increasing blood pressure, decreasing insulin sensitivity and affecting platelet and thrombotic functions. Prolonged or repeated activation of these systems can lead to atherosclerosis. Atherosclerosis is the inflammatory process during which leukocytes interact with dysfunctional endothelium of veins and these changes lead to increased recruitment of leukocytes, lipids, smooth muscle cells and platelets to the arterial wall. Repeated cycles of

these changes cause build up of arterial plaque. Because psychological stress activates sympathetic system and HPA axis and these stimulate production of platelets, it is hypothesized that this is the pathway in which stress increases risk for the development of coronary diseases (Brydon et al, 2006). Existence of atherosclerosis is one of the factors that predispose people to be more vulnerable to acute stress which is the main focus of the second half of this essay.

Acute stress and coronary heart diseases

The pathophysiological processes underlying the effect of acute stress on coronary heart diseases are not fully understood yet but some of the processes include the following reactions. Mental stress can trigger increased secretion of adrenaline and the activation of the sympathetic nervous system involving preferentially sympathetic outflow to the heart whereas sympathetic outflow to skeletal muscles vascular system changes little or may even fall. Cortisol plays insignificant role in acute mental stress triggering coronary episodes (Esler, Lambert & Alvarenga, 2008; Torres & Nowson, 2007; Bhattacharyya & Steptoe, 2007). However literature is not completely united on this last notion as there are current studies pointing out the effect of cortisol during all types of stress including acute stress (Brotman et al, 2007). Further research comparing both cortisol and adrenaline functions in acute stress and their influence on cardiovascular disease would be needed to resolve this discrepancy. Sympathetic outflow to the heart can cause lethal cardiac arrhythmias and coronary artery vasoconstriction in the presence of coronary artery narrowing and myocardial ischaemia. Furthermore, secretion of adrenaline can activate

platelets, increasing risk of thrombosis, and reduce serum potassium concentrations which can disrupt cardiac rhythm. Emotional stress stimulates vagal withdrawal, increases circulation of interleukin-6 and other inflammatory markers. The increased blood pressure associated with acute mental stress can fracture atherosclerotic plaques and possibly lead to myocardial infarction. (Esler at el, 2008; Bhattacharyya & Steptoe, 2007; Strike, Magid, Whitehead, Brydon, Bhattacharyya & Steptoe, 2006; Holmes et al, 2006; Kloner, 2006; Klot, Mittleman, Dockery, Heier, Meisinger, Hormann, Wichmann & Peters, 2008; Krantz & McCeney, 2002). However, not all of these biological processes have been studied in current well-controlled experimental research. The downfall of Esler et al, (2008) interpretations is that they are not based on current behavioural experiments but rather a further interpretation of his experiments done in 1989 in light of current literature. While validity of his interpretation cannot be critically evaluated, nevertheless, it is an interpretation generally supported by literature (Strike et al, 2006; Bhattacharyya & Steptoe, 2007; Kolt et al, 2008). On the other hand, Bhattacharyya & Steptoe (2007) have based their comprehensive literature review and their interpretation and analyses of nearly 100 articles published within last 20 years with the majority of them being published in the last 10 years and therefore offer greater support for the links between acute stress and coronary diseases.

An important predisposing factor for an effect of acute stress on heart and circulatory systems is pre-existing, but not necessarily diagnosed, atherosclerotic coronary artery narrowing, although it is possible that emotional stress that is particularly severe can potentially elicit clinical

events in patients who do not have underlying CHD (Esler at el, 2008; Bhattacharyya & Steptoe, 2007). For example, severe acute emotional stress can stimulate a specific type of myocardial dysfunction associated with left ventricle. Catecholamine (adrenaline and noradrenaline) surge might be the primary factor that leads to myocardial stunning. This myocardial stunning is usually temporary, lasts a few days only, and is generally associated with full recovery (Brotman et al, 2007; Ueyama, Kasamatsu, Hano, Tsuruo & Ishikura, 2008; Wittstein, Thiemann, Lima, Baughman, Schulman, Gerstenblith, Wu, Rade, Bivalacqua & Champion, 2005). Furthermore, Strike et al (2006) pointed out in his laboratory experiment that some people are more likely or predisposed to react pathophysiologically to the stress. These biological differences are most likely regulated by autonomic and neuroendocrine activation at the subcortical level as the experimental group in their research reported about the same levels of stress, anxiety and depression and difficulty of the task as the control group. In this experimental study, emotional triggering of acute coronary syndrome was associated with increased psychophysiological responses (e. g. greater platelet activation, cardiac output responses), and delayed poststress recovery of systolic blood pressure and cardiac output in experimental group who reported that their initial acute coronary syndrome was induced by negative emotion (e. g. stress, anger, depression). These effects remained unchanged after controlling for covariates such as age, BMI, smoking status, and medication status. However generalisability of these results is limited as this experiment was conducted on a small sample (N= 34) of men only as there were too few women in the clinical study from which this sample was drawn and consequently women were fully excluded. Therefore, further

investigations are needed. This might however prove difficult as women are often underrepresented in heart disease research (Steinberg, Arshad, Kowalski, Kukar, Suma, Vloka, Ehlert, Herweg, Donnelly, Philip, Reed & Rozanski, 2004; Kolt et al, 2008; Peters, Klot, Heier, Trentinaglia, Hörmann, Wichmann & Löwel, 2004) for possibly many reasons but interesting are recent findings of Ueyama et al (2008) who reported that oestrogen attenuates the stress-induced hypothalamo-sympathoadrenal outflow from the central nervous system and also increases the levels of cardioprotective substances. However these biological reactions have been researched in experiments on laboratory rats and therefore are only hypothetically generalisable to the human population and further research is required.

The nature and unpredictability of acute mental stress makes it almost impossible to conduct behavioural experiments and it also raises ethical issues of experimenting not only with peoples' health but possibly their lives. Consequently there are very few prospective experimental studies and most of the research findings are based on ex-post facto data not allowing for measuring baseline or controlling of the intervention/phenomenon. There also does not seem to be a consensus in the literature as to what can be considered a trigger for acute stress and how long prior to the cardiac event would this have to have occurred, which can make it hard to differentiate between the effects of chronic and acute stress on the circulatory system. All these issues are clearly evident in two studies compared below, one conducted by Steinberg et al. (2004) and Kloner, Leor, Poole & Perritt (1997). Steinberg et al (2004) found that there was a significant increase (more than twofold) in the frequency of life threatening arrhythmias among patients with

implantable cardioverter-defibrillator in the 30-day period following the attack on the World Trade Centre (compared to 30-day period prior attack and up to 13 months after). However there were no arrhythmic events during first 3 days following the attack and delay in onset could suggest that patients suffered with subacute stress possibly induced by media coverage and also by the fact that only 5 participants out of 200 were actual eyewitnesses of the event. The latter can however turn into a strength of this study as the fact that participants were not likely subjected to strenuous physical exertion of running or other physical activity necessary to get to safety which can be confounding factor in earthquake studies one of which is discussed later. Although the strength of this study was that each cardiac event was measured by a very accurate electrogram, it also means that participants in this study already suffered with relatively serious coronary disease which was worsened rather than caused by the terrorist act. Therefore this research does not offer clear support for the causal effect of acute stress on heart disease merely its influential potential. Kloner et al (1997) studied the effect of The Northridge earthquake on the entire population of Los Angeles County based on the analyses of 19, 617 death certificates from Januarys 1994 (month of the earthquake), 1992 and 1993 (as comparison control months). They found a significant increase in deaths during January 1994 due to ischemic and atherosclerotic cardiovascular disease within the entire population which were not observed for other types of cardiovascular disease, cerebrovascular disease or noncardiac disease. This effect was observable immediately on the day of earthquake so there was no delayed reaction present in this study like it was in Steinberg et al. (2004) and therefore the acuteness of this stressor need not to be

questioned. Another great advantage of this study is that the proportion of men and women were about equal. However as mentioned before physical exertion can have individual, possibly independent, effect on cardiovascular disease according to Klot et al. (2008), who found a significantly increased risk of acute myocardial infarction associated with isolated episodes of vigorous exertion as opposed to the protective effect of regular physical exertion on risks. Nevertheless, although based on large sample of 1301 participants 77% of the studied population was male and it is a self-reported retrospective study of patients who suffered acute myocardial infarction following physical activity therefore generalisability is limited. Further evidence of the adverse effects of physical exertion on coronary syndromes is collated by Strike & Steptoe (2005) in their systematic review. Therefore, it can be concluded that the level of physical activity combined with physical fitness can be seen as confounding factors in research of various disasters and consequently this need to be included or controlled in future studies in order to provide clearer evidence for link between acute stress and heart diseases. Obviously replicability of these studies is impossible and therefore further explorations in this area would need to be done in controlled experimental conditions, the possibility of which is very limited due to the issues discussed above, for example ethical concerns.

However devastating and traumatic disasters are they do not generally happen very often and it is important to explore effects of acute stress in daily living situations. Peters et al (2004) have studied the association between exposure to traffic and cardiovascular disease. They analyzed time spent in traffic during 4 days prior myocardial infarction and they gained

these data through interviews conducted with 691 subjects. Strong point of this research is that authors conducted sensitivity and comparison analyses which showed that there was no considerable recall bias present in the study. An association was found between exposure to traffic and the onset of a myocardial infarction within one hour afterward, even after adjusting for level of exercise on a bicycle or for getting up in the morning, which are known risk factors for coronary syndromes (Strike & Steptoe, 2005; Kloner, 2006). An interesting finding was that this association was stronger in the subgroup of participants who were unemployed than in the subgroup of those who were employed and it would be interesting to see whether there was a significant difference between these groups in time spent in the traffic, which authors failed to investigate. Although people might not be commuting to work, they might be travelling considerably looking for work, attending interviews and being unemployed and/or finding it difficult to find a job are stressors that could explain this difference. Therefore, this discrepancy brings up again the question whether the effects of acute and chronic stress can really be separated.

Assessment of individual research studies can point out evidence and limitations of each piece of research but it does not say much of the overall evidence of the link between acute stress and coronary disease in the literature. Considering that conducting my own systematic review is out of the scope of this essay an already existing systematic review was identified to provide such scientific evidence. Strike & Steptoe (2005) systematic review of literature from 1970 to 2004 has shown that there is consistent evidence in current literature supporting the association of acute stress and

acute coronary syndromes in individuals with an underlying coronary condition, for example atherosclerotic narrowing. Understandably there are some limitations to the area of stress and coronary disease research but the complexity of life in itself and of human biology does not allow for perfect clear cut research evidence eliminating all confounding factors.

Conclusion

Presented research evidence suggests that there is a consistent connection between stress and coronary heart diseases, which are one of the main health threats in modern society. Therefore a good understanding of this relationship is necessary for the health psychologist in order to help promote health and design valuable interventions. However, some limitations of presented findings can be attributed to the author’s limited knowledge of physiological processes within the human body, which could lead to some misinterpretations. Nonetheless, on a very basic level literature suggests that chronic and acute stress affects health differently but they share some common ground as well. Both potentially harm the coronary system through increasing blood pressure, decreasing insulin sensitivity and affecting platelet and thrombotic functions.

Although research in this area seems to be substantial, there are some considerable limitations and restrictions that apply to it; therefore careful consideration of the findings is needed. First of all, most of the research is associative not allowing for causal attributions. Secondly, confounding variables are not well controlled in some research designs and therefore results could be fraudulent. Finally, most of the current literature is of a cumulative nature, consisting mostly of narrative and systematic reviews.

Although methodology of these reviews can be questioned, on the other hand they offer a synthesis of current knowledge. Nonetheless, future research needs to be of experimental design, or at least more prospective studies need to be conducted. This might, however, prove difficult as many ethical concerns would be raised by trying to experiment with people's health and well-being. Further exploration could also be aimed at possible gender and ethnical or cultural differences that might influence not only human biology but also their health behaviours, habits and beliefs. These findings could be very useful in designing future interventions for improving or maintaining health.

In conclusion, it is reasonable to assume that stress affects the health and development of coronary heart diseases in various ways and through many various stressors. Naturally there are some limitations to the research as it is impossible to control or consider all confounding variables and it is impossible to predict the occurrence of some stressors. However, research evidence is substantial enough to come to this conclusion. Consequently, it is important to recommend avoiding stressors as much as possible or cognitively reappraise them in a way that would take the stressful connotation away from the phenomena.