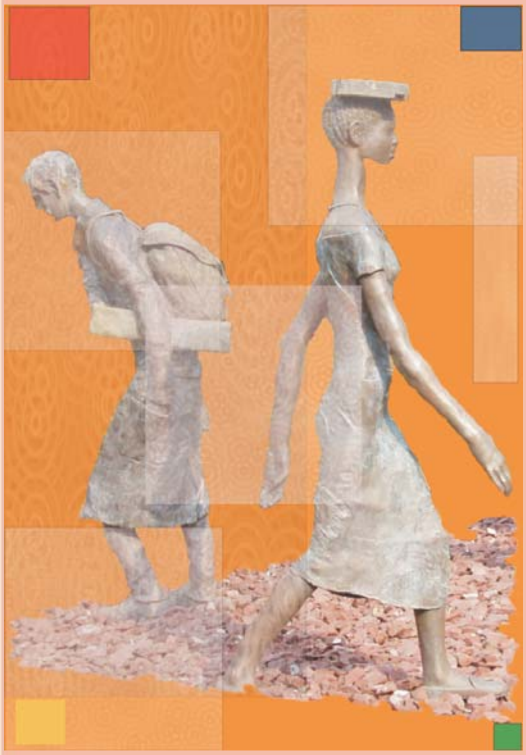
MARJA-LIISA KINNUNEN

ALLOSTATIC LOAD IN RELATION TO PSYCHOSOCIAL STRESSORS AND HEALTH



UNIVERSITY OF JYVÄSKYLÄ

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Marja-Liisa Kinnunen

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ABSTRACT

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This longitudinal study investigated the long-term effects of psychosocial factors on (AL) and the effects of AL on health. AL refers to the activation of various physiological regulatory systems in response to stress, as well as their immediate and long-term effects on the body (McEwen & Stellar, 1993). In the present study, AL was measured by eight variables: noradrenaline, dehydroepiandrosterone-sulfate, waist-to-hip ratio, glycosylated haemoglobin, high-density lipoprotein cholesterol, triglycerides, systolic and diastolic blood pressure. When the last six variables alone were used as an indicator of AL, they were referred as metabolic syndrome (MS), which is a well-known cluster of cardiovascular risk factors. The first goal of the study was to assess AL across men and women at 42 years of age. Second, previous career instability was investigated as possible stressor leading to elevated AL, and the association of AL with concurrent psychosomatic symptoms was studied. Third, the relation of emotion regulation and dysregulation to MS was investigated including the possible mediating role of subjective health. Fourth, the relationship between long-term job strain and MS across sex and occupational groups was examined. Finally, the role of childhood and adulthood factors in the association between socioeconomic status (education and occupational status) and adult systolic and diastolic blood pressure was studied. The study was conducted as part of the Jyväskylä Longitudinal Study of Personality and Social Development (JYLS), which has been ongoing since 1968. The results revealed that 41.9% of men and 21.8% of women had elevated AL at age 42. These individuals reported more psychosomatic symptoms than the others. Individuals with preceding unstable career assessed prospectively at age 36 had an over three-fold risk for high AL six years later compared to individuals with a stable career history. Successful emotion regulation was associated with a reduced risk for MS. Unexpectedly, low MS was associated with high long-term job strain among higher white-collar workers of both sexes. Furthermore, high MS was associated with low long-term job strain in women. A weak association between low educational attainment and development of high blood pressure was found. Adulthood overweight and parents' low occupational status were the key explanatory factors for the association between education and blood pressure. The findings implied that unstable career had long-lasting negative effects on physical health while successful emotion regulation turned out to be beneficial to physical health. The role of other work factors was more complicated and need further research.

Keywords: health, allostatic load, metabolic syndrome, cardiovascular risk factors, emotion regulation, unstable career, job strain, education, occupational status, longitudinal study

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II Kinnunen, M.-L., Kokkonen, M., Kaprio, J., & Pulkkinen, L. (2005). The associations of emotion regulation and dysregulation with the metabolic syndrome factor. *Journal of Psychosomatic Research, 58,* 513–521.

III Kinnunen, M.-L., Feldt, T., Kinnunen, U., Kaprio, J., & Pulkkinen, L.. Association between long-term job strain and metabolic syndrome factor across sex and occupation. *Manuscript submitted for publication*.

IV Kivimäki, M., Kinnunen, M.-L., Pitkänen, T., Vahtera, J., Elovainio, M., and Pulkkinen, L. (2004). Contribution of early and adult factors to socioeconomic variation in blood pressure: thirty-four–year follow-up study of school children. *Psychosomatic Medicine, 66,* 184–189.

1 INTRODUCTION

1.1 Framework of the study

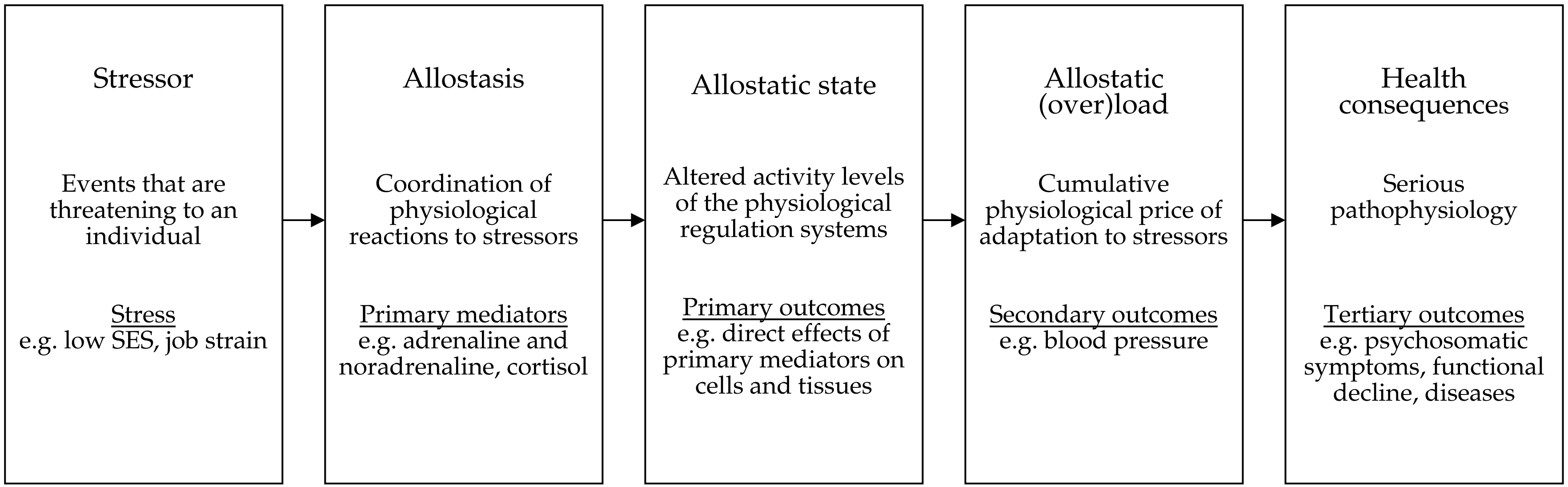
The biopsychosocial model of health (Engel, 1977) argues that, underlying diseases, there are, beyond biological factors, various psychological and social factors to which some individuals are more vulnerable than others. It is postulated that interaction between developmental, psychological and experiential factors, social context, and genes contribute to the development of diseases (Gallo & Matthews, 2003; McEwen & Seeman, 1999; Taylor & Seeman, 1999). However, the negative effects of psychosocial factors' on health have only partly been identified. In the present study, applying the allostatic load model, I investigated psychosocial factors that can lead to elevated health risks.

1.1.1 Allostatic load model

The allostatic load model (McEwen & Stellar, 1993) offers a promising theoretical framework with what to study the biopsychosocial model of health by posting a potential pathway from the external and internal environment to the individual's health. The allostatic load model incorporates events (stressors) that are threatening to an individual and which elicit physiological and behavioural responses as a part of allostasis (Figure 1) (McEwen & Wingfield, 2003). Allostasis is a physical response to everyday life stressors; that is, it refers to the coordination of physiological reactions to current circumstances in order to achieve internal stability when facing predictable and unpredictable stressors (McEwen, 1998; McEwen & Seeman, 1999; McEwen & Wingfield, 2003; Sterling & Eyer, 1988).

The main physiological regulation systems that are responsible for human stress reactions are the hypothalamic-pituitary-adrenal (HPA) axis and the sympathetic nervous system; however the immunological and the haemostatic systems are also involved (Kelly, Hertzman, & Daniels, 1997; Lovallo & Thomas,

FIGURE 1 The allostatic load model.



2000; Seley, 1936, 1946; Tsigos & Chrousos, 2002). The same regulation systems act in allostasis (McEwen, 2003; McEwen & Seeman, 1999; McEwen & Stellar, 1993). In allostatic state the physiological regulation systems show altered activity levels, resulting in an imbalance in their chemical messengers (McEwen & Seeman, 1999; McEwen & Stellar, 1993; McEwen & Wingfield, 2003). Allostasis and the allostatic state are necessary in the short-term, but if the imbalance continues they may have long-term negative effects, namely, allostatic load. Allostatic load refers to the cumulative physiological price of adaptation to stressors (McEwen, 2000; McEwen & Stellar, 1993), and it consists of individual genetic, developmental, and experiential components (McEwen, 2000).

Imbalances leading to allostatic load may occur in cases of frequent stress or if stress reactions are inappropriate (McEwen, 1998). Inadequate stress reactions may include a lack of adaptation to repeated stress, a failure to shut off the allostatic responses of the body, or a deficient response in some allostatic system leading to compensatory hyperactivity by other systems (McEwen, 1998; McEwen & Lasley, 2003). In the development of allostatic load, McEwen and Seeman (1999) describe the chemical messengers (e.g. neurotransmitters and hormones) of the physiological regulation systems and their direct effects on cells and tissues as primary mediators and primary effects, the cumulative outcome of the primary effects as secondary outcomes, and the final result – functional decline and disease – as tertiary outcomes (Figure 1).

More recently, allostatic load as a consequence of prolonged imbalance has also been called allostatic overload (McEwen & Wingfield, 2003). McEwen and Wingfield (2003) have defined two types of allostatic overload. In Type 1 allostatic overload the energy demands of the body exceed the energy supply. This leads to a limited ability to maintain health if the individual is not able to replenish depleted energy (McEwen & Wingfield, 2003). In developed societies, because energy supply is in most cases excessive in relation to energy consumption, Type 1 allostatic overload is rare.

Type 2 allostatic overload occurs if the capacity of the individual to cope with psychological and social challenges fails (McEwen & Wingfield, 2003). Stress reactions have evolved to be triggered in sudden, threatening situations where their purpose is to prepare the body for 'fight or flight'. Hence, stress reactions aim to mobilise the energy stores of the body. When the stressful situation is over, the body is programmed to replenish those energy stores. In modern societies, most of the challenges, however, are psychological and social challenges where 'fight or flight' reactions are inappropriate (VanItallie, 2002). Thus, stress reactions may have far-reaching effects on the body, for example, in form of permanent dysfunctions in glucose or lipid metabolisms. Since Type 2 allostatic overload might be considered as a reflect of the excesses of modern life (Schulkin, 2003), it is more common than Type 1 allostatic overload.

The findings across gender in allostatic load are contradictory. Among the elderly, levels of allostatic load were equal among both sexes (Seeman, Singer, Ryff, Love, & Levy-Storms, 2002), but among working-aged individuals, men had higher allostatic load levels than women (Schnorpfeil et al., 2003). No sex differences have been found in the pathways from stressors to allostatic load, or from elevated allostatic load to impaired health.

1.1.2 Measuring allostatic load

The progression of allostatic load is a long-term process. From the individual's point of view the process may be insidious: a person may be unable to feel the cumulative risk for impaired health until diseases appear. Furthermore, increased health risks are postulated to occur when there are modest dysfunctions in multiple systems of the body as well as when clinically significant dysfunctions in individual systems are present (Karlamangla, Singer, McEwen, Rowe, & Seeman, 2002). These aspects have provided a very challenging task for research, which is to find an optimal instrument for measuring excessive allostatic load.

Seeman, Singer, Rowe, Horwitz, and McEwen (1997) devised a high risk quartile method for measuring allostatic load in the MacArthur Successful Aging Study. They summarised the levels of physiological activity across various regulatory and metabolic systems of the body with ten parameters. Participants were classified into quartiles for each parameter, and allostatic load was defined according to the number of parameters for which the participant fell into the high-risk quartile. The parameters indexed the sympathetic nervous system, the HPA axis, cardiovascular activity, adipose tissue distribution, short-term glucose metabolism, and long-term risks for atherosclerosis. Four of the original ten parameters (overnight 12-hour urinary cortisol, adrenaline and noradrenaline, and dehydroepiandrosterone-sulfate) were classified as primary mediators, and six of them (systolic and diastolic blood pressure, waist-to-hip ratio, glycosylated haemoglobin, total cholesterol, and high-density lipoprotein) were classified as secondary outcomes (McEwen & Seeman, 1999; Seeman, McEwen, Rowe, & Singer, 2001). Since, a reduced measurement (Kubzansky, Kawachi, & Sparrow, 1999) as well as extended measurements with indicators of haemostatic and immune systems (Schnorpfeil et al., 2003; Seeman, Crimmins et al., 2004) have been used. When the summary measurement for allostatic load was used in the MacArthur Studies of Successful Aging, it predicted health better than any single parameter (Seeman et al., 2001).

1.1.3 Metabolic syndrome and blood pressure as indicators of allostatic load

Metabolic syndrome (Alberti & Zimmet, 1998) and one of its components, blood pressure (Guidelines Subcommittee of the World Health Organization – International Society of Hypertension, 1999), are well-known cardiovascular risk factors, but they can also be considered allostatic load indicators. According to the World Health Organization (WHO) definition, metabolic syndrome is a combination of insulin resistance, abdominal obesity or overweight, hypertension, and dyslipidemia (Alberti & Zimmet, 1998). The sympathetic nervous system with its transmitters adrenaline and noradrenaline, the HPA axis with its hormones, for instance, cortisol (Björntorp, Holm, Rosmond, & Folkow, 2000; Brunner et al., 2002; Chrousos, 2000; Lee, Jung, Park, Rhee, & Kim, 2001), and the immune system (Sakkinen, Wahl, Cushman, Lewis, & Tracy, 2000) have all been considered likely candidates for the mechanisms underlying metabolic syndrome. These physiological regulatory systems could also be considered primary mediators, with their primary effects resulting in the development of metabolic syndrome. Metabolic syndrome, in turn, might be accounted a secondary outcome of allostatic load. The final - tertiary - outcome of this progression may be coronary heart disease.

When metabolic syndrome is operationalized, different indices for the components have be used. Insulin excretion and blood glucose are mostly used as indices for insulin resistance. When only secondary data has been available, glycosylated haemoglobin (GHb) has been used in the same purpose although it rather represents the balance of glucose metabolism than insulin resistance. Abdominal obesity is commonly indexed by waist circumference or waist-to-hip ratio (WHR), whereas overweight is measured using the body mass index (BMI). Hypertension refers to chronically elevated blood pressure and it is indexed by systolic and diastolic blood pressure. Dyslipidemia includes elevated total cholesterol, low high-density lipoprotein (HDL) cholesterol, high low-density lipoprotein (LDL) cholesterol, high triglycerides, or a combination of these.

Metabolic syndrome is commonly used as a dichotomous variable, that is, an individual is rated either having or not having metabolic syndrome. Different dichotomizing criteria have been proposed, for example, by the WHO (Alberti & Zimmet, 1998), the Adult Treatment Panel III (ATP III; Ford, Giles, and Dietz, 2002), or the European Group for study of Insulin Resistance (EGIR; 2002), and these criteria overlap widely (European group for study of insulin resistance, 2002; Marchesini et al., 2004). The development of metabolic syndrome, however, seems to be a continuous phenomenon, indicating that there are individuals with elevated levels of metabolic syndrome even though they do not meet the diagnostic criteria for the syndrome (Valkonen, Kolehmainen, Lakka, & Salonen, 2002). Therefore explorative or confirmatory factor analyses, or principal component analysis (PCA) might be a better approach to the identification of metabolic syndrome, at least in study samples that mostly comprise individuals who do not meet the diagnostic criteria.

According to previous factor analytic studies, metabolic syndrome has consisted of two or more underlying factors (Hanley et al., 2002; Meigs, 2000; Shen et al., 2003). Mainly, those factors have been a core metabolic factor and a blood pressure factor (Hanley et al., 2002; Meigs, 2000). Using confirmatory factor analysis, metabolic syndrome was found to be constructed of four factors, i.e., insulin resistance, obesity, lipids, and blood pressure, where the blood pressure factor was the poorest indicator of metabolic syndrome (Shen et al., 2003). Thus, blood pressure and hypertension tend to be part of metabolic syndrome. However, blood pressure, even if it co-occurs with metabolic syndrome, has its own developmental background independent of the other metabolic syndrome components.

Heredity and detrimental health behaviour are shown to be risk factors for metabolic syndrome, hypertension, and ultimately, coronary heart disease. Smoking is a definite risk factor (Bello & Mosca, 2004; Dzien, Dzien-Bischinger, Hoppichler, & Lechleitner, 2004; Geslain-Biquez et al., 2003; Sheridan, Pignone, & Mulrow, 2003; World Health Organization, 2002), but the role of alcohol has been more complex. Light to moderate alcohol consumption has lately been considered more a protective than a risk factor (Freiberg, Cabral, Heeren, Vasan, & Ellis, 2004; Kiechl et al., 1996; World Health Organization, 2002), but binge drinking has shown to elevate risks for metabolic syndrome (Dixon, Dixon, & O'Brien, 2002; Yoon, Oh, Baik, Park, & Kim, 2004). In Finland, binge drinking has also been associated with the progression of carotic atherosclerosis (Kauhanen, Kaplan, Goldberg, Salonen, & Salonen, 1999) and fatal myocardial infarction (Kauhanen, Kaplan, Goldberg, & Salonen, 1997). However, genetics, sedentary lifestyle, binge drinking, excessive salt intake, and smoking are insufficient to explain the whole spectrum of the incidence of these diseases (Beaglehole & Magnus, 2002). Recently, chronic stress has been included among the metabolic syndrome risk factors (Chrousos, 2000; Rosmond, 2005), indicating that environmental and experiential factors as stressors might have a role in the syndrome developmental process. Indeed, evidence of psychosocial factors leading to metabolic syndrome, hypertension (Rozanski, Blumenthal, & Kaplan, 1999; Kaplan & Nunes, 2003) and coronary heart disease (Rosengren et al., 2004) has been found. To sum up, both metabolic syndrome and blood pressure as cardiovascular risk factors could also be considered secondary outcomes in the allostatic load model, and, thus, they may contribute to allostatic load.

1.1.4 Psychosocial factors as stressors

The central tenet of the allostatic load model is that the primary cause of health risks are stressors, which lead to activation in the body. A wide variety of life situations may act as stressors and result in Type 2 allostatic overload, if coping with these stressors fails. In fact, there are more studies of stressors leading to elevated allostatic load than studies of the health consequences of allostatic load. In longitudinal studies, low social support (Seeman, Glei et al., 2004; Singer & Ryff, 1999), low levels of education (Seeman, Crimmins et al., 2004), and long-term economical deprivation (Singer & Ryff, 1999) have been associated with elevated allostatic load. Cross-sectionally, high allostatic load has been related to hostility (Kubzansky et al., 1999) and high job demands (Schnorpfeil et al., 2003).

Even more studies can be found where metabolic syndrome and blood pressure are considered indicators of allostatic load. In a review of the empirical research, which included 86 studies, the hypothesis that adverse psychosocial factors play an important role in the pathogenesis of hypertension was highly supported (Kaplan & Nunes, 2003). With respect to metabolic syndrome, low socioeconomic status (Brunner et al., 1997; Lidfeldt et al., 2003; Wamala et al., 1999), poor working conditions (Hemingway & Marmot, 1999; Karlsson, Knutsson, & Lindahl, 2001), many life changes (Ravaja, Keltikangas-Järvinen, & Viikari, 1996), and poor social relationships (Hemingway & Marmot, 1999; Horsten, Mittelman, Wamala, Schenck-Gustafsson, & Orth-Gomér, 1999; Orth-Gomér & Unden, 1990) have been connected to metabolic syndrome. Psychological factors found to be associated to some extent with metabolic syndrome include, for example, aggression (Ravaja, Keltikangas-Järvinen, & Keskivaara, 1996), temperament (Ravaja & Keltikangas-Järvinen, 1995), tension (Räikkönen, Matthews, & Kuller, 2002), hostility (Niaura et al., 2000; Ravaja, Kauppinen, & Keltikangas-Järvinen, 2000), and locus of control (Ravaja, Keltikangas-Järvinen, & Viikari, 1996).

1.1.5 Health consequences of allostatic load

Studying the consequences of allostatic load is challenging because the process leading from allostasis via allostatic overload to the tertiary outcomes, that is, decline in health, is a long-term one. In fact, only a few studies have investigated these aspects of the allostatic load longitudinally. The most convincing results have been obtained from the MacArthur Studies of Successful Aging where the effects of allostatic load on health have been studied using the high risk quartile method to index allostatic load. The results showed that high allostatic load was associated with physical disabilities, declining cognitive functioning (Karlamangla et al., 2002; Seeman et al., 2001; Seeman et al., 1997), cardiovascular diseases (Seeman et al., 2001; Seeman et al., 1997), and increased mortality (Seeman, Crimmins et al., 2004; Seeman et al., 2001; Seeman et al., 1997). However, many other health outcomes might be considered to be tertiary outcomes of allostatic load, while a whole cascade of allostatic states leading to allostatic load has emerged from studies of the causes of diseases (McEwen, 2003). Examples of such diseases are chronic mood and anxiety disorders (McEwen, 2003).

1.2 Emotion regulation and dysregulation

If emotion regulation is inappropriate it may also act as a stressor leading to elevated allostatic load. Emotion regulation comprises internal processes through which an individual influences what emotions to have, when to have them, and how to experience and express them (Gross, 1998). The goal for emotion regulation is to modulate, maintain, or change the occurrence, duration, intensity, or expression of emotions consciously or unconsciously (Eisenberg, Fabes, Guthrie, & Reiser, 2000; Gross, 1999; Thompson, 1994). In other words, an individual may develop habitual capacity for flexibility and change in his or her goals and strategies by means of optimal emotion regulation (Diamond & Aspinwall, 2003). If this goal is not achieved and emotion regulation has dysfunctional aspects, emotion dysregulation occurs (Cole, Michel, & Teti, 1994). Emotion dysregulation may include difficulties in processing information and events, problems in integrating emotions with other processes, or difficulties in experiencing or expressing emotions (Cole et al., 1994). Although some people may develop stable emotion dysregulation styles, in most cases emotion dysregulation occurs only as an occasional event (Cole et al., 1994).

Recently, research has paid attention to the possible role of emotion regulation and dysregulation in health. Most studies, however, have concentrated on investigating the relationship of emotion regulation to subjective health or to psychological disorders to the neglect of its physical health implications. Emotion regulation as an adaptive way of coping with daily life may require time to affect physical health (King & Emmons, 1990; Thompson & Calkins, 1996; Räikkönen et al., 2002). If emotion regulation or dysregulation strategies are used only in the short term they will probably not have long-term effects on health. Thus, a longitudinal framework is essential to investigating whether emotion regulation and dysregulation affect health in the long run.

Thus far, emotion regulation through repairing a negative emotion in a more positive direction has been associated with good subjective physical health as indicated by low levels of self-reported physical symptoms (Goldman, Kraemer, & Salovey, 1996; Salovey, Stroud, Woolery, & Epel, 2002), good general health, more vitality, and fewer limitations imposed by pain (Extremera & Fernández-Berrocal, 2002). In contrast, emotion dysregulation manifested by emotional ambivalence has been linked to anxiety, depression, paranoia, obsessive-compulsive tendencies, phobias, and psychoticism (King & Emmons, 1990, 1991).

Some evidence of an association between emotion dysregulation and objectively observed health, particularly, cardiovascular risk factors, has been found. Emotional dysregulation, manifested by an alexithymic emotion regulation deficiency in which difficulties are experienced in identifying and describing one's own feelings to others (Deary, Scott, & Wilson, 1997; Kauhanen, 1994; Kauhanen, Kaplan, Cohen, Julkunen, & Salonen, 1996; Kirmayer, Robbins, & Paris, 1994), has been related to hypertension, unfavourable serum lipoprotein levels (Kauhanen et al., 1996), and greater percentage of body fat (Waldstein, Kauhanen, Neumann, & Katzel, 2002). In addition, non-expression of emotions through inhibition has been linked to hypertension and coronary heart disease (Nyklíček, Vingerhoets, & Denollet, 2002).

The neuro-endocrinal systems in emotion regulation include the HPA axis (Donzella, Gunnar, Krueger, & Alwin, 2000; Stansbury & Gunnar; 1994) and the sympathetic nervous system (Donzella et al., 2000; Gross, 1998; Gross & Levenson, 1993, 1997; Porges, Doussard-Roosevelt, & Maiti, 1994; Rottenberg, Wilhelm, Gross, & Gotlieb, 2003), both of which are the same systems as assumed to underlie metabolic syndrome. These findings are grounds for hypothesizing that there may very possibly be a connection between emotion (dys)regulation and metabolic syndrome.

1.3 Work factors

1.3.1 Education and occupational status

In this study, work factors consist of factors that have found to have an effect on individual's work: education and occupational status, instability in one's working career, and job strain. All these factors have been found to affect health. One of the possible pathways between work factors and health is that the former act as potential stressors leading to elevated allostatic load.

Education and occupational status refer to an individual's achieved social position (Pulkkinen, Feldt, & Kokko, 2005), although they represent different facets of it. As Oakes and Rossi (2003) point out, education is relatively stable over time and it can refer to individuals outside the labour market; however, it does not capture changes in socioeconomic circumstances in adulthood well. Occupational status is thought to reflect material and psychosocial exposures, and conditions related to paid employment (Lahelma, Martikainen, Laaksonen, & Aittomäki, 2004), but it may not be very informative measure when applied to individuals outside the labour market.

Education and occupational status are commonly used as indices and even synonyms for socioeconomic status (SES). SES, however, is much broader concept. One extension of SES is income, which refers to material resources and determines the purchasing power at an individual's disposal (Lahelma et al., 2004). Income is closely linked to education and occupational status in that education is thought to relate to occupational status which, in turn, determines the level of income. These aspects do not, however, take into account the individual's social capital which has recently been included in the concept of SES (Oakes & Rossi, 2003). Regardless of these considerations, term 'SES' is used to describe education and occupational status in the present study.

It is well known that low SES has an inverse relation to health, for instance, to morbidity and mortality in connection with coronary heart disease (Brunner et al., 1997; Kunst, Groenhof, Mackenbach, & EU Working Group on Socioeconomic Inequalities in Health, 1998; Salomaa et al., 2000). Additionally, low SES has shown to be associated with elevated risk for metabolic syndrome (Brunner et al., 1997; Lee, Jung, Park, Rhee, & Kim, 2005; Lidfeldt et al., 2003; Wamala et al., 1999) and hypertension (Colhoun, Hemingway, & Poulter, 1998). Pathways explaining the relationship between low SES and poor health have been proposed. First, it has been argued that individuals with low SES face more environmental challenges than others, which, in turn, leads to poor health (Kristenson, Eriksen, Sluiter, Strake, & Ursin, 2004; Singh-Manoux, Ferrie, Chandola, & Marmot, 2004). Second, individuals with low SES tend to have more unhealthy behaviour (e.g., smoking, sedentary life style) than individuals with high SES (Kristenson et al., 2004; Lynch, Kaplan, & Salonen, 1997). This may lead, for example, to unfavourable levels of metabolic syndrome indicators among individuals with low SES. Third, psychobiological differences between individuals with different SES might be important mediators for the effects of SES on health (Gallo, Bogart, Vranceanu, & Matthews, 2005; Gallo & Matthews, 2003; Kristenson et al., 2004; Taylor & Seeman, 1999). That is to say, individuals with low SES are not only exposed to more stressful experiences but they also respond to such situations differently from individuals with high SES (Gallo et al., 2005; Kristenson et al., 2004). Psychological resources may also differ between levels of SES. As recent reviews have concluded, negative emotions (Gallo et al., 2005; Gallo & Matthews, 2003), beliefs in personal control, personal mastery, and self-efficacy (Taylor & Seeman, 1999) differ according to SES.

All these pathways have been supported in previous studies, but they have shown to be insufficient to determine the relationship between SES and health alone. For instance, adverse lifestyle explains about 25% of the variance in SES scores in relation to health outcome (Kristenson et al., 2004). Therefore, more research on the relationship between SES and health is needed to clarify the role of SES as a stressor when health behaviour is taken into account.

1.3.2 Career instability

Instability in one's working career may be viewed as a health risk. In this study, career is defined as an individual's objective participation in working life rather than subjective commitment to work. It is operationalized as three career lines: stable, changeable, and unstable. A stable career line refers to a working career where an individual has worked in his or her own field without repeated interruptions; a changeable working career refers to shifting from work to occupational training or to taking care of children at home; and an unstable career includes periods of unemployment, frequent changes of job, or work that does not correspond to one's training (Pulkkinen, Ohranen, & Tolvanen, 1999). Although working career lines have been stable in most studies (Holland, 1996), instability has also been shown to be rather persistent over time (Rönkä, Kinnunen, & Pulkkinen, 2000).

The general economic situation has strong effect on individuals' careers. After a favourable economic situation in the late 1980s, Finland experienced a severe recession in the early 1990s. This led to a huge increase of in unemployment: whereas the unemployment rate was 5.1% in 1987 it was 15.4% in 1995 (Statistics Finland 1998). Those who had a long-term history of unemployment before the recession were more likely to remain unemployed both during and after it (Kokko, in press).

The previous studies connecting career and health have mostly focused on unemployment, which has been shown to be related to unhealthy behaviour (Wadsworth, Montgomery, & Bartley, 1999), lower physical and psychological well-being (McKee-Ryan, Song, Wanberg, & Kinicki, 2005; Wilson & Walker, 1993), and increased mortality (Voss, Nylén, Floderus, Diderichsen, & Terry, 2004; Wilson & Walker, 1993). Furthermore, unemployment has been shown to be associated with poor economic status (Kokko & Pulkkinen, 1998; Winefield, 1995), reduced self-esteem (Kokko & Pulkkinen, 1998) and a reduced level of life satisfaction even after reemployment (Lucas, Clark, Georgellis, & Diener, 2004). A parallel finding was that an unstable career line, including unemployment and many changes of jobs, preceded social functioning problems (Rönkä et al., 2000). Duration of unemployment has been shown to play a role in the relationship between unemployment and health: long-term unemployed individuals had more psychological distress than those who were only unemployed for a short time (Kokko & Pulkkinen, 1998). To sum up, protracted instability in one's career line may maintain stress at a high level and lead to elevated allostatic load.

1.3.3 Job strain

Job strain has been shown to be a source of health problems. According to the Job Demands-Control (JD-C) model, high job strain exists when work is characterized by a combination of high job demands and low decision control at work (Karasek, 1979; Karasek & Theorell, 1990). Job demands refer to work load, whereas job control refers to an individual's ability to control these demands. The job strain hypothesis postulates that high job strain produces stress reactions and thus health risks.

Some evidence of the association between high job strain and cardiovascular risk factors has been found. Two longitudinal studies found an association between blood pressure and job strain, but the results were somewhat conflicting. Whereas in one study high job strain across a three-year follow-up was associated with the highest blood pressure levels (Schnall, Schwartz, Landsbergis, Warren, & Pickering, 1998), an increase in job strain over an eight-year follow-up was related to the highest blood pressure levels in another study (Landsbergis, Schnall, Pickering, Warren, & Schwarz, 2003). Cross-sectional studies have found a relationship between high job strain and high blood pressure or hypertension in both sexes (Fauvel, Quelin, Ducher, Rakotomalala, & Laville, 2001), in men but not in women (Cesana et al., 2003; Greenlund et al., 1995), and in women but not in men (Alfredsson et al., 2002; Blumenthal, Towner Thyrum, & Siegel, 1995). However, some studies did not find such a relationship in either sex (Netterstrøm, Kristensen, Damsgaard, Olsen, & Sjøl, 1991; Steptoe, Cropley, & Joekes, 1999; Steptoe & Willemsen, 2004).

Apart from blood pressure, cardiovascular risk factors have been studied less in relation to job strain. An association between HDL cholesterol and job stain has been found in one study (Alfredsson et al., 2002) but not in others (Jönsson, Rosengren, Dotevall, Lappas, & Wilhemsen, 1999; Netterstrøm et al., 1991; Riese, Van Dooren, Houtman, & De Geus, 2000). Furthermore, no relationship was found between job strain and total cholesterol (Greenlund et al., 1995; Jönsson et al., 1999; Kawakami, Haratani, & Araki, 1998; Netterstrøm et al., 1991; Riese et al., 2000), triglycerides (Netterstrøm et al., 1991; Riese et al., 2000), or LDL cholesterol (Jönsson et al., 1999). When the focus has been on central obesity or overweight, no relation to job strain has been found (Overgaard, Gyntelberg, & Heitmann, 2004).

Job strain has been considered to be a moderator in the relationship between low SES and cardiovascular diseases (Bishop et al., 2003), but this statement has been supported only partly. Studies on men have found greater relationship between job strain and blood pressure among men with lower SES (Landsbergis, Schnall, Warren, Pickering, & Schwartz, 1999; Tsutsumi, Kayaba, Tsutsumi, & Igarashi, 2001), revealing that individuals with low SES would be more vulnerable to job strain-induced health problems than individuals with high SES. Contrary to these findings, in a study of mild hypertensive individuals, those with high SES had higher ambulatory blood pressure than those with lower SES (Blumenthal et al., 1995). Furthermore, among individuals with low SES high job strain was related to higher heart rate than among individuals with high SES, but no differences between SES groups was found in regard to blood pressure (Matthews et al., 2000).

Hence, although some evidence of an association between high job strain and cardiovascular risk factors has been found, the results have not been consistent. The role of sex and SES is also unclear in the relationship between job strain and cardiovascular risk factors. Moreover, it has remained unresolved, whether high job strain associates with the cluster of risk factors, namely, metabolic syndrome. If high job strain produces stress reactions, as the job strain hypothesis states, such a relationship may exist.

1.4 Subjective health

Impaired health may not only be a consequence of allostatic load but may also act as a stressor leading to elevated allostatic load. In turn, a subjective experience of good health may lower the experience of stress thus protecting the body from illnesses. Additionally, good subjective health may indicate a fit, physically well-functioning person. It might also be that good subjective health promotes a health awareness, which leads to less risk-taking behaviour (Idler & Kasl, 1991).

Subjective health is often measured by asking an individual to rate his or her health by a question "How would you describe your health now?". It is, however, not clear what this question alone captures or what constitutes the basis of the positive relationship often found between self-rated health and future health outcomes, for instance, functional decline and mortality. Halford, Anderzén, and Arnetz (2003) found associations between endocrine measures of stress and self-rated health, suggesting that chronic stress with its biological consequences might be one of the mechanisms. Benyamini, Leventhal, and Leventhal (2003) showed that a global perception of health was the most common factor for individuals' self-rated health judgements, but there were other health-related aspects which affected self-rated health, such as chronic illness and medication in participants who rated their health poor, and happiness and health behavioural issues in participants rating their health as good.

Regardless of what the single question of self-rated health captures, poor self-rated health has successfully predicted increased mortality (Heistaro, Jousilahti, Lahelma, Vartiainen, & Puska, 2001; Idler & Benyamini, 1997; Miilunpalo, Vuori, Oja, Pasanen, & Urponen, 1997; Pijls, Feskens, & Kromhout, 1993), improved physical fitness (Miilunpalo et al., 1997), and functional capacity (Idler & Kasl, 1995). Although unhealthy behaviour such as overweight, sedentary lifestyle, and heavy drinking has been associated with poor self-rated health (Manderbacka, Lahelma, & Martikainen, 1998), health behaviour has not adequately explained the association between self-rated health and mortality (Bardage, Isacson, & Pedersen, 2001; Heidrich, Liese, Löwel, & Keil, 2002; Heistaro et al., 2001; Piljs et al., 1993).

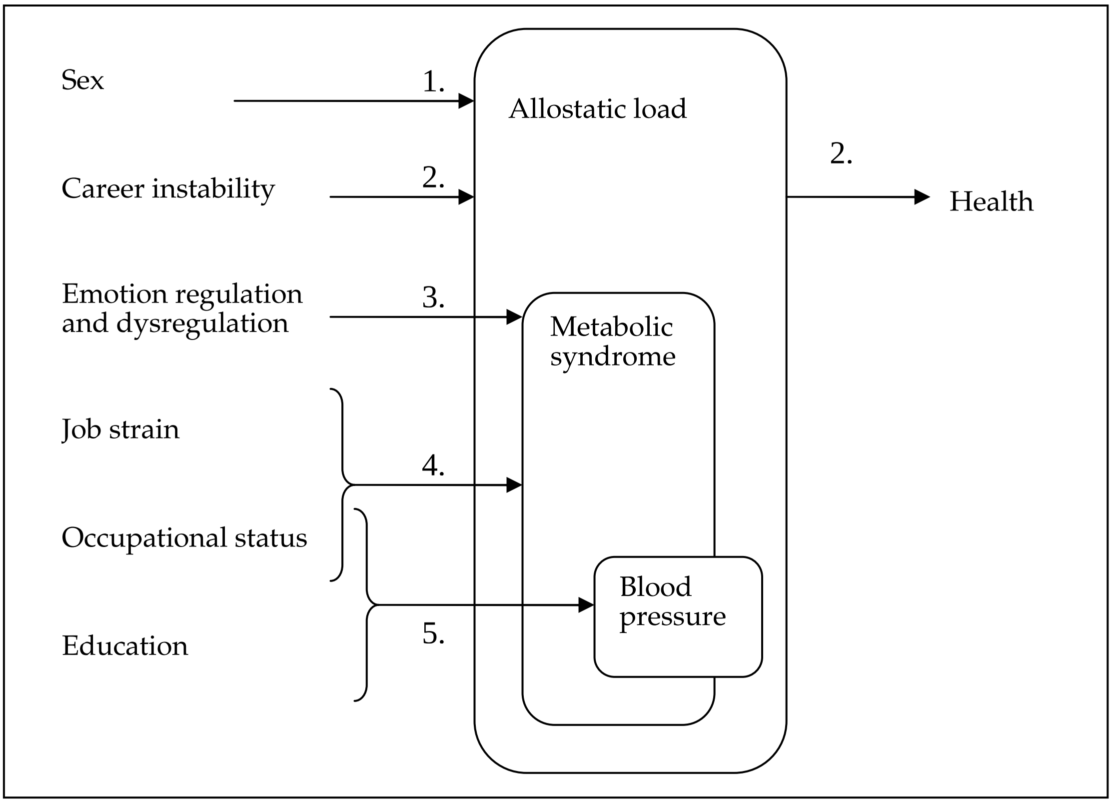
Subjective health, however, is more than a single-question rating. A high level of self-reported physical symptoms, low quality of life with regard to its physical aspects (Lidfeldt et al., 2003), and distress (Vitalino et al., 2002) have been found to be related to high incidence of metabolic syndrome. In the light of these findings there seems to be a possibility that good subjective health protects individuals from elevated allostatic load.

1.5 Aims of the present study

In the present study, I aimed to investigate the long-term effects of psychosocial factors on health using the allostatic load model. The study design was a prospective, longitudinal one using data drawn from the Jyväskylä Longitudinal Study of Personality and Social Development (JYLS; Pulkkinen, 1982, 1998). Specifically, the level of allostatic load of the participants at age 42 was determined. In Study I, eight parameters (allostatic load) was measured whereas in Studies II and III these eight parameters were reduced to six (metabolic syndrome), and in Study IV to two parameters (blood pressure) (Figure 2). Emotion regulation and dysregulation, and work factors (education, occupational status, career instability, and job strain) were studied as potential stressors leading to elevated allostatic load. Also of interest were sex differences in the level of allostatic load and in the pathways from stressors through allostatic load to perceived psychosomatic symptoms. Subjective health as a mediator was also studied. In order to reach these goals, the study had five specific aims:

1. To assess the level of allostatic load and to explore sex differences in allostatic load among the participants at 42 years of age (Study I). It was hypothesized that some proportion of the participants would have elevated allostatic load. According to previous findings in a working-

FIGURE 2 The framework of the present study. Numbers in the figure refer to the specific aims of the study.



aged population (Schnorpfeil et al., 2004), men more often than women were expected to have elevated allostatic load.

2. To study whether previous career instability would lead to elevated allostatic load, and whether allostatic load in turn would be associated with concurrent psychosomatic symptoms (Study I). It was hypothesized that an unstable career lines would act as a stressor leading to elevated allostatic load and to health problems.
3. To investigate longitudinally whether emotion regulation and dysregulation were related to metabolic syndrome, and, if so, whether the relationship was mediated by subjective health (Study II). Emotion regulation was expected to be positively and dysregulation negatively related to both metabolic syndrome and subjective health irrespective of gender.
4. To investigate whether the long-term job strain increased metabolic syndrome, and whether the relationship differed across sex and occupational groups (Study III). Long-term job strain was assumed to act as a source of chronic stress leading to increased risk for metabolic syndrome.
5. To study the role of childhood and adulthood factors in the association between SES (education and occupational status) and adult systolic and diastolic blood pressure (Study IV). Low education and occupational status were assumed to be associated with high blood pressure.

2 METHOD

2.1 Participants and procedure

The study was part of the Jyväskylä Longitudinal Study of Personality and Social Development (JYLS; Pulkkinen, 1982, 1998). In the JYLS, the same individuals from childhood into early middle age have been followed over thirty years. The original sample of 369 eight-year-old children was drawn from 12 randomly selected second-grade school classes from both urban and suburban areas of the medium-sized town of Jyväskylä in Central Finland in 1968. Follow-ups were at ages 9, 14, 20, 27, 30, 36, and 42. At ages 27, 36 and 42, the participants completed mailed Life-Situation Questionnaires (LSQ I-III) and they were personally interviewed by trained interviewers. The LSQ and the interviews included questions on education, working conditions, occupational status, health behaviour, and, at ages 27 and 36, health. During the interview sessions, the participants filled in several self-administered questionnaires, for instance, at age 36 and 42, the Meta-Regulation Scale (MRS; Mayer & Stevens, 1994), the Ambivalence Over Expressiveness Questionnaire (AEQ; King & Emmons, 1990), and additionally at age 42, the Self-Reported Emotional Intelligence questionnaire (SEI; Schutte et al., 1998). At age 42, the health questions were repeated as a part of a 1.5-hour medical examination by a physician (M-L Kinnunen) and a nurse. The medical examination, with laboratory tests, was performed between January, 2001 and September, 2001.

There was no initial attrition and the follow-up attrition rates have been low (Pulkkinen et al., 2003; Sinkkonen & Pulkkinen, 1996). For example, 161 men and 152 women participated in the data collection at age 36, and 151 men and 134 women at age 42 (Pulkkinen et al., 2003). Sample attrition analyses showed that the participants at ages 36 (Sinkkonen & Pulkkinen, 1996) and 42 (Pulkkinen et al., 2003) were representative of the original sample. The JYLS sample also has been found to be representative of the national age cohort born in 1959 (Pulkkinen et al., 2003; Sinkkonen & Pulkkinen, 1996). At age 42, both men and women represented their age cohort with respect to marital status and occupational status, compared with peer data provided by Statistics Finland (2001). The average education (in years) of the male participants did not differ from that of their age cohort. Female participants, however, had a slightly longer education than women in their age cohort.

2.2 Measures

2.2.1 Objective health

2.2.1.1 Anthropometric measurements and blood pressure

Anthropometric measurements. Waist circumference at age 42 was measured at the middle of the space between the lowest rib and iliac crest. *Waist-to-hip ratio (WHR)* at age 42 was calculated on the basis of waist circumference, and on hip circumference measured at the level of the widest circumference over the greater trochanters. *Body mass index* (*BMI*) at age 42 was calculated by dividing weight in kilograms by the square of height in meters (kg/m^2). Weight and height at age 42 were measured with participants barefoot and in light clothing during the medical examination. *Overweight at age 36* was indicated by BMI higher than 24.9 kg/m^2, where BMI was calculated from self-reported weight at age 36 and from measurement of height at age 42.

Blood pressure (BP). For each participant, three blood pressure measurements were recorded at age 42 during the medical examination after 15 minutes' rest, from the right arm, to the nearest 2 mmHg, using a standard mercury sphygmomanometer. The first and fifth Korotkoff sounds were recorded as systolic (SBP) and diastolic (DBP) blood pressure, respectively. The second measurement was used in the analyses in Studies I-III and the average of the second and third measurements in Study IV.

2.2.1.2 Laboratory tests

Blood samples at age 42. The blood samples for measurements of *high-density lipoprotein (HDL cholesterol), triglycerides (TG), glycosylated haemoglobin (GHb), and fasting plasma glucose* were taken after an overnight fast at each participant's local health centre and sent to the Central Finland Clinical Laboratory in Jyväskylä for analysis. Fasting plasma glucose, HDL cholesterol and TG were determined by enzymatic methods using automatic analyzer equipment (Hitachi 917, Tokyo, Japan) and reagents from Boehringer, Mannheim, Germany, for glucose (GLU kit no. 1876899) and HDL cholesterol (HDL/LDL-C plus kit no.1930648); and from Roche, Basel, Switzerland, for TG (TG GPO-PAP kit no. 1730711). GHb was measured using a high performance liquid chromatography (Perkin-Elmer). The blood sample for *the dehydroepiandrosterone-sulfate (DHEA-S)* analyses, drawn only from participants living in the Jyväskylä district, was sent to the Clinical Laboratory of Tampere University Hospital. DHEA-S was determined by a competitive radioimmunologyassay (Wallac, Turku, Finland) using ^{125}I-labelled DHEA derivate as a tracer and sheep anti-DHEA-S antibody as a specific binder (^{125}I-DHEA sulfate, Sorin Biomedica Diagnostics, Saluggia, Italy).

Urine sample at age 42. At the medical examination the participants living in the Jyväskylä district were asked to collect overnight 12-hour urine from 8 p.m. to 8 a.m. and to take the urine sample to the local health centre where the volume of urine was measured. 10 ml of urine was then frozen and sent to the Department of Clinical Chemistry at Kuopio University Hospital for noradrenaline and creatinine measurements. *Noradrenaline* concentration was measured by high performance liquid chromatography (Shimadzu LC-10A, Kyoto, Japan) and *creatinine* concentration was determined with the kinetic Jaffe rate method (Labsystems CLD, Konelab, Finland). The noradrenaline concentration was reported as micrograms per gram of creatinine to adjust for body size (Seeman et al., 1997).

2.2.1.3 Assessment of allostatic load

Allostatic load with eight parameters was assessed at age 42. The allostatic load variables were chosen to be congruent with the allostatic load measurements of the MacArthur Successful Aging Study (Seeman et al., 1997), with three exceptions. First, cortisol measurement was not included, and second, our analyses lacked adrenaline measurements. Third, we choose TG instead of the total cholesterol - HDL ratio to index the long-term risks for atherosclerosis. The choice was made to standardize the risk factors for cardiovascular diseases with the criteria for metabolic syndrome established by the WHO (Alberti & Zimmet, 1998). The other seven parameters were DHEAs and overnight 12-hour urinary noradrenaline as primary mediators, and SBP and DPB, HDL cholesterol, GHb, and WHR as secondary outcomes.

The high risk quartile method for assessment of allostatic load was calculated as in the MacArthur Successful Aging Study: the participants were classified into quartiles in each of the eight parameters, and allostatic load was determined on the basis of the sum of the parameters for which the participant fell into the high-risk quartile (the top quartile of the parameters, except for HDL cholesterol and DHEA-S, where high-risk quartile was the lowest quartile) (Seeman et al., 1997). Participants with antihypertensives (1 man, 2 women) or lipid-lowering medications (3 men) were classified according to the actual values recorded for the various components of allostatic load (Seeman et al., 2002). First, the high-risk quartile method was applied using the same cut-off criteria for both sexes. Second, we defined cut-off criteria for men and women separately. In both methods, allostatic load ranged from 0 to 8 where scores 0-2 were treated as low and scores of 3 or more as high allostatic load.

2.2.1.4 Metabolic syndrome

The following six variables indicated metabolic syndrome at age 42: SBP and DBP, waist circumference, HDL cholesterol, TG, and plasma glucose. In Study II, metabolic syndrome was based on a confirmatory factor analysis in order to specify how metabolic syndrome was indicated by its six variables; it was named as a metabolic syndrome factor. In Study III, metabolic syndrome was constructed by grouping the indicators for metabolic syndrome by principal component analysis (PCA). The first principal component, which contributed 49.9% of the total variance of the indicators, was called a metabolic syndrome factor and it was used in the further analyses.

In Studies II and III, the proportion of participants with metabolic syndrome was estimated using the criteria proposed by Ford et al. (2002). According to these authors, the syndrome is characterized by the following values: BP 130/85 or more, TG ≥1.7 mmol/l, plasma glucose ≥ 6.1 mmol/l, elevated waist circumference (over 102 cm for men and over 88 cm for women), and HDL cholesterol under 1.04 mmol/l for men and 1.29 mmol/l for women. If these values are exceeded in respect of three of these five variables, then metabolic syndrome is considered to be present.

2.2.2 Subjective health

Self-rated health at ages 36 and 42 was measured by means of the question "How would you describe your health now?". The response scale ranged from 1 (= very good) to 5 (= very bad). In Studies I and II a 5-point scale was used, but in Study III the item was treated as a dichotomous variable (1 = very good or good, 2 = moderate, bad, or very bad).

Psychosomatic symptoms at ages 36 and 42 were based on 19 items (e.g., stomach ache, tiredness and weakness, difficulties in falling asleep) taken from the symptom check-list of Aro (1988). The occurrence of each symptom during the previous six months was rated on a scale from 0 (= never) to 4 (= very often). In Study I, each question was dichotomized (never/at least sometimes) and psychosomatic symptoms were represented by the sum score of these 19 items. In Studies II and III, the mean score of the items represented psychosomatic symptoms.

2.2.3 Emotion regulation and dysregulation

Emotion regulation was indexed by the self-rated cognitive emotion regulation strategies of Maintenance and Repair, and by Self-perceived emotion regulation. The emotion regulation strategies of Maintenance and Repair were measured at ages 36 and 42 with items taken from the Meta-Regulation Scale (MRS; Mayer & Stevens, 1994), where the response scale was from 1 (= Describes me very badly) to 4 (= Describes me very well). Maintenance was a sum score of the items "I would not want to change this mood" and "I am not trying to change my mood because I believe it is important to experience it".

Repair was the sum score of the items "I am imagining something nice to improve my mood" and "I am planning positive things to keep my mood up". Self-perceived emotion regulation was assessed at age 42 only. It was based on a single item, "I have control over my emotions", derived from Self-Reported Emotional Intelligence questionnaire (SEI; Schutte et al., 1998). The response scale ranged from 1 (= Describes me very badly) to 5 (= Describes me very well).

Emotion dysregulation measured at ages 36 and 42 was marked by Emotional ambivalence, which was the sum score of seven items (e.g., "I would like to talk about my problems with others, but at times I just cannot"; "I try to suppress my anger, but I would like other people to know how I feel") derived from the Ambivalence Over Expressiveness Questionnaire (AEQ; King & Emmons, 1990). The response scale ranged from 1 (= Describes me very badly) to 4 (= Describes me very well).

2.2.4 Work factors

Education at age 42 was classified using six categories modified from the International Standard Classification of Education 1997 (ISCED 1997; UNESCO) where 1 = lower secondary education, 2 = upper secondary education or post-secondary non-tertiary education, 3 = college level education, 4 = lower first stage of tertiary education, 5 = higher first stage of tertiary education, and 6 = second stage of tertiary education.

Occupational status at age 42 (named occupational group in Study III) was classified in three groups (1 = blue-collar workers, 2 = lower white-collar workers, 3 = higher white-collar workers) according to the self-reported occupational title given in the LSQ III at age 42. Blue-collar workers included, for instance, cleaners and factory workers; lower white-collar workers included, for instance, nurses and technicians; and higher white-collar workers included, for instance, managers and physicians. *Parental socioeconomic status* in Study IV was based on parents' occupational status, which was derived from responses to questions about father's and mother's job titles in participants' interviews at age 27. Parental occupational status was classified as blue-collar, lower white-collar, and higher white-collar. Information about the parent with the higher socioeconomic status was used in the analyses.

Career instability between ages 27 and 36 was based on answers to questions from the LSQ II and the personal interview at age 36. Three categories of careers were defined: 1 = an unstable career including participants with varied jobs or jobs not commensurate to their training, and unemployed participants; 2 = a changeable career, in which participants moved from the labour market to occupational training or to take care of children; and 3 = a stable career in which participants worked in their own field without interruptions, and women who returned to their jobs after maternity leave (Pulkkinen et al., 1999; Rönkä, Kinnunen, & Pulkkinen, 2001).

Long-term job strain. The indicators of job strain at ages 36 and 42 were defined as the combination of job demands and control at work (Karasek, 1979;

Karasek & Theorell, 1990). Job demands were indicated by five items on time demands at work (e.g., "I have to rush in order to complete my allotted tasks") whereas control at work was assessed with seven items (e.g., "How much influence do you have on the tasks that constitute your job?"). In all items the response scales ranged from 1 (= not at all) to 4 (= a lot). At age 36, low, moderate and high job strain categories were formed by dividing the time demands and control at work variables into three equally sized groups and combining them using cross-tabulation (i.e. low, moderate, and high job demands combined with high, moderate, and low control at work). Job strain at age 42 was constructed using the same principle. Using the three job strain categories at ages 36 and 42, three long-term job strain categories were constructed to indicate job strain over a 6-year follow-up. Low long-term job strain contained low or moderate job strain at age 36 and low job strain at age 42, whereas high long-term job strain contained high or moderate job strain at age 36 and high job stain at 42. Moderate long-term job strain contained all the other combinations of job strain categories.

2.2.5 Health behaviour at age 42

Binge drinking was measured by self-reports of how often a person drank 5 or more units of alcohol per drinking occasion. The scale ranged from 1 to 6 (1= not at all, 2 = at most twice a year, 3 = once every 2 months, 4 = once, twice or three times a month, 5 = once a week, 6 = several times a week).

Current smoking status was measured by asking, "Do you smoke or have you ever smoked?" and was coded into three categories (1 = nonsmoker, 2 = occasional smoker, 3 = daily smoker).

2.3 Data analyses

Following the variable-oriented approach, Pearson product-moment correlations were computed to examine interrelationships between the allostatic load variables in Study I, and between all the studied variables in Studies II and IV. The equality tests of the correlation coefficients between men and women were based on z transformations (McNemar, 1969). Student's t-test (Study I), Kruskal Wallis test (Studies II and III), and the analysis of variance (ANOVA; Study III) were used to explore the mean differences of the variables in men and women (Studies I-III) and across occupational groups (Study III). Equally of the proportions of high and low allostatic load groups in men and women were tested by the Chi square test (χ^2).

Logistic regression model was used to explore the associations between career instability and allostatic load (Study I). Analyses of covariance (ANCOVA) were used to assess if psychosomatic symptoms could be explained by allostatic load (Study I), and if long-term job strain, sex, and occupational group were associated with the metabolic syndrome factor (Study III). In Study II, measurement models for the emotion regulation and dysregulation components, subjective health, and the metabolic syndrome factor were specified and the relationships between these latent variables were studied using the structural equation modelling (SEM) approach. When comparing men and women, the multi-group procedure was used. In Study IV, multiple linear regression models and SEM were used to test for explanatory factors for the SES – blood pressure relationship in adulthood.

All analyses were conducted with SSPS 10.0 for Windows (Norusis, 2000) (Studies I-III) or with the SAS 8.12 statistical program package (SAS Institute, Cary, NC, USA) (Study IV), except structural equation modelling, for which LISREL 8.5 (Jöreskog & Sörbom, 1996) or LISREL 8.54 (Jöreskog & Sörbom, 1996) software was used.

Summary of goals, variables, and methods used in studies I-IV are shown in Table 1. Participant numbers differed across the studies according to the goals of each study.

Study	Participants	Study design	Variables	Data analyses
Study I	62 men 55 women	Career stability between ages 27 and 36 → Allostatic load (42) → Psychosomatic symptoms (42)	Allostatic load (42) -DHEA-S -U-NA -SBP -DBP -WHR -HDL -TG -GHb Career stability between ages 27 and 36 Psychosomatic symptoms (42) Control variables: -Binge drinking (42) -Current smoking status (42) -Occupational status (42)	Pearson product-moment correlations Student's *t* test for independent samples Cross tabulations with χ^2 test Logistic regression analysis Analyses of covariance (ANCOVA)
Study II	85 men 96 women	Emotion (dys)regulation between ages 36 and 42 → Metabolic syndrome (42) Emotion (dys)regulation between ages 36 and 42 → Subjective health between ages 36 and 42 → Metabolic syndrome (42)	Metabolic syndrome (42) -SBP -DBP -Waist circumference -HDL -TG -Plasma glucose Emotion regulation: - Repair (36, 42) -Maintenance (36, 42) -Self-perceived emotion regulation (42) Emotion dysregulation: -Emotional ambivalence (36, 42) Subjective health -Self-rated health (36, 42) -Psychosomatic symptoms (36, 42)	Pearson product-moment correlations The Kruskal Wallis test Cross tabulations with χ^2 test Structural equation modelling (SEM) based on covariance matrices with multigroup method and maximum likelihood (ML) estimation procedure
Study III	64 men 62 women		Metabolic syndrome (42) -SBP -DBP	t- test

		Long-term job strain (L) Sex (S) Occupational group (O) (42) L × S L × O → Metabolic syndrome (42)	-Waist circumference -HDL -TG -Plasma glucose Long-term job strain between ages 36 and 42 Sex Occupational status (42) Control variables: -Overweight (36) -Self-rated health (42) -Psychosomatic symptoms (42) -Smoking (42) -Binge drinking (42) -Education (42)	Cross tabulations with χ^2 test Principal component analysis (PCA) Analysis of variance (ANOVA) ANCOVA
Study IV	105 men 101 women	Socioeconomic status (42) → Blood pressure (42) Early and adulthood factors	Blood pressure (42) -SBP -DBP Socioeconomic status (42) -Education -Occupational status Early factors: -Birth weight -Parental SES (14) Adulthood factors: -Unemployment between ages 27 and 36 -Smoking (42) -Alcohol consumption (42) -BMI (42) -Antihypertensive medication (42) Control variables: -Sex -Childhood SBP and DBP	Pearson product-moment correlations Multiple linear regression analysis SEM based on correlation matrices with ML estimation procedure

TABLE 1 Summary of goals, variables, and methods used in studies I-IV. The number between the parentheses indicates the age when the measurement has taken place. DHEA-S = dehydroepiandrosterone-sulfate, U-NA = urine noradrenaline, SBP = systolic blood pressure, DBP = diastolic blood pressure, WHR = waist-to-hip ratio, HDL cholesterol = high-density lipoprotein, TG = triglycerides, GHb = glycosylated haemoglobin, SES = socioeconomic status, BMI = body mass index.

3 OVERVIEW OF THE ORIGINAL STUDIES

Study I
Kinnunen, M.-L., Kaprio, J., & Pulkkinen, L. (2005). Allostatic load of men and women in early middle age. ***Journal of Individual Differences, 26,*** **20–28.**

The first study aimed to investigate allostatic load, a harmful long-term consequence of stress, from three perspectives. First, sex differences in allostatic load at age 42 were studied. Second, it was investigated whether prospectively studied career instability as a potential stressor would lead to an elevated allostatic load and, third, of interest was whether allostatic load in turn would be associated with concurrent psychosomatic symptoms. Allostatic load at age 42 was the sum of the physiological parameters, eight in total, for which the participant fell into the high-risk quartile. Career stability between ages 27 and 36 was categorized into three groups (unstable career, changeable career, stable career).

The results revealed both sex differences and similarities in allostatic load. Men had elevated allostatic load more often than women (41.9% of men, 21.8% women) in a sample combining men and women, but the sex difference disappeared when men and women were studied separately. In addition, men scored higher in common cardiovascular disease risk factors, whereas women scored higher in mediators of physiological regulation systems. Participants with preceding unstable career assessed prospectively at age 36 had an over three-fold risk for high allostatic load six years later compared to participants with a stable career history; sex, binge drinking, and smoking had no impact on this relationship. Binge drinking, however, was associated with allostatic load when the cut-off point criteria for allostatic load were differentiated for men and women. Furthermore, participants with high allostatic load reported more psychosomatic symptoms.

The divergent distribution to of the allostatic load parameters in men and women suggested that men have a higher risk for cardiovascular diseases whereas women have higher health risks beyond the traditional risk factors. It is important to evaluate allostatic load for men and women separately as gender-combined samples carry the danger that women's health risks remain undetected. An unstable career as a long-term stressful life condition, however, was found to have long-lasting effects on health equally in men and women. The results were in line with the allostatic load model, which postulates that a long-term stressor may produce elevated allostatic load. This, in turn, is a potential source of ill-health.

Study II
Kinnunen, M.-L., Kokkonen, M., Kaprio, J., & Pulkkinen, L. (2005). The associations of emotion regulation and dysregulation with the metabolic syndrome factor. ***Journal of Psychosomatic Research, 58,*** **513–521.**

The aim of the second study was to investigate longitudinally if emotion regulation and dysregulation were related to a metabolic syndrome factor, and if this relationship was mediated by subjective health. Previously, emotion regulation has been associated with good, and dysregulation with poor, subjective health; but it was unknown if emotion regulation was related to metabolic syndrome, well-recognized as a risk factor for cardiovascular disease. At ages 36 and 42, emotion regulation was indexed by the strategies of Repair and Maintenance, and by Self-perceived emotion regulation. Emotion dysregulation was marked by Emotional ambivalence. Subjective health consisted of self-rated health and psychosomatic symptoms at ages 36 and 42.

The results showed similar long-term effects of emotion regulation and dysregulation on health across gender. High Repair was associated directly with the low metabolic syndrome factor whereas the other associations between emotion regulation and the metabolic syndrome factor were indirect, via subjective health. High Maintenance, high Self-perceived emotion regulation, and low Emotional ambivalence were related indirectly to the low metabolic syndrome factor through good subjective health. Contrary to these findings, the use of high Maintenance at age 42 proved to be partially unfavourable for men due to its associations with high SBP in men. Additionally, high Repair correlated with low Maintenance in both sexes.

The results indicated the positive role of cognitive emotion regulation for objective health. An improvement in mood may attenuate stress, and as a result, it may lead to reduced risk for metabolic syndrome via physiological regulation systems. The result emphasizes the role of the subjective experience of health also when an objectively defined phenomenon, for instance metabolic syndrome, is in focus. Additionally, the two kinds of association of emotion regulation with health supported previous statements to the effect that emotion regulation strategies are neither inherently good nor bad. In conclusion, subjectively perceived successful emotion regulation may be favourable, and dysregulation detrimental, to health in the long run. Emotion regulation strategies may also have negative consequences on health when they are attempted but fail; or if they are rigidly used in impropriate situations.

Study III

Kinnunen, M.-L., Feldt, T., Kinnunen, U., Kaprio, J., & Pulkkinen, L. Association between long-term job strain and metabolic syndrome factor across sex and occupation. ***Manuscript submitted for publication*****.**

The main purpose of the third study was to investigate whether long-term job strain as a source of chronic stress increased the level of the metabolic syndrome factor, and whether the relationship differed across sex and occupational groups. Participants' job strain measured at ages 36 and 42 was defined by the Job Demand-Control (JD-C) model (Karasek, 1979; Karasek & Theorell, 1990), where high job strain is defined as the combination of high demands and low job control. High, moderate, and low long-term job strain categories were formed to indicate job strain over a six-year follow-up. The metabolic syndrome factor was assessed at age 42. The models were adjusted for education, subjective health (self-rated health, psychosomatic symptoms), and health behaviour (overweight, smoking, binge drinking).

High long-term job strain was not connected to high levels of the metabolic syndrome factor in either women or men. Furthermore, occupational group itself had no impact on the metabolic syndrome factor. We did, however, find that males had higher levers of the metabolic syndrome factor. Moreover, both sex and occupational group moderated the association between long-term job strain and the metabolic syndrome factor, but in an unexpected way. In women, low long-term job strain was associated with higher levels of the metabolic syndrome factor. Among white-collar workers high long-term job strain was related to low levels of the metabolic syndrome factor. Overweight at baseline, at most moderate self-rated health, being a smoker and binge drinking associated with the higher levels of the metabolic syndrome factor, while education and psychosomatic symptoms did not.

The results offered substantial support for the need to consider the role of sex differences and occupational group in determining the association between long-term job strain and metabolic syndrome. In light of inconsistent support for the JD-C model, further research is needed to determine whether there are additional organizational and dispositional characteristics that possibly moderate the effects of long-term job strain on metabolic syndrome.

Study IV

Kivimäki, M., Kinnunen, M.-L., Pitkänen, T., Vahtera, J., Elovainio, M., and Pulkkinen, L. (2004). Contribution of early and adult factors to socioeconomic variation in blood pressure: thirty-four–year follow-up study of school children. ***Psychosomatic Medicine*****,** ***66*****, 184–189.**

The fourth study focused on the role of childhood and adulthood factors in the association between socioeconomic status (SES) and adult systolic and diastolic blood pressure from the life-course. Previous findings have suggested a relationship between low SES and high blood pressure, and between childhood factors, such as birth weight and parental SES, and later health outcomes.

Prospective, lifelong studies in this area have been rare. Hence, the impact of childhood factors, adulthood lifestyle, and body mass (BMI) on the SES – blood pressure association was studied. Adulthood SES was assessed by occupational status and education, whereas parental SES was indicated by parental occupational status. Blood pressure, health behaviour (binge drinking, smoking) and BMI were measured at age 42. The models were adjusted for sex and blood pressure at age 15.

High education was related to elevated adult blood pressure after adjusting for sex and childhood blood pressure. However, after further adjustment for parental SES and adult BMI, education was no longer significantly related to blood pressure. Variation in birth weight, unemployment, smoking, binge drinking, and use of antihypertensive medication had marginal or no impact on the education – blood pressure association. No socioeconomic variation was found for DBP or occupational status. Binge drinking correlated positively with blood pressure, although it did not change the SES – blood pressure association.

The findings supported the hypothesis that low educated individuals would be more vulnerable to health risks than high educated individuals, although the support was weak. Furthermore, the hypothesis that childhood environment predicts adult health was confirmed as the pathway from adverse childhood SES to elevated blood pressure in early middle age was found. The association, however, went via educational level and adulthood body mass, thus testifying to the complexity of the relationship between childhood factors and later health outcomes.

4 DISCUSSION

4.1 Allostatic load in middle age

The allostatic load model offered a framework within which to study the long-term effects of stressful situations on health. The present research effort aimed at investigating the allostatic load model by means of a prospective, longitudinal approach using data drawn from the JYLS. In addition to allostatic load measured with eight parameters, allostatic load was also measured with six (metabolic syndrome) and two (blood pressure) of those eight parameters. Psychosocial factors (emotion regulation and dysregulation, education, occupational status, career instability, job strain) were studied as possible stressors that may lead to elevated allostatic load. Sex differences were also investigated.

As expected, using the high risk quartile method of Seeman et al. (1997), elevated allostatic load was found in 42% of men and 22% of women, regardless of the fact that most of the participants reported themselves as healthy. However, the hypothesis that men would have elevated allostatic load more often than women was only partially supported. A sex difference emerged, when the same criteria for elevated allostatic load were applied in both sexes, which is in line with a previous finding where working-aged men had higher allostatic load than their female counterparts (Schnorpfeil et al., 2003). When the criteria were differentiated for men and women, the sex difference disappeared and one-third of both sexes had elevated allostatic load.

The hypothesis that allostatic load would be a health risk was supported. Elevated allostatic load was also associated with concurrent psychosomatic symptoms in both men and women. However, in this instance a cross-sectional analysis had to be performed as allostatic load variables were only available from the last data wave of the JYLS. The next data wave, scheduled to take place when the participants are about 50 years old, will provide a better opportunity to study the relationship between allostatic load and health.

Allostatic load turned out to be sensitive in a sex-specific way to the parameters used. Men fell more often into the risk quartiles of secondary outcomes and women into those of primary mediators, which supports a previous finding among elderly people in the US (Seeman et al., 2002). As the secondary outcome parameters of allostatic load were congruent with metabolic syndrome, including blood pressure, a higher incidence of metabolic syndrome and hypertension was found in men than in women. The finding is typical in European cohorts (The European group for study of insulin resistance, 2002; Vanhala, Kumpusalo, Pitkäjärvi, & Takala, 1997), indicating that men have a higher risk for developing diabetes and coronary heart disease. In primary health care, physicians commonly identify individuals with high secondary outcomes, as these are well-recognized as risk factors for cardiovascular diseases and, therefore, widely used in clinical practice. Women's higher scores in primary mediators, measurements of which are more complex, suggest higher health risks beyond the traditional risk factors. If secondary outcome parameters alone are used to locate risk individuals, it carries the danger that women with an elevated risk profile in primary mediators will pass undetected. Thus primary mediators should also be considered in efforts to detect individuals who have an elevated risk for ill health, while defining the cut-off criteria separately for men and women in secondary outcomes can be introduced as standard practice. In this way, individuals with greater health risks could be better identified in both sexes. Targeting the prevention of cardiovascular diseases at these individuals might then be possible.

4.2 The role of emotion regulation in allostatic load

The role of stressors is fundamental in the long-term pathway from allostasis to allostatic load. The hypothesis that in the long-term certain emotion regulation strategies would act as stressors for elevated metabolic syndrome and poor subjective health was supported.

The emotion regulation measurements used in the present study were relatively stable through out the six-year follow-up, reflecting the consistency of the way a person regulates his or her emotions. Thus, as traits in emotion regulation are thought to be more relevant in regard to health than momentary states of emotion regulation (King & Emmons, 1990), the present findings that emotion regulation and dysregulation were associated with metabolic syndrome and subjective health were in line with expectations. A high tendency to repair one's mood over the six-year period was related to lower risk for metabolic syndrome. A high tendency to maintain one's current mood, good self-perceived emotion regulation, and low emotional ambivalence were related indirectly to metabolic syndrome through good subjective health. These results suggest that successful emotion regulation may attenuate stress and, thus, via physiological regulation systems reduce the risk for metabolic syndrome and allostatic load. Furthermore, although the present focus was on metabolic syndrome as objectively defined, subjective health had an important mediating role in the pathways between emotion regulation and metabolic syndrome. To my knowledge this was the first study to demonstrate an association between emotion regulation and lower risk for metabolic syndrome. The associations with subjective health supported previous findings concerning the link between the maintenance of positive mood and a reduction in self-reports of illness (Goldman et al., 1996), and between high emotional ambivalence and increased physical symptoms (King & Emmons, 1990, 1991).

Emotion regulation strategies are not inherently good or bad; what matters is to be able to choose an appropriate way to regulate one's emotions in situations as they arise (Ben-Ze'ev, 2000; Gross, 2002; Thompson & Calkins, 1996). For example, a continuous tendency to improve one's mood may act as a two-edged sword for health. It may lead to ignoring or denying matters of an unpleasant nature instead of actively dealing with them, which, in turn, may be harmful to one's health. Some support for this notion was found in the present study where, in addition to having an association with lower risk for metabolic syndrome, high repair was indirectly related to poor subjective health.

4.3 Work factors and allostatic load

This research underlined the complexity of the association between work factors and health. The most powerful predictor of work factors on health turned out to be stability of the career line: an unstable career was related to a three-fold risk for elevated allostatic load six years later in both men and women. A weak relationship between education and blood pressure was found but, in contrast, education had no impact on metabolic syndrome. Occupational status did not have a main effect on allostatic load, metabolic syndrome, or blood pressure, but it moderated the effect of long-term job strain on metabolic syndrome. Contrary to expectations, individuals with high occupational status and high long-term job strain had the most favourable profile in metabolic syndrome. Previously observed intergenerational trends in SES (Marmot, Shipley, Brunner, & Hemingway, 2001; Power & Matthews, 1997), which may reflect both genetic inheritance and environmental influences, were supported. Childhood environment also predicted adult health. The association, however, went via educational level and adulthood body mass, thus demonstrating the complexity of the links between childhood factors and later health.

An unstable career as a long-term stressful life condition had long-lasting effects on health. The finding may also reflect selection in the uptake of health care services. For example, unemployed persons and non-permanent workers typically miss medical checkups made by occupational health services. Therefore they need to take more initiating actions if they are to receive the same opportunities for effective diagnostic and treatment services within public health care as are available within occupational health care to individuals with permanent jobs. They may also, as a result of lower involvement in health care systems, have lower awareness of health risks. The findings underline the importance of the early identification of susceptible individuals, especially those with an unstable career line.

The reason why an unstable career line affected health equally in men and women may have its roots in Finnish society. In Finland, men and women are equally employed on a full-time basis, and they are individually taxed even when married. As a consequence of financial independence, unemployment and short work contracts are perceived as stressful situations by both sexes. Support for this view has been found in both Finland and Sweden, where the labour market situation is very similar. An unstable career line has preceded social functioning problems (Rönkä et al., 2000) and unemployment has predicted subsequent mortality (Nylen, Voss, & Floderus, 2001) in both sexes.

Stronger links with life-style risk factors may partially explain the greater blood pressure differences between educational levels than between occupational groups. Education is more stable over time than the other SES indicators and has been a stronger correlate of atherosclerosis than occupation and income in Finnish samples (Mäkelä, 1985; Lynch, Kaplan, Salonen, Cohen, & Salonen, 1995). However, if only employed people are selected for study, the effect of education on health may be reduced.

In addition to the interaction between job strain and occupational status, another unexpected interaction occurred between long-term job strain and sex: women with the lowest long-term job strain had higher metabolic syndrome than the other women. There might be many explanations for these results. Individuals with the best stress-coping skills might be selected to jobs with high job strain. Furthermore, other aspects of work, such as specific job rewards (Siegrist, 1996, 2002; van Vegchel, de Jonge, Bosma, & Schaufeli, 2005) and social support at work (Johnson & Hall, 1988) have been important in modifying the work–health relationship. If the reward–effort balance at work differs among women or within occupational groups, health consequences may vary within these groups regardless of the level of job strain. Women – or higher white-collar workers – with high long-term job strain but low metabolic syndrome might also have more perceived social support at work than others. Furthermore, work is only one, although very important, part of an individual's life. Multiple roles in life – having both work and family – have been found to lower job-related stress reactions after working hours (Steptoe, Lundwall, & Cropley, 2000). Family-life and other activities outside work may act as a buffer against the negative consequences of job strain. These aspects require further research.

Low SES has been associated with more negative emotions which, in turn, have been related to greater risk for coronary heart disease (Gallo & Matthews, 2003). Hence, successful emotion regulation may reduce the negative affect of low SES on health. A high tendency to repair one's negative mood in a more positive direction and to maintain one's current positive mood may act as buffers against the effects of low SES on health. In contrast, avoidance of negative thoughts and moods may lead to denial of unpleasant situations and thus, active coping may be restricted, as pointed out earlier. Furthermore, if the maintenance of one's current mood means excessive maintenance of negative mood, there may be harmful consequences. Therefore, it is important to develop flexibility in choosing the most appropriate emotion regulation strategy for a given situation. If the capacity for flexibility in emotion regulation is low in individuals with low SES, it may, at least partially, be responsible for their poorer health.

Regardless of men's more unfavourable levels of allostatic load, metabolic syndrome and blood pressure, and more disadvantageous trends in health behaviour, their subjective health was as good as women's. The development of metabolic syndrome also seemed to have the same structure in men and women. Moreover, when the associations between stressors and health were examined, the pathways were similar. That is to say, women were as vulnerable as men to the effects of the stressors. Also the effects of health behaviour were the same in both sexes. Thus, the sex differences found in allostatic load levels and cardiovascular risk factors may have different origins than in stressors and health behaviours. Heredity and the effects of sex hormones might be influential in this respect.

Unhealthy behaviour was related to elevated allostatic load. Adulthood BMI was related to metabolic syndrome and also mediated the association between SES and blood pressure. A surprising finding was that alcohol consumption affected health more than smoking: smoking was associated only with metabolic syndrome and only when employed people were studied, while binge drinking was associated with elevated allostatic load, metabolic syndrome, and blood pressure. In previous studies, tobacco has been a more important risk factor for cardiovascular diseases (Bello & Mosca, 2004; Dzien et al., 2004; Geslain-Biquez et al., 2003; Sheridan et al., 2003) and moderate alcohol consumption has protected from cardiovascular risk factors (Freiberg et al., 2004; Kiechl et al., 1996). However, our measurement of smoking was a single, three category variable that did not capture overall exposure to different tobacco products over the life-course. The finding that binge drinking was detrimental on health is in line with previous findings from Finland where binge drinking was an important risk factor for coronary heart disease regardless of the total level of alcohol consumption (Kauhanen et al, 1997; Kauhanen et al, 1999). This finding must be taken account in future research and, moreover, in alcohol policy, at least in Finland.

Health behaviour, however, did not change the relationship between unstable career and allostatic load, or the divergent association between long-term job strain and metabolic syndrome across either gender or occupation. Furthermore, alcohol consumption had no impact on the relationship between SES and blood pressure.

4.4 Methodological evaluation

The longitudinal study design had many benefits for this research. The prospective data gave us undeniable advantages in studying the role of stressors in allostatic load. The data were collected at two time-points in, for instance, emotion regulation and job strain. As chronic stress is more detrimental to health than short-term stress, it is important to measure long-term exposure to stressful situations. The longitudinal design also gave an opportunity to investigate the effects of lifelong factors, from birth to adulthood, on health. Too often questions of this kind are studied retrospectively using cross-sectional study designs.

Another benefit was that the study sample was randomly selected without any initial selection to attrition. Despite the length of the follow-up – over thirty years – the attrition rates of the participants have been low. The participants also have been shown to be socio-demographically representative of their national age cohort (Pulkkinen et al., 2003; Sinkkonen & Pulkkinen, 1996). This lends more reliability to the results. In contrast, the relatively small and ethically homogeneous sample imposes limitations on generalization of the findings.

Some disadvantages of the measurements used in the present study should be mentioned. The measurement of allostatic load was a limited one, especially as we took metabolic syndrome and blood pressure as allostatic load indicators. As far as the eight-parameter measure of allostatic load is concerned, only two primary mediators were included in the summary measurement. This might, at least in part, be responsible for the sex difference in allostatic load scores where women were found to fall more often into the primary mediator and men into the secondary outcome risk quartiles. It also meant that our allostatic load measurement mostly consisted of cardiovascular risk factors. The construct would have gained more power had cortisol and adrenaline, at least, been indexed in the model. Furthermore, measuring the allostatic load indicators on only one occasion was insufficient to clarify the theoretical sequential order in the development of allostatic load. It also limited the possibility of carrying out cross-lagged analyses.

With regard to single health measurements, in a non-diabetic population an oral glucose tolerance test instead of glycosylated haemoglobin might have better identified those individuals with glucose intolerance. Blood pressure at 15 years of age may reflect both genetic and environmental influences. Lack of information about the reliability of the instruments used to assess blood pressure at 15 years of age is a potential weakness of this study.

People do not randomly achieve different levels of SES, as many psychosocial factors contribute to differences in SES and work factors. Aggressive boys have been shown to be at risk for long-term unemployment in later life (Kokko, Bergman, & Pulkkinen, 2003; Kokko & Pulkkinen, 2000; Kokko, Pulkkinen, & Puustinen, 2000), and personality characteristics have been associated with unstable career (Pulkkinen et al., 1999) and adverse SES (Pulkki-Råback, 2004). Furthermore, a pessimistic explanatory style, powerlessness, anomie, and use of avoidant coping strategies have shown to be more frequent among individuals with low than high SES (Taylor & Seeman, 1999). The selection theory did not, however, form part of the present study design. Additionally, the operationalization of job demands and job control can be criticised. The job control measure lacked skill discretion, which is an important part of control, and the content of job demands is also broader than that used in the present study (Karasek et al., 1998).

4.5 Implications for future research and clinical prevention

Reducing the health risks due to psychosocial factors is one of the challenges facing health care in the future. Interventions aimed at moderating psychosocial processes that have a negative impact on health have been insufficient. In fact, no practical interventions have yet been developed (Beaglehole & Magnus, 2002). This, however, should not present an obstacle to investigating this area and trying to develop better ways of intervening in health risk factors of this kind.

Until new interventions have been developed we must continue to focus on the traditional risk factors, that is, on overweight, smoking, and alcohol consumption. This concerns not only the health care services but the whole of society. The mass media can seek to influence public opinion via material promoting a healthy lifestyle. In the workplace healthy choices may be encouraged by providing opportunities for non-smoking interventions and exercise. Policy-making has an important role in health prevention. For example, the lowering of alcohol taxation in Finland in 2004 seems to have increased alcohol consumption. This may have long-lasting effects on health across the whole country. In addition to the direct consequences of increased alcohol consumption, alcohol-related risk for cardiovascular diseases is increasing. A positive example of health promotion is the Finnish policy on smoking, which has been forbidden in many places through legislative action. Opportunities for activities that counter a sedentary lifestyle should also be more available to all. An excellent example of such an initiative can be found in Jyväskylä, where the city has organised a free recreational zone by Jyväsjärvi lake. Not only does the lake provide a natural ice skating rink and an opportunity to ski in winter, but the path constructed along the lake shore allows people to train Nordic walking, cycling, jogging or roller skating in summer.

Unfortunately, health behaviour interventions have not been very effective. Even though smoking has decreased dramatically among men in the past 50 years in Finland, the rates among women have slowly increased. Furthermore, both alcohol consumption and overweight have increase over the past decades. Therefore interventions for psychosocial factors need to be actively developed. For instance, if it becomes possible in the future to measure situational flexibility in emotion regulation with better methods, this would do much to further studies in emotion regulation. If situations where dysregulation occurs could be identified, interventions aimed at more suitable emotion regulation in those situations could be developed. This, in turn, would most likely improve the effectiveness of traditional risk factor intervention, as eating, smoking, and drinking are widely known to be behavioural ways of regulating one's emotions. When these alternative interventions are available, behavioural changes in more favourable directions may occur.

Work factors contributed to elevated allostatic load. As in previous studies selection to low SES and adverse work career have been found, interventions to reduce social exclusion at an early stage of life should be implemented. For instance, active interference is needed if an adolescent is in danger of dropping out of school. Furthermore, as prosocial skills and child-centred parenting have been shown to protect aggressive boys from unemployment (Kokko & Pulkkinen, 2000), interventions where by these skills are developed should be encouraged. An example of this kind of intervention is the MUKAVA project, which is focused on developing the social skills of school children in Finland (Pulkkinen, 2004).

To sum up, the allostatic load model is promising for the study of the effects of psychosocial factors on health from the life-course prospective. There are, however, unresolved issues relating to the indicators of allostatic load, such as the sequential development of allostatic load and the use of the same criteria for men and women, which carries the danger that some at-risk women are passed over, at least in the middle-aged population. According to the theory, allostatic load develops slowly from primary stress reactions via health risk factors to actual diseases. As we only had concurrent health data, more longitudinal studies are needed to reveal the full extent of the pathway from stressors to diseases.

TIIVISTELMÄ

Väitöskirjani tavoitteena oli tutkia terveyden biopsykososiaalista näkökulmaa allostaattisen kuorman mallin avulla. Allostaattinen kuorma on fysiologisten stressireaktioiden kasautuva, pitkäaikainen seuraus, joka voi johtaa sairauksien syntyyn (McEwen & Stellar, 1993). Stressireaktioissa elimistön säätelyjärjestelmät aktivoituvat saaden aikaan lyhyt- ja pitkäaikaisia seurauksia, esimerkiksi aiheuttaen sairauksien riskitekijöiden muodostumista. Niinpä allostaattista kuormaa voidaan kuvata säätelyjärjestelmien välittäjäaineiden lisäksi tunnetun sydän- ja verisuonisairauksien riskitekijärypään, metabolisen oireyhtymän, avulla. Metabolinen oireyhtymä koostuu huonontuneesta sokeriaineenvaihdunnasta, poikkeavista veren rasva-arvoista, ylipainosta – erityisesti keskivartalolihavuudesta – ja kohonneesta verenpaineesta (Alberti & Zimmet, 1998).

Tutkimukseni *ensimmäisenä* tavoitteena oli määrittää keski-ikää lähestyvien miesten ja naisten allostaattinen kuorma. *Toisena* pyrkimyksenä oli tutkia työuran vakauden yhteyttä allostaattiseen kuormaan ja allostaattisen kuorman yhteyttä psykosomaattisiin oireisiin. *Kolmantena* tarkoituksena oli selvittää tunteidensäätelyn suhde metaboliseen oireyhtymään sekä subjektiivisen terveyden osuus siinä yhteydessä. *Neljäntenä* päämääränä oli analysoida pitkäaikaisen työkuormituksen, sukupuolen ja ammattiaseman kytkeytymistä metaboliseen oireyhtymään. *Viidentenä* tavoitteena oli tutkia erilaisten lapsuusajan ja aikuisuuden tekijöiden merkitystä sosioekonomisen aseman (koulutuksen ja ammattiaseman) sekä verenpaineen välisessä suhteessa. Näiden päätavoitteiden lisäksi pyrkimyksenä oli sukupuolierojen selvittäminen.

Väitöskirjani on osa professori Lea Pulkkisen aloittamaa ja johtamaa Lapsesta aikuiseksi -tutkimusta (Pulkkinen, 1982; Pulkkinen ym., 2003). Tutkimus alkoi vuonna 1968, jolloin mukaan valittiin Jyväskylän kaupungin kansakouluista 12 toista luokkaa. Luokkien kaikki oppilaat, 196 poikaa ja 173 tyttöä, osallistuivat tutkimukseen. Oppilaat olivat syntyneet pääasiassa vuonna 1959, joten he olivat tutkimuksen alkaessa 8-vuotiaita. Seuraavat päätutkimusvaiheet toteutettiin tutkittavien ollessa 14-, 27-, 36- ja 42-vuotiaita. 8- ja 14-vuotiaana tietoa kerättiin toveri- ja opettaja-arvioinneilla. Aikuisena tietolähteinä ovat olleet postitetut elämäntilannekyselyt sekä puolistrukturoidut haastattelut itsenäisesti täytettävine lomakkeineen. Tutkittavat osallistuivat 42-vuotiaina haastattelun lisäksi terveystarkastukseen, johon kuului myös laboratoriokokeita. Heiltä pyydettiin samalla suostumus kouluterveydenhuollon terveyskertomusten käyttöön. Osallistumiskatoa ei esiintynyt aineistonkeruun alussa, jonka jälkeenkin osallistuminen on ollut hyvin aktiivista (Pulkkinen ym., 2003). Osallistujat ovat edustaneet valikoitumattomasti sekä alkuperäistä tutkimusjoukkoa että koko ikäluokkaansa. Tutkimuksessa käytettiin pitkittäisasetelmaa ja pääanalyysimenetelminä olivat logistiset ja lineaariset regressioanalyysit, kovarianssianalyysit sekä rakenneyhtälömallintaminen.

Tutkimuksessa käytettiin allostaattisen kuorman osoittimena riskinel-jännesmenetelmää, jossa allostaattinen kuorma koostuu elimistön eri säätely- ja

aineenvaihduntajärjestelmien mittausten riskineljänneksiin kuulumisen summasta (Seeman ym., 1997). Mukaan valittiin lisämunuaiskuoren hormoni dihydroepiandrosterioni glukokortikoidien toiminnallisena vastaanvaikuttajana sekä hermostoa suojaavana tekijänä ja 12 tunnin virtsakeräyksen noradrenaliinipitoisuus autonomisen hermoston toiminnan kuvaajana. Mittariston loput muuttujat – systolinen ja diastolinen verenpaine, keskivartalolihavuuden mittaus, veren rasva-arvot sekä verensokeriaineenvaihdunnan mittaus – muodostivat tunnetun veri- ja sydänsairauksien rypään, metabolisen oireyhtymän, jota käytettiin myös itsenäisenä allostaattisen kuorman osoittimena. Tutkimus toi julki, että 42-vuotiaana miehillä oli kaksi kertaa useammin korkea allostaattinen kuorma kuin naisilla (41,9 % miehistä, 21,8 % naisista), kun riskineljännesmenetelmän riskirajat oli määritelty molemmille sukupuolille samoiksi. Myös metabolinen oireyhtymä ja verenpaine olivat miehillä naisten arvoja korkeammat. Kun allostaattisen kuorman riskirajat määritettiin erikseen miehille ja naisille, sukupuoliero hävisi: kolmanneksella tutkittavista oli tuolloin korkea allostaattinen kuorma. Niillä tutkittavilla, joilla oli korkea allostaattinen kuorma, oli muita enemmän psykosomaattisia oireita.

Mikäli työura oli ollut epävakaa 27 ikävuodesta 36 ikävuoteen, oli korkean allostaattisen kuorman riski 42-vuotiaana sekä miehillä että naisilla yli kolminkertainen vakaaseen työuraan verrattuna. Epävakaa työura sisälsi työttömyyden lisäksi lyhyet, omaa ammattia vastaamattomat työsuhteet, kun taas vakaaseen työuraan sisältyivät työsuhteet omalla ammattialalla ilman pitkiä katkoksia. Epävakaa työura siis osoittautui pitkäkestoiseksi stressaavaksi elämäntilanteeksi, joka uhkasi myöhempää terveyttä.

Tutkittaessa aikuisiän tunteidensäätelyn yhteyttä metaboliseen oireyhtymään sekä subjektiivisen terveyden osuutta siinä subjektiivinen terveys sisälsi itse arvioidun terveyden ja itse ilmoitetut psykosomaattiset oireet 36- ja 42-vuotiaina. Tunteidensäätelyä kuvaisivat 36- ja 42-vuotiaina kognitiivisista tunteidensäätelystrategioista tunteiden korjaaminen ja ennallaan säilyttäminen, tunne-elämän ambivalenttius sekä 42-vuotiaana itse koettu tunteidensäätelyn onnistuminen. Kun yksilöllä oli taipumus korjata kielteisiä tunteita myönteisimmiksi, hänellä oli matala metabolinen oireyhtymä eli vähäinen sydän- ja verisuonisairauksien riski. Lisäksi tutkittavan pyrkiessä säilyttämään kunkin hetkisen tunteensa ja arvioidessa tunteidensäätelynsä hyväksi oli hänen subjektiivinen terveytensä hyvä, mikä taas oli yhteydessä matalaan metaboliseen oireyhtymään. Tunne-elämän ambivalenttius huononsi subjektiivista terveyttä ja lisäsi sitä kautta metabolista oireyhtymää.

Tutkittaessa pitkäaikaisen työkuormituksen, sukupuolen ja ammattiaseman yhteyttä metaboliseen oireyhtymään korkea työkuormitus määritettiin työn korkean vaatimustason sekä vähäisten vaikutusmahdollisuuksien yhdistelmäksi (Karasek, 1979; Karasek & Theorell, 1990), ja se mitattiin sekä 36- että 42-vuotiaana. Ammattiasema ja pitkäaikainen työkuormitus eivät yksinään muuttaneet metabolista oireyhtymää, mutta sukupuoli ja ammattiasema muunsivat pitkäaikaisen työkuormittavuuden yhteyttä metaboliseen oireyhtymään yllättävällä tavalla. Niillä naisilla, joilla oli matalin pitkäaikainen työkuormitus, oli korkein metabolinen oireyhtymä. Ylemmistä toimihenkilöistä niillä, joilla oli korkein pitkäaikainen työkuormitus, oli muita ylempiä toimihenkilöitä matalampi metabolinen oireyhtymä.

Sosioekonomisen aseman ja aikuisuuden verenpaineen välistä yhteyttä tutkittaessa tarkasteltiin syntymäpainon, vanhempien ammattiaseman ja nuoruusiän verenpaineen, aikuisiän alkoholinkäytön, tupakoinnin sekä suhteellisen painon merkitystä. Tulokset osoittivat alhaisen koulutustason kytkeytyvän heikosti korkean systolisen verenpaineen kehittymiseen. Koulutuksen ja verenpaineen välinen polku mutkistui, kun vanhempien ammattiaseman ja aikuisuuden suhteellisen painon merkitys otettiin huomioon. Vanhempien matala ammattiasema nivoutui tutkittavien heikkoon koulutustasoon, mikä liittyi aikuisiän korkeaan suhteelliseen painoon. Ylipaino oli puolestaan yhteydessä korkeaan verenpaineeseen. Vanhempien ammattiasema ja aikuisuuden paino olivat siis merkittäviä koulutuksen ja verenpaineen välisessä suhteessa. Lisäksi miehillä ja niillä tutkittavilla, joilla oli jo nuoruudessa muita korkeampi verenpaine, oli muita useammin korkea verenpaine 42-vuotiaanakin. Muut lapsuuden ja aikuisiän tekijät eivät muuttaneet koulutuksen yhteyttä 42-vuotiaan verenpaineeseen. Ammattiasema ja verenpaine eivät kytkeytyneet toisiinsa.

Tutkimukseni osoitti, että käytettäessä allostaattisen kuorman mallia jo 42-vuotiaista on löydettävissä yksilöitä, joilla on kohonnut terveysriski. Tätä kohonnutta riskiä ennakoivat niin psykologiset kuin sosiaalisetkin tekijät. Vaikka allostaattinen kuorma – sekä sen osatekijät metabolinen oireyhtymä ja verenpaine – oli miehillä naisia korkeampi, stressin aiheuttajat nivoutuivat samalla tavalla kohonneeseen allostaattiseen kuormaan molemmilla sukupuolilla. Miehet ja naiset siis reagoivat stressitilanteisiin yhtäläisesti. Terveyserojen taustalla voivatkin olla esimerkiksi geneettiset tekijät tai sukupuolihormonien vaikutukset.

Onnistunut tunteidensäätely suojasi kohonneelta terveysriskiltä, mikä välittynee elimistön stressireaktioiden tarkoituksenmukaisen käytön kautta. Epävakaa työura osoittautui selkeästi terveysriskiksi, mutta koulutuksen ja ammattiaseman yhteys terveyteen oli monimutkaisempi. Koulutuksen yhteyttä terveyteen välitti ylipaino: vähemmän koulutetut olivat ylipainoisempia, ja heillä oli siten useammin kohonnut verenpaine. Ammattiaseman tarkastelu taas osoitti, että ylemmät toimihenkilöt sietivät stressiksi oletettua pitkäaikaista työkuormitusta hyvin, ainakin silloin kun terveyden mittarina oli metabolinen oireyhtymä. Ehkäpä työkuormitusta sisältäviin tehtäviin valikoituu yksilöitä, jotka kykenevät käsittelemään stressitilanteita onnistuneesti. Väestön terveyden edistämiseksi sosioemotionaalisen kehityksen tukeminen ja varhainen puuttuminen koulutukselliseen syrjäytymiseen sekä työuran epävakaistumiseen ovat tutkimukseni valossa ensiarvoisen tärkeitä. Myös ylipainon kehittymiseen tulisi tarttua jo ajoissa. Vaikka nämä voivat tuntua vaativan vain yksilön ratkaisuja, myös työyhteisöjen ja yhteiskunnan tulisi tukea yksilöiden terveellisiä valintoja.

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