

**Sleep, health behaviours and weight among ageing employees**  
A follow-up study

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ACADEMIC DISSERTATION

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## LIST OF ORIGINAL PUBLICATIONS

I Haario P, Rahkonen O, Laaksonen M, Lahelma E, Lallukka T. Bidirectional associations between insomnia symptoms and unhealthy behaviours. *Journal of Sleep Research* 2013; 22: 89-95.

II Lallukka T, Haario P, Lahelma E, Rahkonen O. Associations of relative weight with subsequent changes over time in insomnia symptoms: a follow-up study among middle-aged women and men. *Sleep Medicine* 2012; 13: 1271-1279.

III Lyytikäinen P, Lallukka T, Lahelma E, Rahkonen O. Sleep problems and major weight gain: a follow-up study. *International Journal of Obesity* 2011; 35: 109-114.

IV Lyytikäinen P, Rahkonen O, Lahelma E, Lallukka T. Association of sleep duration with weight and weight gain: a prospective follow-up study. *Journal of Sleep Research* 2011; 20: 298-302.

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## **ABBREVIATIONS**

BMI	Body Mass Index
CI	Confidence Interval
GHQ	The General Health Questionnaire
MET	Metabolic Equivalent
OR	Odds Ratio
WHO	World Health Organization

## **ABSTRACT**

Insomnia symptoms and short sleep duration constitute a notable public-health problem. They impair wellbeing and are risk factors for several diseases, both of which may affect societal functioning.

The aim of this study was to examine whether insomnia symptoms are associated with subsequent unhealthy behaviours and weight gain, and whether unhealthy behaviours and weight are associated with subsequent insomnia symptoms. Additionally, the aim was to examine whether sleep duration is associated with weight gain.

The data were derived from the Helsinki Health Study cohort baseline and follow-up mail surveys. The baseline data were collected in 2000-2002 among employees of the City of Helsinki aged 40-60 (n=8960, response rate 67%). The follow-up data were collected in 2007 (n=7332, response rate 83%). Insomnia symptoms were measured on frequency about having trouble falling asleep, waking up at night, having trouble staying asleep and waking up tired after one's usual amount of sleep, all during the previous four weeks. The respondents were also asked about their average sleep duration week days. Unhealthy behaviours included heavy and binge drinking, smoking, physical inactivity and unhealthy food habits. Weight was assessed using body mass index (BMI), kilograms and weight gain. Analyses of variance, logistic regression and multinomial regression were used in the statistical analyses.

Poor sleep, more specifically insomnia symptoms and short sleep duration, were associated with weight gain, and BMI showed an association with changes in insomnia symptoms. These associations were evident mainly among women. Insomnia symptoms showed a bidirectional association with heavy drinking, and were also associated with subsequent physical inactivity. Additionally, binge drinking showed an association with subsequent insomnia symptoms. This study confirms associations among poor sleep and weight and mainly weak and inconsistent associations among insomnia symptoms and unhealthy behaviours.

## TIIVISTELMÄ

Unettomuusoireet ja lyhyt unen kesto ovat kansanterveysongelmia. Ne heikentävät hyvinvointia ja ovat monen sairauden riskitekijöitä ja saattavat vaikuttaa koko yhteiskunnan toimintaan.

Tämän tutkimuksen tavoitteena oli tutkia, ovatko unettomuusoireet yhteydessä myöhempään terveyskäyttäytymiseen ja painonnousuun ja ovatko terveyskäyttäytyminen ja paino yhteydessä myöhempään unettomuusoireisiin. Lisäksi tavoitteena oli tutkia, onko unen kesto yhteydessä painonnousuun.

Tutkimuksen aineistona käytettiin Helsinki Health Study -kohorttitutkimuksen perus- ja seurantakyselyä. Peruskysely kerättiin vuosina 2000-2002 Helsingin kaupungin 40-60-vuotiaiden työntekijöiden keskuudessa (n=8960, vastausaktiivisuus 67 %). Seurantakysely kerättiin vuonna 2007 (n=7332, vastausaktiivisuus 83 %). Unettomuusoireita mitattiin kysymällä nukahtamisvaikeuksia, vaikeuksia pysyä unessa ja heräilyä yöllä sekä heräämistä väsyneenä tavallisen yön jälkeen viimeksi kuluneiden neljän viikon aikana. Lisäksi tiedusteltiin keskimääräistä unen kestoa arkisin. Terveyskäyttäytymisen riskitekijöinä olivat alkoholin suurkulutus, humalahakuinen juominen, tupakointi, vähäinen vapaa-ajan liikunta sekä epäterveelliset ruokatavat. Paino määritettiin painoindeksinä (BMI), kilogrammoina ja painonnousuna seurannan aikana. Tilastollisina menetelminä käytettiin varianssianalyysia, logistista regressioanalyysia ja multinomiaalista regressionanalyysia.

Huono uni, tarkemmin sanottuna unettomuusoireet ja lyhyt unen kesto olivat yhteydessä painonnousuun ja BMI oli yhteydessä unettomuusoireiden muutoksiin. Nämä yhteydet todettiin pääsääntöisesti naisilla. Unettomuusoireiden yhteys alkoholin suurkulutukseen oli kaksisuuntainen. Unettomuusoireet olivat yhteydessä myös vähäiseen vapaa-ajan liikuntaan. Lisäksi, humalahakuinen juominen oli yhteydessä myöhempään unettomuusoireisiin. Tämän tutkimuksen mukaan huonon unen ja painon välillä on yhteyksiä, mutta unettomuusoireiden ja terveyskäyttäytymisen välillä yhteydet ovat enimmäkseen heikkoja ja epäjohdonmukaisia.



## 1. INTRODUCTION

We spend about a third of our lifetime asleep (Cappuccio et al. 2010b), and still there is surprisingly little understanding of why we need sleep (Sleepdex - Resources for Better Sleep). It is known that sleep is necessary for individual wellbeing and health maintenance. It is thus necessary for health, and humans can survive longer without food than without sleep (Sleepdex - Resources for Better Sleep).

Previous research on sleep focuses mainly on the cognitive and biological consequences of sleep loss, given the belief that sleep is purely for the brain. As early as in 1953 the sleep research pioneer Nathaniel Kleitman overthrew the belief that sleep was simply the cessation of most brain activity, showing that something active happens as well (Siegel 2003). About ten years later, in 1964, Hammond suggested that sleep may influence and also be influenced by health, reporting a U-shaped association between sleep duration and death (Hammond 1964). More recently, sleep research has focused on the nature of sleep on the level of the nerve cells (Siegel 2003), and is now broader and more diverse in scope.

Currently there is research interest in the health effects of sleep, and increasing awareness of the association between poor sleep and poor health (Ferrie et al. 2011). In the present epidemiological study, poor sleep refers, first, to insomnia symptoms such as difficulties in initiating and maintaining sleep as well as non-restorative sleep (Jenkins et al. 1988, Current Care Guideline: Insomnia 2012), and second to sleep duration, ranging from long to short.

Insomnia symptoms are common and affect more people than previously thought (Ferrie et al. 2011). They appear to be more prevalent in Finland than in many other European countries (Ohayon and Partinen 2002). In particular, occasional insomnia symptoms have increased somewhat, but sleep duration shortened only slightly among employed middle-aged people in Finland between 1972 and 2005 (Kronholm et al. 2008).

Insomnia symptoms, and both short and long sleep duration may be transient or chronic. In particular, chronic poor sleep increases the risk of many illnesses and affects the quality of life (Krystal 2003, Current Care Guideline: Insomnia 2012). Therefore, sleep has become an important subject of public-health research (Kronholm 2005), and its epidemiology a growing area within sleep research (Ferrie et al. 2011). Poor sleep has been linked with several public-health problems (Cappuccio et al. 2010a, Hublin et al. 2011, Kronholm et al. 2011). It is

suggested that there are associations among poor sleep and unhealthy behaviours such as alcohol consumption, smoking, unhealthy food habits and physical inactivity (Fabsitz et al. 1997, Fogelholm et al. 2007, Wallander et al. 2007, Buxton et al. 2009). Poor sleep is also assumed to be associated with body weight (Fogelholm et al. 2007). However, it may be either an antecedent or a consequence of unhealthy behaviours, overweight, obesity and weight gain or both, or then a third factor may connect them. Its causes and consequences are still poorly understood. The direction of association among sleep and unhealthy behaviours and weight is still unclear, thus there is a need to examine both directions, in other words whether sleep is associated with unhealthy behaviours and weight, or whether unhealthy behaviours and weight are associated with sleep.

Alcohol consumption and smoking are associated with several diseases and millions of deaths worldwide each year (WHO Expert Consultation 2011). Unhealthy food habits and physical inactivity are also linked to several non-communicable diseases (WHO Expert Consultation 2004). According to a systematic analysis of health-examination surveys and epidemiological studies, an estimated 1.46 billion adults worldwide are at least overweight (Finucane et al. 2011), and more than half of adults in most countries in Europe are overweight or obese. Overweight and obesity are well-established risk factors contributing to the overall burden of disease worldwide (Swinburn et al. 2011). As shown, these behavioural risk factors as well as poor sleep are associated with major diseases and deaths. It is therefore worth finding out whether the risk factors are associated with each other.

Few studies focus on the associations among sleep and unhealthy behaviours and weight, and there is a lack of longitudinal studies involving middle-aged employed people. The need for novel evidence of these associations is thus clear, not least in order to improve public health through the prevention of major chronic diseases. The aim of this prospective study therefore was to examine the associations of poor sleep with unhealthy behaviours and weight among middle-aged employees of the City of Helsinki, Finland.

## **2. CONCEPTS**

### **2.1 Sleep, insomnia symptoms and sleep duration**

Sleep is essential for individual wellbeing and health maintenance (Lockley 2010), although we still do not know exactly why. The simple answer is that adequate sleep is necessary in order to stay alert and awake (Siegel 2003). It has been suggested that sleep probably has multiple functions for the body and the brain (Siegel 2005). Given its physiological and neurobehavioural effects, it seems to serve critical biological needs (Lockley 2010). Sleep is also important for mental health (Roth and Roehrs 2003), health behaviours (Janson et al. 2001) and physical functioning (Stenholm et al. 2011). Sleep has been defined as “a condition of body and mind, which typically recurs for several hours every night, in which the nervous system is inactive, the eyes closed, the postural muscles relaxed, and consciousness practically suspended” (Oxford Dictionaries). Sleep timing and structure are regulated by the circadian clock, sleep-wake homeostasis and a homeostatic process, and also by willed behaviour (Lockley 2010).

Insomnia is generally defined on the basis of an individual’s report of having difficulty with sleep (Roth 2007). More specifically, insomnia manifests as having trouble falling asleep, waking up several times per night, having trouble staying asleep or waking up feeling tired and worn out after the usual amount of sleep, and is associated with daytime consequences (Roth, Roehrs 2003). It may be self-induced, secondary or primary (Ohayon 2002). Self-induced insomnia is attributable to life-style factors or the use, abuse or withdrawal of psycho-active substances, and secondary insomnia to mental-health or medical conditions, breathing or other sleep disorders. Primary insomnia is not attributable to any other condition (Ohayon 2002).

There is a multitude of situations in life that may cause occasional insomnia symptoms in an individual who usually sleeps well (Ohayon 2002). Some people exhibit insomnia symptoms repetitively, which may eventually become chronic. Insomnia symptoms may thus be transient, short-term or chronic. Transient insomnia symptoms typically last less than two weeks, and short-term insomnia symptoms between two and 12 weeks. When insomnia symptoms persist over three months, they are considered chronic (Current Care Guideline: Insomnia 2012).

Sleep duration means the average time spent asleep in a day, and together with the amount of sleep individuals need, is influenced by a complex combination of lifestyle factors and also by age (Bixler 2009). There is high variability in sleep duration and in the need for sleep among individuals, everyone having his or her own requirements (Ferrara and De Gennaro 2001). There are people who naturally sleep far more or less than average (Ferrara and De Gennaro 2001). Most of those who sleep less suffer from sleep deprivation (Sleepdex - Resources for Better Sleep), which is the condition of not having enough sleep.

The research on insomnia symptoms lacks established terminology, which thus varies across studies (Ohayon 2002). The concept and definition remain elusive, thus the term insomnia is used in a variety of ways in the literature (Roth 2007). Definitions of short and long sleep duration also vary across studies.

The concepts of poor sleep, insomnia symptoms and short or long sleep duration are used in this thesis. Included in the concept of poor sleep are insomnia symptoms and short or long sleep duration, which even if they are associated (Grandner, Kripke 2004), still indicate different issues (Sivertsen et al. 2009).

## **2.2 Health behaviours**

Health behaviours comprise behavioural patterns, habits and lifestyles. Unhealthy behaviours are risk factors for major non-communicable diseases, such as cardiovascular diseases, some types of cancer and diabetes. In 2001 such diseases accounted for almost 60 per cent of the 56 million deaths annually, thus their prevention presents a major challenge to global public health (WHO Expert Consultation 2004). A significant proportion of the mortality is attributable to unhealthy behaviours, which are modifiable.

There are many ways of defining health behaviours. One option is to distinguish health-enhancing from health-impairing behaviours (Conner 2002). Excessive alcohol consumption, smoking and unhealthy food habits are health-impairing behaviours in that they have harmful effects on health or may predispose to disease. Otherwise, physical activity and healthy food habits are health-enhancing behaviours in that they have health benefits or protect against certain diseases (Conner 2002).

Alcohol drinking refers to the consumption of different kinds of alcoholic beverages, including beer, cider, wine and spirits. Consumption is referred to as moderate, heavy or binge drinking. Excessive consumption through heavy or binge drinking may cause the development of dependency, with serious social and health consequences. Thus, excessive alcohol drinking has harmful effects on health because it may predispose to several diseases and promote exposure to accidents or violence. Moderate alcohol drinking, on the other hand, has been associated with a reduced risk of some diseases (Arranz et al. 2012). The adverse effects of heavy and binge drinking differ. Several diseases are attributable to continued heavy drinking, whereas some accidents or violence are specifically related to excessive alcohol consumption in a single session (Conner 2002). The consumption of alcohol in Finland is on the average level for Europe, but binge drinking is a major problem (Current Care Guideline: Treatment of alcohol abuse 2012).

Smoking remains a preventable risk factor for morbidity and mortality in developed countries (Neubauer et al. 2006). A smoking habit can be defined by smoking cigarettes, cigars or a pipe occasionally or on a regular basis, and the numbers of cigarettes smoked per day vary among smokers. The nicotine in tobacco is addictive, and causes strong dependence (Current Care Guideline: Tobacco dependence and cessation 2012).

Physical activity is defined as any bodily movement produced by the skeletal muscles and leading to energy expenditure (Caspersen et al. 1985). There are many types of activity, commonly divided into occupational physical activity, which consists of walking, standing and moving during the course of the day, and leisure-time physical activity meaning habitual, unplanned physical activities and planned exercise. Different dimensions of physical activity may be described in terms of duration, frequency, intensity and volume (WHO Expert Consultation 2010). Duration means the length of time and frequency means the number of times the activity is performed, whereas intensity refers to the rate at which it is performed or the magnitude of the effort required to perform it. The volume of physical activity is a product of its duration, frequency and intensity (WHO Expert Consultation 2010).

Food habits refer to eating patterns in which people engage. However, the types of food consumed and the frequency of food items or specific food groups consumed and also the portion sizes vary among and within individuals. Food habits differ from the other above-mentioned health behaviours in that food is essential for life.

### **2.3 Body mass index and weight gain**

Etiology of obesity is multi-factorial, which involves complex interactions among genetic background, hormones and different kinds of social and environmental factors (Chan and Woo 2010). Worldwide, an estimated 1.46 billion adults are at least overweight (Finucane et al. 2011). Overweight and obesity are major causes of co-morbidities and other health problems that can lead to morbidity and mortality (Chan and Woo 2010).

Overweight and obesity are defined as abnormal or excessive fat accumulation (WHO 2012). Body weight is often assessed in terms of body mass index (BMI), which is a commonly used indicator of excess weight. BMI is calculated as weight in kilograms divided by height in square metres, and the risk of co-morbidities and other health problems increases as BMI increases (WHO 2012). Although it is a useful population-level measure of overweight and obesity, it must be taken into account that it may not correspond to the same degree of fatness in different individuals (WHO 2012). Obesity can also be measured in terms of waist circumference, waist-to-hip ratio and the percentage of body fat (WHO/FAO Expert Consultation 2003).

Weight gain occurs when energy intake exceeds energy expenditure (Harnack and Schmitz 2005), and this leads to the excessive storage of fat in adipose tissue. It is usually the consequence of an increased intake of energy and/or a decrease in physical activity (WHO/FAO Expert Consultation 2003). These changes in dietary and physical activity patterns tend to be attributable to environmental and societal changes, such as in food processing, marketing, education and transport (WHO 2012). Thus, overweight, obesity and weight gain are preventable.

### **3. A REVIEW OF THE LITERATURE**

The literature review in this study focuses primarily on large-scale epidemiological studies on adults (aged 18 years or more). It includes prospective studies on, firstly, the associations among insomnia symptoms and unhealthy behaviours, secondly, the association between BMI and changes in insomnia symptoms, and thirdly, the association between insomnia symptoms and weight gain, with special emphasis on reviews of the association between sleep duration and weight gain. Finally, previous evidence on these associations is summarised. Cross-sectional studies among insomnia symptoms and unhealthy behaviours and weight in adults, not presented in detail in the review, are listed in Appendices 1-4.

#### **3.1 Insomnia symptoms and unhealthy behaviours**

Most studies examining associations among insomnia symptoms and unhealthy behaviours such as smoking, alcohol consumption, physical inactivity and unhealthy food habits, are cross-sectional (Phillips, Danner 1995, Tachibana et al. 1996, Fabsitz et al. 1997, Härmä et al. 1998, Sherrill et al. 1998, Kageyama et al. 2005, Strine et al. 2005, Fogelholm et al. 2007) (Appendices 1-3).

A recent review (Shochat 2012) highlights current lifestyle trends that research has shown to be associated with sleep, although it reports only a few prospective studies on the association between physical activity and sleep (Shochat 2012). It is also noted that smoking is recognized as a behaviour that interferes with sleep, but more prospective studies are needed to understand the direction of the association. The review also discusses the association between alcohol consumption and sleep, but only in children, adolescents and young adults.

One Swedish study examines the association between insomnia symptoms and several unhealthy behaviours simultaneously. According to the findings, men with insomnia symptoms have a greater tendency to be physically inactive, current smokers and to show symptoms of alcohol dependence (Janson et al. 2001). Moreover, it identifies physical inactivity and alcohol dependence as independent risk factors. Most of the studies on insomnia symptoms and unhealthy behaviours concern only one form of behaviour at a time, thus the focus in this review section is on the main literature concerning the association among insomnia symptoms and each form of unhealthy behaviour separately.

### *Insomnia symptoms and alcohol consumption*

There are a few cross-sectional studies on insomnia symptoms and alcohol consumption (Appendix 1). It is suggested in a large population-based cross-sectional study that insomnia symptoms are less common among never-drinkers than light drinkers (Poikolainen et al. 2005). The same study also found that never-drinkers were as likely as light drinkers to have frequent insomnia symptoms, but less likely to have occasional insomnia symptoms. One large case-control study reports an association between alcohol consumption and an increased risk of insomnia symptoms (Wallander et al. 2007), and it is also suggested that alcohol dependence is associated with the risk (Janson et al. 2001). Other cross-sectional studies suggest associations between alcohol consumption and insomnia symptoms (Tachibana et al. 1996, Fabsitz et al. 1997, Härmä et al. 1998), although a recent study found the opposite, showing that high alcohol intake was protective against insomnia symptoms (Jausset et al. 2011). Another cross-sectional study reports an association between drinking alcohol sometimes or daily and non-restorative sleep, but not with other insomnia symptoms (Ohayon and Bader 2010). Owens et al. (1998) found no association between alcohol consumption and insomnia symptoms.

Stein and Friedmann (2005) review nine cross-sectional epidemiological and clinical studies covering the years 1979-2001, the results of which suggest an association among alcohol consumption and insomnia symptoms. One clinical review (Roehrs and Roth 2001) examines the effects of ethanol on sleep. According to the findings, alcohol affects insomnia symptoms, and the effects of ethanol may be bi-directional: alcohol drinking is associated with insomnia symptoms leading to daytime sleepiness, which impairs performance, and this may also relate to alcohol drinking.

Four prospective studies focus on alcohol consumption and insomnia symptoms. One of these assesses the association among individuals with chronic and remitted alcohol dependence (Crum et al. 2004), reporting an association between chronic alcohol dependence and subsequent insomnia symptoms following adjustment for several covariates (Table 1). However, insomnia symptoms at baseline were not taken into account. Moreover, the age range of the participants is wide, 18 years and above at the beginning of the study, and the focus is on individuals who met the criteria for chronic alcohol dependence at the time of the follow-up and also at the baseline. Because most of the individuals who were alcohol-



dependent at baseline had achieved remission during the follow-up, the group of chronic alcohol-dependent individuals with insomnia symptoms is very small (n=14).

Another prospective study on whether alcohol consumption was associated with incident chronic insomnia in the general population during an average 7.5 years of follow-up shows no association (Singareddy et al. 2012). However, alcohol use disorders were associated with incident chronic insomnia. Furthermore, according to the descriptive statistics those who had one alcoholic drink per day on average had the lowest risk of chronic insomnia in comparison to those who had either no or two or more drinks per day. The lack of an association between alcohol consumption and changes in insomnia symptoms is confirmed in two other prospective studies (Fernandez-Mendoza et al. 2012, Vgontzas et al. 2012).

A recent cross-sectional study examines binge drinking and insomnia symptoms in middle-aged 50 year-old and older adults from the 2004 Health and Retirement Study, which is a longitudinal population-based study of non-institutionalized Americans (Canham et al. 2014). Almost half of the binge drinkers report insomnia symptoms, while 39% from those who report occasional binge drinking and 36% of non-drinkers report insomnia symptoms. However, when smoking was taken into account the association attenuated.

### *Insomnia symptoms and smoking*

There are only a few cross-sectional (Appendix 2) and prospective epidemiological studies on smoking and insomnia symptoms (Table 1). It has been shown that current smokers report more insomnia symptoms than non-smokers or ex-smokers (Phillips and Danner 1995, Strine et al. 2005, Arber et al. 2009). Cross-sectional studies also report an association between smoking and insomnia symptoms (Wetter and Young 1994, Kageyama et al. 2005, Mehari et al. 2014), and one retrospective study reveals an association between smoking and an increased risk of insomnia symptoms among patients with a new sleep-disorder diagnosis (Wallander et al. 2007). Another cross-sectional study reports the opposite however, suggesting that smoking is inversely associated with insomnia symptoms among men (Fabsitz et al. 1997).

One prospective study examines whether smoking at baseline and follow-up is associated with subsequent insomnia symptoms among men, but reports no association (Janson et al. 2001). Two other prospective studies examine smoking and its association with changes in insomnia symptoms (Fernandez-Mendoza et al. 2012, Vgontzas et al. 2012): the former found an association between smoking and incident and developing chronic insomnia (Fernandez-Mendoza et al. 2012), whereas the latter did not find any association with changes in insomnia symptoms (Vgontzas et al. 2012).

Two prospective studies used the same data, which were derived from a community-based random sample in 2 New York counties. A recent prospective study (Brook et al. 2014) examines the role of smoking from adolescence to adulthood and insomnia in early 40s. Heavy/continuous smokers had a higher likelihood of insomnia symptoms compared with non-smokers. A prior prospective study (Brook et al. 2012), observed that longitudinal patterns of heavy smoking among women were associated with insomnia in late mid-life.

#### *Insomnia symptoms and physical activity*

A few cross-sectional studies (Appendix 3) focus on the association among physical activity and insomnia symptoms (Fabsitz et al. 1997, Härmä et al. 1998, Owens and Matthews 1998, Sherrill et al. 1998, Fogelholm et al. 2007, Chasens and Yang 2011, Chang et al. 2013). According to the findings, high levels of physical activity are associated with a reduced risk of insomnia symptoms (Fabsitz et al. 1997, Sherrill et al. 1998, Chang et al. 2013), and physical inactivity with an increased risk (Janson et al. 2001). One of the studies considers the association between insomnia symptoms and physical activity among adults with prediabetes (Chasens and Yang 2011), finding that fewer insomnia symptoms were associated with higher numbers of steps walked daily. Fogelholm et al. (2007) report findings from a large nationally representative cross-sectional study suggesting an association between physical activity and fewer insomnia symptoms, independent of obesity.

Two prospective studies focus on insomnia symptoms and physical activity among the elderly (Table 1) (Morgan and Clarke 1997, Morgan 2003). Both of them, with two follow-up points during an eight-year follow-up period, are based on the same data, which were derived from the Nottingham Longitudinal Study of Activity and Ageing (NLSAA). An earlier study

(Morgan and Clarke 1997) investigated whether health and lifestyle factors were associated with the incidence of insomnia symptoms at one follow-up point, after four years. According to the results, low and intermediate levels of physical inactivity among elderly general-practice patients are associated with the incidence of insomnia symptoms following adjustment for age and gender. A later study on the possible associations between both physical and social activity and changes in insomnia symptoms (Morgan 2003) showed in an eight-year follow-up that low and intermediate levels of physical activity were predictive of the incidence of insomnia among the elderly. Moreover, intermediate levels of physical activity were associated with the persistence of insomnia symptoms at one follow-up point, after four years. The participants in these prospective studies were aged 65 years or over. The gender differences are not reported because there was no evidence of an interaction between gender and physical activity (Morgan 2003).

#### *Insomnia symptoms and unhealthy food habits*

One cross-sectional study on insomnia symptoms and unhealthy food habits focuses on the association between a Mediterranean diet and insomnia symptoms such as difficulty initiating or maintaining sleep and early awakening, among elderly women and men (65 years and over) (Jaussent et al. 2011). The results showed that following such a diet was protective of two or three insomnia symptoms in women, but not in men. Another cross-sectional study on Japanese female workers examines the association between dietary intake, food habits and insomnia symptoms (Katagiri et al. 2014). The findings suggest that unhealthy food habits were associated with insomnia symptoms.

**Table 1.** Prospective studies on the association among insomnia symptoms and unhealthy behaviours

<b>Author, follow-up time</b>	<b>Sample</b>	<b>Unhealthy behaviour/ Measure</b>	<b>Insomnia symptoms/ Measure</b>	<b>Methods/Covariates</b>	<b>Adjusted association at follow-up (if available)</b>
Morgan and Clarke 1997, 4 years	Men and women, n=1299  Age: ≥65 years	Physical inactivity. Detailed inventory of indoor, outdoor, social and practical activities classified into low, intermediate and high activity/ Self-reported	Quality of sleep; problems with sleep/ Self-reported	Logistic regression/  Age, gender	Low (OR 2.94 95% CI 2.14-3.64) and intermediate (OR 2.89 95% CI 1.91-3.62) levels of physical activity were associated with the incidence of insomnia symptoms.
Janson et al. 2001, 10 years	Men n=2602  Age: 30-69 years	Smoking. Having ever smoked regularly for at least six months, current smokers, ex-smokers/ Self-reported	Difficulties falling asleep and difficulties maintaining sleep/ Self-reported	Multiple logistic regression/  Age, baseline insomnia symptoms, medical disorder, BMI >27 kg/m <sup>2</sup> , change in BMI, physical inactivity, alcohol dependence	No association between smoking (at baseline and follow-up) and subsequent insomnia symptoms.
Morgan 2003, 8 years	Men and women, n=1042  Age: ≥65 years	Physical inactivity. Outdoor activities, indoor activities, walking, shopping, leisure activities, muscle strength and joint flexibility classified into low, moderately low, intermediate, moderately high/ Self-reported	Quality of sleep; problems with sleep/ Self-reported	Logistic regression/  Age, gender, total walking, social engagement, health index, BMI, depressed mood	Low (OR 5.20 95% CI 2.00-13.60) and intermediate (OR 2.40 95% CI 1.10-5.20) levels of physical activity were associated with an elevated risk of incident insomnia. Intermediate levels of physical activity were associated with the persistence of insomnia (OR 5.00 95% CI 1.00-24.70).

**Table 1.** (continued)

<b>Author, follow-up time</b>	<b>Sample</b>	<b>Unhealthy behaviour/ Measure</b>	<b>Insomnia symptoms/ Measure</b>	<b>Methods/Covariates</b>	<b>Adjusted association at follow-up (if available)</b>
Crum et al. 2004,  median length of 12.6 years	Men and women, n =1920  Age: > 18 years	Alcohol consumption. DSM-III-criteria from DIS were used to assess alcohol abuse and/ or dependence/ Self-reported	Trouble falling asleep, staying asleep, waking up too early/ Self-reported	Multiple logistic regression/  Age, gender, race, educational level, marital status, psychiatric and illicit drug disorder history, service use, age at onset of first alcohol- related problem	Chronic alcohol dependence was associated with subsequent insomnia symptoms (OR 2.60 95% CI 1.11-6.08).
Fernandez-Mendoza et al. 2012,  Average duration 7.5 years	Men and women, n=1395  Age: ≥20 years	Alcohol consumption. Number of alcoholic drinks and cigarettes smoked per day/ Self-reported	Chronic insomnia defined as a complaint of insomnia ≥1 year, poor sleep defined as a moderate to severe complaint of difficulty falling asleep, difficulty staying asleep, early final awakening, non-restorative sleep/ Self-reported	Multinomial logistic regression/  Sampling weight, gender, socio-demographic factors	Alcohol consumption was not associated with changes in insomnia symptoms.  Smoking was associated with incident insomnia symptoms (OR 1.02 95% CI 1.01-1.03) and the development of chronic insomnia (OR 1.06 95% CI 1.01-1.13).

**Table 1.** (continued)

<b>Author, follow-up time</b>	<b>Sample</b>	<b>Unhealthy behaviour/ Measure</b>	<b>Insomnia symptoms/ Measure</b>	<b>Methods/Covariates</b>	<b>Adjusted association at follow-up (if available)</b>
Singareddy et al. 2012  Average duration 7.5-years	Men and women, n=1395  Age: ≥20 years	Alcohol consumption. Number of alcoholic drinks per day, current or past diagnosed alcohol-use disorder/ Self-reported	Chronic insomnia defined as a complaint of insomnia ≥1 year, poor sleep defined as a moderate to severe complaint of difficulty falling asleep, difficulty staying asleep, early final awakening, non-restorative sleep/  Self-reported	Means/  Sampling weight   Multinomial logistic regression/  Age, gender, obesity, race, cigarettes, alcohol, caffeine use, physical health problems, sleep apnoea, mental health problems, poor sleep  Univariate analysis/  Sampling weight	Those who had on average one alcoholic drink per day showed the lowest risk of chronic insomnia in comparison to those who drank no alcohol or who had 2 or more drinks per day.  Moderate use of alcohol was not associated with incident chronic insomnia.  Alcohol-use disorder was associated with incident chronic insomnia (OR 4.83 95% CI 1.89-12.37).
Vgontzas et al. 2012,  Average duration 7.5 years	Men and women , n=1395  Age: ≥20 years	Alcohol consumption. Number of alcoholic drinks cigarettes smoked per day/ Self-reported	Chronic insomnia defined as a complaint of insomnia ≥1 year, poor sleep defined as a moderate to severe complaint of difficulty falling asleep, difficulty staying asleep, early final awakening, non-restorative sleep/ Self-reported	Multinomial logistic regression/  Unadjusted	Alcohol consumption and smoking were not associated with changes in insomnia symptoms.

**Table 1.** (continued)

<b>Author, follow-up time</b>	<b>Sample</b>	<b>Unhealthy behaviour/ Measure</b>	<b>Insomnia symptoms/ Measure</b>	<b>Methods/Covariates</b>	<b>Adjusted association at follow-up (if available)</b>
Brook et al. 2012, Average 25 years	Women, n=498  Age: 40-65 years	Smoking. Number of cigarettes smoked per day/ Self-reported	Difficulty falling asleep, difficulty staying asleep, waking up too early. If participants suffer insomnia symptoms, was also asked if such problem(s) interfered with daily functioning and how distressed she was about the problem/ Self-reported	Multivariate logistic regression/  Age, marital status, body mass index, health conditions, depressed mood, educational level	Heavy smoking was associated with subsequent insomnia symptoms (OR 2.76 95% CI 1.10-6.92). Moderate smoking and late quitting were not associated with subsequent insomnia symptoms.
Brook et al. 2014, Average 29 years	Men and women, n=528  Age: 14-43 years	Smoking. Number of cigarettes smoked per day/ Self-reported	Difficulty falling asleep, difficulty staying asleep, waking up too early. If participants suffer insomnia symptoms, was also asked if such problem(s) interfered with daily functioning and how distressed she was about the problem and how noticeable their insomnia symptom(s) were to others/ Self-reported	Logistic regression/  Age, gender, educational level, marital status, obesity, smoking, depressive mood, anxiety, ADHD	Heavy smoking was associated with subsequent insomnia symptoms (OR 3.35 95% CI 1.06-10.56). Late starting, occasional smoking and quitting/decreasing smoking were not associated with subsequent insomnia symptoms.

### 3.2 Body mass index and changes in insomnia symptoms

Most studies concerning insomnia symptoms and BMI are cross-sectional in design (Owens and Matthews 1998, Ito et al. 2000, Kim et al. 2001, Patterson et al. 2004, Tworoger et al. 2005, Fogelholm et al. 2007, van den Berg et al. 2008, Bidulescu et al. 2010, Jaussent et al. 2011, Yan et al. 2011). Some of them are quite old or small-scale, and the definitions of insomnia symptoms vary (Appendix 4). Even if most of them show an association between insomnia symptoms and BMI, they cannot prove causality or reverse causality: only prospective studies can identify changes in insomnia symptoms.

It has been observed that obesity is positively associated with insomnia symptoms (Patterson et al. 2004, Vgontzas et al. 2008, Hung et al. 2013), but not all cross-sectional studies report such associations (Yan 2011). One of them, which examined factors associated with objectively and subjectively reported insomnia symptoms in 20-40 year old women, showed an association between a higher BMI and objectively measured insomnia symptoms, but no association with self-reported insomnia symptoms (Tworoger et al. 2005). Jaussent et al. (2011) observe that obesity increases the risk of having trouble falling asleep in men, but tends to decrease it in women: obesity is thus protective of insomnia symptoms among women.

There are some longitudinal studies examining the association between BMI and the incidence, persistence or remission of insomnia symptoms. Janson et al. (2001) investigated the association between overweight and insomnia remission among men, finding that men who were overweight or obese (BMI  $>27$  kg/m<sup>2</sup>) were less likely to go into remission, and that subjects in remission had a lower BMI at follow-up (Table 2). One Canadian study examined the mean BMI and other potential risk factors of insomnia symptoms or insomnia syndrome incidence in a cohort of good sleepers followed over a one-year period (LeBlanc et al. 2009): no association between a higher BMI and incidences of insomnia symptoms or insomnia syndrome was found. Gureje et al. (2011), in turn, studied the occurrence and risk associated with the incidence and persistence of insomnia symptoms among elderly persons in Sub-Saharan Africa (Table 2). According to the results, those with a higher BMI tended to have an elevated risk of persistence of their insomnia, with those in the obese range being at the highest risk, compared to underweight persons: however, the trend did not reach statistical significance. Thus, baseline BMI did not predict the incidence of insomnia symptoms or insomnia syndrome.



Three longitudinal studies used the same data, although the objectives varied (Fernandez-Mendoza et al. 2012, Singareddy et al. 2012, Vgontzas et al. 2012). The participants were from the adult Penn State Cohort, the average follow-up time being 7.5 years (Table 2) and the mean follow-up duration being 4.5 years for women and 10.5 years for men. One of these studies examined the role of objectively measured short sleep duration and mental health in persistent insomnia symptoms (Vgontzas et al. 2012). The authors also investigated whether obesity (BMI  $\geq 30$ ) was a predictor of insomnia persistence, although obesity at baseline was a covariate that only included good sleepers and those with chronic insomnia at baseline, thus excluding poor sleepers at baseline. The results revealed an association between obesity and partially remitted insomnia symptoms compared to normal sleep, as well as between obesity and partially remitted insomnia symptoms compared to fully remitted insomnia symptoms. Obesity was associated with insomnia persistence, but the results did not reach statistical significance.

The aim in another study was to determine the risk factors for the incidence of chronic insomnia (Singareddy et al. 2012). The results showed that obese individuals had a higher risk of developing insomnia, but further analysis revealed only a marginally significant association between obesity and the incidence of chronic insomnia following adjustment for socio-demographic and behavioural factors. Moreover, the association disappeared following adjustment for poor sleep at baseline and sleep apnoea, and physical and mental health. One third of these longitudinal studies report an association between obesity and the incidence of poor sleep (Fernandez-Mendoza et al. 2012).

**Table 2.** Prospective studies on the association between BMI and insomnia symptoms

<b>Author, follow-up time</b>	<b>Sample</b>	<b>Weight/ Measure</b>	<b>Insomnia symptoms/Measure</b>	<b>Methods/Covariates</b>	<b>Adjusted association at follow-up (if available)</b>
Janson et al. 2001, 10 years	Men, n=2602  Age: 30-69 years	Overweight (BMI >27) / Self-reported	Difficulties falling asleep and/or maintaining sleep/ Self-reported	Means/  Unadjusted  Multiple logistic regression/  Age, smoking, physical inactivity, alcohol dependence and medical disorders	Participants in remission had lower BMI at follow-up (25.3 vs. 26.5).  Participants who had BMI >27 kg/m <sup>2</sup> were less likely to be in remission (OR 0.43 95% CI 0.23-0.78).
LeBlanc et al. 2009, 1 year	Men and women, n=464  Age: 18-83 years	Mean BMI/ Self-reported	The Insomnia Severity Index and The Pittsburgh Sleep Quality Index. Insomnia syndrome (this group met all diagnostic criteria of insomnia) and insomnia symptoms (without fulfilling all the diagnostic criteria of insomnia syndrome) were used/ Self-reported	Analysis of variance/  The Insomnia Severity Index at baseline and the Pittsburgh Sleep Quality Index total scores at baseline	Higher BMI was not associated with the incidence of insomnia symptoms or insomnia syndrome.

**Table 2.** (continued)

<b>Author, follow-up time</b>	<b>Sample</b>	<b>Weight/ Measure</b>	<b>Insomnia symptoms/Measure</b>	<b>Methods/Covariates</b>	<b>Adjusted association at follow-up (if available)</b>
Gureje et al. 2011,  1 year	Men, n= 565 Women, n=742 Age: ≥65 years	BMI groups/ Measured	Difficulty initiating and maintaining sleep, early-morning awakening and non-restorative sleep, daytime sleepiness and dissatisfaction with sleep. Insomnia syndrome (this group met all the diagnostic criteria of insomnia) and insomnia symptoms (without fulfilling all the diagnostic criteria of insomnia syndrome) were used/ Self-reported	Logistic regression analysis/  Age, gender	Baseline BMI was not a predictor of the incidence of insomnia symptoms or insomnia syndrome.  Compared (OR 1.00) with persons with the lowest BMI (<18.5), there was a trend for those with higher BMI (18.5-29.9) to be at an elevated risk of persistence of their insomnia (OR 2.00 95% CI 0.90-4.30 and OR 1.40 95% CI 0.60-3.00) with those in the obese range (BMI ≥30) being at the highest risk (OR 2.20 95% CI 0.70-6.60) (not statistically significant).
Fernandez-Mendoza et al. 2012,  Average duration 7.5 years	Men and women, n=1395  Age: ≥20 years	Obesity (BMI ≥30)/ Measured	Chronic insomnia defined as complaining of insomnia ≥1 year, poor sleep defined as moderate to severe complaining of having difficulty falling asleep and staying asleep, early final awakening, non-restorative sleep/ Self-reported	Multinomial logistic regression/  Gender, socio-demographic factors	Obesity was not associated with developing chronic insomnia.  Obesity was associated with the incidence of poor sleep (OR 1.70 95% CI 1.13-2.55).

**Table 2.** (continued)

<b>Author, follow-up time</b>	<b>Sample</b>	<b>Weight/ Measure</b>	<b>Insomnia symptoms/Measure</b>	<b>Methods/Covariates</b>	<b>Adjusted association at follow-up (if available)</b>
Vgontzas et al. 2012,  Average duration 7.5 years	Men and women, n=1395  Age: ≥20 years	Obesity (BMI ≥30)/ Measured	Chronic insomnia defined as complaining of insomnia ≥1 year, poor sleep defined as moderate to severe complaining of having difficulty falling and staying asleep, early final awakening, non-restorative sleep/ Self-reported	Multinomial logistic regression/  Unadjusted	Obesity was associated with partially remitted insomnia, compared to normal sleep (OR 3.83 95% CI 1.71-8.58) and to fully remitted insomnia (OR 2.97 95% CI 1.02-9.65) and with insomnia persistence (OR 1.89 95% CI 0.93-3.85) (not statistically significant) compared to normal sleep.
Singareddy et al. 2012,  Average duration 7.5 years	Men and women, n=1395  Age: ≥20 years	Obesity (BMI ≥30)/ Measured	Chronic insomnia defined as complaining of insomnia ≥1 year, poor sleep defined as moderate to severe complaining of having difficulty falling and staying asleep, early final awakening, non-restorative sleep/ Self-reported	Means/  Sampling weight  Multinomial logistic regression/  Age, gender, obesity, race, cigarettes, alcohol, caffeine use, physical health problems, sleep apnea, mental-health problems, poor sleep	Obese individuals had a higher risk of insomnia.  Obesity was associated with the incidence of chronic insomnia (a marginally significant association OR 1.47 95% CI 0.96-2.26) following adjustment for socio-demographic and behavioural factors.

### **3.3 Insomnia symptoms and weight gain**

Most of the cross-sectional studies show an association between insomnia symptoms and BMI (Ito et al. 2000, Fogelholm et al. 2007, van den Berg et al. 2008, Bidulescu et al. 2010), although Owens and Matthews (1998) and Yan et al. (2011) found no association (Appendix 4). Kim et al. (2000) report the opposite result: insomnia symptoms were associated with self-reported weight loss.

There are a few prospective studies on insomnia symptoms and weight gain among middle-aged and elderly people (Table 3). Lauderdale et al. (2009) examined whether objectively measured sleep duration and sleep fragmentation (measured sleep quality determined from actigraphy) were associated with a change in BMI over a five-year follow-up. They observed no longitudinal associations between sleep fragmentation and change in BMI. A Swedish study investigated the association between insomnia symptoms and diabetes incidence in women during a 32-year follow-up, and also tested whether insomnia symptoms were associated with weight gain (Björkelund et al. 2005). Again, no association between insomnia symptoms and weight gain was observed at any of the four follow-up points. Similar results are reported in a Swiss study showing that insomnia symptoms did not predict obesity (Hasler et al. 2004): the main focus of the study was on short sleep duration and obesity in young adults. Ross et al. (2011) observed an association among older women (mean age 81) between trouble falling asleep and weight loss, but only in those not taking sleep medication. Other insomnia symptoms were unassociated with weight change.

Various sleep questionnaires and objective measures of insomnia symptoms have been used in prospective studies on insomnia symptoms and weight gain in adults, and weight and height have been either measured or self-reported. Weight gain is defined as a change in BMI or in pounds. Some of these prospective studies had quite a long or short follow-up time, and Lauderdale et al.'s (2009) is the only one to take baseline weight into account in the analysis.

**Table 3.** Prospective studies on the association between insomnia symptoms and weight gain

<b>Author, follow-up time</b>	<b>Sample</b>	<b>Weight/ Measure</b>	<b>Insomnia symptoms/ Measure</b>	<b>Methods/Covariates</b>	<b>Adjusted association at follow-up (if available)</b>
Hasler et al. 2004, 13 years	Men and women, n=496  Age: 27-40 years	Obesity (BMI $\geq$ 30)/ Self-reported	Impaired sleep quality, insomnia, awakenings during the sleep episode and daytime sleepiness / Self-reported	The generalized estimating equations/  Gender, stratified sampling, education, physical activity, smoking, binge eating, childhood depression and family history of weight problems	Insomnia symptoms did not predict obesity.
Björkelund et al. 2005, 32 years	Women, n=1462  Age: 38-60 years	BMI, Waist-to-hip ratio (WHR)/ Measured	1) Having reported insomnia symptoms and/or having consulted a doctor for insomnia symptoms and/or hospital admission for this reason, 2) Use of sleeping pills and/or 3) Sleep <6h during 24h/ Self-reported	The Pearson correlation test/  No information on covariates	Insomnia symptoms were not associated with weight gain.
Lauderdale et al. 2009, 5 years	Men and women, n=612  Age: Middle-aged	BMI/ Measured	Sleep fragmentation/ Objectively measured	Linear regression/  Age, baseline BMI, smoking, physical activity, race-age group, education, tiredness and snoring	There were no longitudinal associations between sleep fragmentation and change in BMI.
Ross et al. 2011 1 year	Women, n=988  Age: $\geq$ 65years	Pounds/ Measured	Trouble falling asleep, trouble staying asleep, early morning awakening/ Self-reported	Linear regression/  Age, stress, heart trouble	Trouble staying asleep was associated with weight loss among women not taking sleep medication (Mean pounds -1.94 95% CI -3.73(-0.15)).  Other insomnia symptoms were not associated with weight change.

### 3.4 Sleep duration and weight gain

The association between sleep duration and BMI, obesity and waist circumference is well documented in several cross-sectional studies (Singh et al. 2005, Kohatsu et al. 2006, Moreno et al. 2006, Bjorvatn et al. 2007, Fogelholm et al. 2007, Rontoyanni et al. 2007, Patel et al. 2008, Magee et al. 2009, Park et al. 2009, Anic et al. 2010, Theorell-Haglow et al. 2010, Watson et al. 2010, Hsieh et al. 2011). Moreover, according to Cappuccio et al.'s (2010a) meta-analysis, short sleep duration is associated with an increased risk of obesity.

Several prospective studies also observe such an association (Hasler et al. 2004, Gangwisch et al. 2005, Patel et al. 2006, López-García et al. 2008, Chaput et al. 2009, Watanabe et al. 2010, Itani et al. 2011, Kobayashi et al. 2011, Yiengprugsawan et al. 2012, Xiao et al. 2013). Other prospective studies focus on the association between sleep duration and weight gain. Kobayashi et al. (2011) and Xiao et al. (2013), for example, report an association between short sleep duration and subsequent weight gain in both men and women, and this has been confirmed among women and men pooled in the analyses (Chaput et al. 2008, Chaput et al. 2009). Some studies report an association among men (Nishiura et al. 2010, Watanabe et al. 2010), and others among women (Patel et al. 2006, López-García et al. 2008). A few prospective studies show an association between long sleep duration and weight gain (Chaput et al. 2008, López-García et al. 2008), whereas others report no association (Stranges et al. 2008, Lauderdale et al. 2009).

The focus in this section is on the association between sleep duration and subsequent weight gain. There are many reviews on the association with obesity (Knutson and Van Cauter 2008, Magee et al. 2008, Marshall et al. 2008, Spiegel et al. 2009, Beccuti and Pannain 2011, Horne 2011, Knutson 2012, Morselli et al. 2012), but only three focusing on the association between short sleep duration and subsequent weight gain were published in 2008-2009 (Patel and Hu 2008, Van Cauter and Knutson 2008, Patel 2009): very few prospective studies report an association.

A review summarizes 13 longitudinal studies on the association between sleep duration and weight gain in adults, conducted between 2004 and 2010 (Magee and Hale 2011). Eight of these studies found an association between short sleep duration and weight gain whereas five found no association, and four of the eight also found an association between long sleep duration and weight gain. It seems from the results of the prospective studies that there is no

clear association between short sleep duration and weight gain in adults. The definition of short sleep and the covariates used in the analyses vary across the studies, however, and some do not include key covariates such as insomnia symptoms. Of the 13 studies in question, five adjusted for insomnia symptoms: only two of these found an association between sleep duration and weight gain, one of them only in women and the other one only a modest association among women. Baseline weight was adjusted for in nine of the studies. However, short sleep duration is inconsistently associated with weight gain in adults.

### **3.5 A summary of the previous evidence**

Previous prospective studies show some evidence of an association between unhealthy behaviours and subsequent insomnia symptoms, and between BMI and changes in insomnia symptoms. None of them found an association between insomnia symptoms and weight gain, however. Many prospective studies and reviews on the subject of sleep duration and subsequent weight gain have been published, most of which report an association between short sleep duration and weight gain.

Although some studies do examine associations among insomnia symptoms and unhealthy behaviours and weight among middle-aged employees, there are few large-scale prospective studies. Moreover, there is insufficient evidence of an association, and its direction is unclear.

The prospective studies on insomnia symptoms and food habits are lacking and no such prospective study has examined the associations between insomnia symptoms and subsequent unhealthy behaviours.

Most previous prospective studies on the association between BMI and changes in insomnia symptoms focus on obesity, and none investigates whether different BMI groups are associated with persistence, an increase in symptoms, their incidence or remission. Thus, more information is needed on whether the different BMI groups are differently associated with changes in insomnia symptoms. At this point, the existing evidence suggests that insomnia symptoms are not associated with weight gain. Furthermore, the association between sleep duration and subsequent weight gain among adults remains unclear. The



differences in findings may be attributable to differences in the definition of short sleep duration and insomnia symptoms, to measurement issues or the covariates used.

#### 4. AIMS

The general aim in this study was to examine the associations of poor sleep with unhealthy behaviours and weight during a five-to-seven-year follow-up period among middle-aged women and men employed at baseline. Socio-demographic, work-related and health-related factors were taken into account to determine whether they contributed to the associations. The covariates in question are commonly used in studies of insomnia symptoms, sleep duration, unhealthy behaviours and weight (Janson et al. 2001, Crum et al. 2004, Chaput et al. 2008, López-García et al. 2008, Ross et al. 2011, Haaramo et al. 2012, Lallukka et al. 2012, Singareddy et al. 2012).

The specific aims were:

- To examine prospectively the associations among insomnia symptoms and alcohol drinking, smoking, unhealthy food habits and physical inactivity (sub-study I)
- To examine prospectively whether BMI contributes to changes in insomnia symptoms (sub-study II)
- To examine prospectively whether insomnia symptoms and sleep duration are associated with weight gain (sub-studies III, IV).

Figure 1 shows the investigated associations of poor sleep with unhealthy behaviours and weight. Insomnia symptoms are assumed to be associated with unhealthy behaviours and weight gain, and unhealthy behaviours and weight with insomnia symptoms. Moreover, sleep duration is assumed to be associated with weight gain.

Figure 1 also shows the covariates that may affect the associations investigated in this study. Depending on the sub-study, the covariates included different socio-demographic factors, health behaviours, physical health, mental disorders and work arrangements.

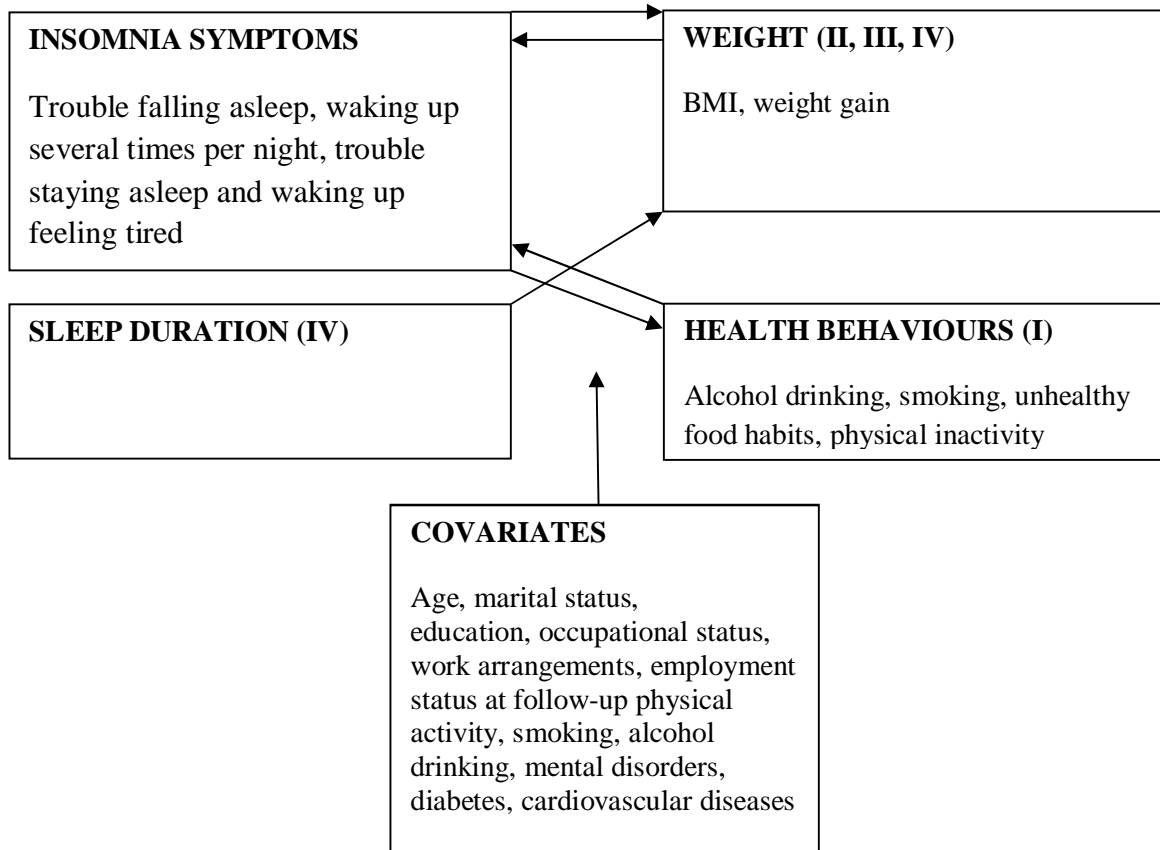


Figure 1. The schematic framework of the study

## **5. MATERIAL AND METHODS**

### **5.1 Study design**

This study is part of the Helsinki Health Study (Lahelma et al. 2013), which is a prospective cohort study among middle-aged employees of the City of Helsinki, Finland. The City of Helsinki is the largest employer in Finland, with almost 40,000 in different occupational groups and doing different types of work. The Helsinki Health Study was set up to facilitate prospective studies on social and work-related determinants of health and wellbeing. The baseline and follow-up survey questionnaires were sent through the internal mail system if possible, or otherwise through ordinary mail (Lahelma et al. 2013). The questions in the baseline and follow-up surveys were identical. Data from both of the surveys were used in each of the four sub-studies (I-IV).

### **5.2 Participants**

The baseline survey questionnaire was sent to 13,344 employees of the City of Helsinki who reached the age of 40, 45, 50, 55 and 60 during each survey year (2000, 2001 and 2002). At baseline, 8,960 participants responded to the survey (response rate 67%), of which 80 per cent were women, corresponding to the figure in the Finnish municipal sector in general (Lahelma et al. 2013).

The follow-up survey was conducted in 2007 among all respondents to the baseline survey. Those who had died (n=137) or could not be identified (n=16) were excluded and the final number of employees to whom the follow-up questionnaires were sent was 8,807. At follow-up, 7,332 participants responded to the survey (response rate 83%) (Lahelma et al. 2013). The follow-up time was between five and seven years.

All the participants were employed at baseline, and 71 per cent were employed at follow-up. The non-response rate at baseline was rather high (33%). According to non-response analyses, the data are broadly representative of the target population. Those who did not respond at baseline or at follow-up were somewhat younger, in lower occupational classes and had poorer health, but the differences were minor. The differences between responders and non-responders were smaller at follow-up (Lahelma et al. 2013).

### 5.3 Sleep

#### *Insomnia symptoms*

The four-item Jenkins Sleep Questionnaire (Jenkins et al. 1988) was used to obtain information on insomnia symptoms. The question was: “How often in the past 4 weeks did you have the following symptoms? 1) Trouble falling asleep, 2) Waking up several times per night, 3) Trouble staying asleep and 4) Waking up feeling tired and worn out after the usual amount of sleep.” The six response categories were: “not at all”, “1–3 nights”, “4–7 nights”, “8–14 nights”, “15–21 nights”, “22–28 nights”. These responses were categorised in three different ways depending on the association under study. The responses were categorised in four, three or two groups.

The categorisation into four groups (sub-study III) included the response alternatives: “not at all”, “1–3 nights”, “4-14 nights” and “15-28 nights”, indicating having no insomnia symptoms, rare insomnia symptoms, occasional insomnia symptoms and frequent insomnia symptoms, respectively. The four items were also combined to form a summary measure including all items with a similar categorisation, as above (sub-study III).

In sub-study II, “no or rare insomnia symptoms” included the response alternatives “not at all” and “1-3 nights”; “occasional insomnia symptoms” included “4-7 nights” and “8-14 nights”; and “frequent insomnia symptoms” included “15-21 nights” and “22-28 nights”. Similarly in sub-study II: “no or rare insomnia symptoms” meant no or rare insomnia symptoms at baseline and follow-up; “Insomnia symptoms in full remission at follow-up” referred to having occasional or frequent insomnia symptoms at baseline but no or rare insomnia symptoms at follow-up; “Insomnia symptoms in partial remission at follow-up” indicated frequent symptoms at baseline but occasional symptoms at follow-up; “Insomnia symptoms increased from occasional to frequent” meant having occasional insomnia symptoms at baseline but frequent symptoms at follow-up; “Incident insomnia symptoms” indicated no or rare insomnia symptoms at baseline, but occasional or frequent insomnia symptoms at follow-up; “Persistent occasional insomnia symptoms” indicated occasional insomnia symptoms at both baseline and follow-up; finally, “Persistent frequent insomnia symptoms” indicated frequent insomnia symptoms at both baseline and follow-up.

In some of the analyses (sub-study I) all four insomnia-symptom items were combined to form a summary measure, which was then categorised into two groups: no or occasional insomnia symptoms, which included the response alternatives “not at all”, “1-3 nights”, “4-7 nights” and “8-14 nights”, and frequent insomnia symptoms, which included the response alternatives “15-21 nights” and “22-28 nights”.

The reference groups in the analyses were “not at all”, “no or rare insomnia symptoms” and “no or occasional insomnia symptoms”. The term “insomnia symptoms” was used in sub-studies I and II, and the term “sleep problems” in sub-study III. The former is used throughout the text in this thesis.

The non-parametric Spearman correlation test was used to assess the correlations between having trouble falling asleep, waking up several times per night, having trouble staying asleep and waking up tired. As Table 4 shows, the highest correlation between insomnia symptoms was between “having trouble staying asleep” and “waking up several times per night” (0.67). The correlations between the other insomnia symptoms varied between 0.45 and 0.54. The Cronbach’s alpha score, which indicates internal consistency between insomnia symptoms, was 0.840.

Table 4. The correlations between insomnia symptoms (the four-item Jenkins Sleep Questionnaire) among women and men (n=6756)

	Having trouble falling asleep	Waking up several times per night	Having trouble staying asleep	Waking up tired
Having trouble falling asleep	1.00			
Waking up several times per night	0.47***	1.00		
Having trouble staying asleep	0.51***	0.67***	1.00	
Waking up tired	0.45***	0.54***	0.53***	1.00

\*\*\*= p-values <0.001

### *Sleep duration*

Sleep duration was addressed in the question: “How many hours on average do you sleep per night during the week?” The response categories were: five hours or less, six hours, seven hours, eight hours, nine hours and 10 hours or more. These alternatives were classified into five groups: five hours or less, six hours, seven hours, eight hours and nine hours or more. Short sleep duration is defined in this thesis as five hours or less per night, and long duration as nine hours or more. Sleep duration of seven hours was the reference group in the analyses.

## **5.4 Health behaviours**

### *Heavy drinking*

The question: “How much, on average, do you consume of the following beverages?” was used to measure heavy drinking. The analysis covered three types of alcoholic beverages: “beer or cider”, “wine or other mild alcoholic drinks” and “hard liquor”. The respective response alternatives were “never”, “less than a bottle a week”, “1-4 bottles a week”, “5-12 bottles a week”, “13-24 bottles a week”, “25-47 bottles a week” and “over 48 bottles a week” for beer or cider; “never”, “less than a glass a week”, “1-4 glasses a week”, “1-2.5 bottles a week”, “3-4.5 bottles a week”, “5-9 bottles a week” and “over 10 bottles a week” for wine or other mild alcoholic drinks; and “never”, “under half a bottle a month”, “0.5-1.5 bottles a month”, “2-3.5 bottles a month”, “4-9 bottles a month”, “10-19 bottles a month”, and “over 20 bottles a month” for hard liquor.

A portion was defined as 12 grams of pure alcohol and, based on that, alcohol consumption was measured in accordance with the sum of self-reported portions of beer, cider, wine, mild alcoholic beverages and hard liquor. Heavy drinking, based on the Current Care Guideline (Current Care Guideline: Treatment of alcohol abuse 2012), was defined as a weekly consumption of over 140 grams of alcohol for women and over 280 grams for men. Alcohol consumption was categorised in two groups: “no heavy drinking” meaning a weekly consumption of under 140 and 280 grams for women and men, respectively, and “heavy drinking” meaning a weekly consumption of over 140 and 280 grams among women and men, respectively (sub-study I).

### *Binge drinking*

The question used to measure binge drinking was: “How often do you drink at least six portions of alcohol on a single occasion?” There were five response alternatives: “never”, “less than once a month”, “once a month”, “once a week”, “a couple of times a week” and “daily or almost daily”. Binge drinking is defined in the Current Care Guidelines (Current Care Guidelines: Treatment of alcohol abuse 2012) as consuming on a single occasion at least once a week seven or more portions for men, and five or more portions for women. Given the response alternatives in the questionnaire, it was not feasible to use these cut-off points in this study. Therefore, for men, six or more portions consumed on a single occasion once a month or less indicated “no binge drinking”, and six or more portions on a single occasion at least once a week indicated “binge drinking”. For women, six or more portions consumed on a single occasion at least once a month indicated “binge drinking”; the ‘other’ category served as a reference group.

### *Smoking*

Current smoking was covered by the question: “Are you currently a regular smoker (cigarettes, cigars or/and a pipe)?” The responses were categorised as currently smoking and currently non-smoking, including former smokers.

### *Unhealthy food habits*

Food habits were assessed on a food frequency questionnaire (FFQ) in which respondents are asked: “How often do you eat the following food items? Think of the *past 4 weeks*”. The respondents were also asked about the type of fat they typically used on bread and in cooking. Eight food items were selected to describe healthy food habits: 1) vegetable-based fat on bread; 2) vegetable-based fat in cooking; 3) dark bread at least once a day; 4) fresh vegetables at least once a day; 5) cooked vegetables at least five times a week; 6) fresh fruits and/or berries at least once a day; 7) fish at least twice a week; and 8) low-fat or skimmed milk (but not high-fat milk) daily. Food habits were classified as unhealthy if the respondent consumed only two or less of the above eight items, and the ‘other’ category served as a



reference group (sub-study I). The categorisation of healthy and unhealthy food habits was based on current Finnish national dietary guidelines (The National Nutrition Council (VRN), 2005).

### *Physical inactivity*

Physical inactivity was measured on a question about the average weekly hours of physical activity during leisure time or while commuting during the previous 12 months. Four grades of intensity were mentioned: walking, brisk walking, jogging and running, or equivalent activities. The response alternatives for each intensity grade were: “no activity”, “0-0.5 hours a week”, “0.5-1 hours a week”, “2-3 hours a week” and “four hours or more a week”. Approximate metabolic equivalent (MET) values were assigned to each grade of intensity (Kujala et al. 1998). One MET is defined as the energy expenditure of a person sitting quietly. In calculating the number of MET hours per week the time used was multiplied by the MET values of each intensity grade, and the four values were then summed. Physical activity was dichotomised as follows: under 14 MET hours per week indicating physical inactivity, and 14 or more MET hours per week indicating physical activity (sub-study I).

## **5.5 Body mass index and weight gain**

Body mass index (BMI) was calculated from self-reported weight and height measurements to an accuracy level of one kilogram and one centimetre, respectively. The resulting index was categorised into five groups: underweight (less than 20 kg/m<sup>2</sup>); normal weight (20-24.9 kg/m<sup>2</sup>); overweight (25-29.9 kg/m<sup>2</sup>); obese (30-34.9 kg/m<sup>2</sup>); and severely obese (35 kg/m<sup>2</sup> or more). Weight gain was calculated from the baseline and the follow-up weight. Major weight gain was defined in this study as at least five kilograms during the follow-up.

## 5.6 Covariates

Several socio-demographic, health-related and work-related factors are used as covariates in this thesis. All the covariates were derived from the baseline with the exception of employment status, which derived from the follow-up. The categories and covariates varied depending on the associations under investigation and the sub-study in question.

Marital status, education and occupational class are significant covariates in research on poor sleep, given various observations that individuals who are separated, divorced or widowed tend to have a lower level of education, to be unemployed and to have a higher prevalence of poor sleep (Lallukka et al. 2012). These socio-demographic factors have been linked to higher BMI (Salonen et al. 2009, Hermann et al. 2011). It has also been observed that socio-demographic factors are linked to unhealthy behaviours (Dowler 2001, Matzger et al. 2004, Lee et al. 2008, Lahelma et al. 2010, Nédó and Paulik 2012). Thus, marital status was used as a covariate in all four sub-studies, classified in three categories: unmarried, cohabiting/married and divorced/widowed. Education was categorised as “basic education”, “intermediate education” and “higher education” (sub-studies III, IV), and occupational class in four hierarchical groups: professionals, semi-professionals, routine non-manual employees and manual workers (sub-studies I, II). Employment status at follow-up was dichotomised as those who were employed and those who were retired, unemployed or otherwise non-employed (sub-study II). It is also acknowledged that work arrangements may affect sleep (Ohayon et al. 2002) and weight (Karlsson et al. 2001). Thus, work arrangements were adjusted for and categorised into three groups: “regular daytime work”, “shift work without night shifts” and “all other work arrangements” (sub-studies III, IV).

Given that the incidence of insomnia symptoms has been shown to be higher among those with cardiovascular diseases and diabetes (Foley et al. 1999), these ailments were adjusted for when changes in insomnia symptoms were examined (sub-study II). These conditions are also associated with obesity (Eckel et al. 2002). The assessment of cardiovascular diseases was based on self-reported lifetime doctor-diagnosed angina pectoris, stroke, claudication or other conditions. If the response to any alternative was “yes”, the respondent was classified as having suffered from a cardiovascular disease. Diabetes was similarly assessed and categorised into diabetics, including diabetes types 1 and 2, and non-diabetics.

Mental disorders are the most commonly studied risk factors for poor sleep, and associations between the two have been found (Ohayon 2002). Such disorders have also been linked to obesity (Kivimäki et al. 2009) and unhealthy behaviours (Jacka et al. 2012), and were therefore adjusted for in all four sub-studies (I-IV). Common mental disorders were assessed on the 12-item General Health Questionnaire (GHQ-12) (Goldberg 1972). The GHQ scores varied from zero to 12. They were divided into two groups: 0-2 indicating “no common mental disorders” and 3-12 indicating “common mental disorders”. The cut-off point of three or more symptoms is commonly used to indicate common mental disorders (Goldberg 1972).

Insomnia symptoms, sleep duration and unhealthy behaviours are considered in this thesis in terms of exposure and outcomes, but are also used as covariates. Insomnia symptoms (sub-studies I, IV) and sleep duration (sub-studies I, III) were used as covariates because they are associated with each other (Grandner and Kripke 2004) and affect both weight (Janson et al. 2001, Cappuccio et al. 2008) and unhealthy behaviours (Janson et al. 2001, Kageyama et al. 2005, Buxton et al. 2009). Alcohol consumption (sub-studies I-IV) was also used as a covariate, given the known fact that it has effects on sleep (Wallander et al. 2007) and weight (Chaput et al. 2009). Smoking also turned out to be positively related to poor sleep (Wallander et al. 2007). Physical inactivity (sub-studies I-IV) was used as a covariate because it is assumed to be associated with poor sleep (Janson et al. 2001), and it is associated with weight (Fogelholm and Kukkonen-Harjula 2000).

## **5.7 Statistical methods**

All the analyses were conducted separately for women and men (sub-studies I-IV). Those in sub-study I also covered the pooled data and gender was adjusted for.

Logistic regression analysis was used in sub-study I to examine the associations among insomnia symptoms and unhealthy behaviours such as heavy drinking, binge drinking, smoking, unhealthy food habits and physical inactivity. Odds ratios (OR) and their 95% confidence intervals (CI) were also calculated. When the aim was to examine baseline insomnia symptoms and unhealthy behaviours at follow-up among women and men separately, the first model was adjusted for age and the second additionally for corresponding unhealthy behaviour at baseline. The third model was further adjusted for marital status, occupational class and sleep duration, and the final model for common mental disorders. The

first model was then adjusted for age and the second additionally for baseline insomnia symptoms in order to examine baseline unhealthy behaviours and insomnia symptoms at follow-up among women and men separately. The third model was additionally adjusted for marital status, occupational class and sleep duration, and the final model for common mental disorders. Furthermore, women and men were combined in the analysis. The adjustments and the models were the same as above, but each model was additionally adjusted for gender.

Multinomial logistic regression analysis was used in sub-study II to examine the associations between BMI and changes in insomnia symptoms, and the odds ratios (OR) and their 95% confidence intervals (CI) were calculated. The models were adjusted as follows: the first one for age; the second one for age, marital status and occupational class; the third one for age, alcohol consumption and physical inactivity; the fourth one for age and common mental disorders; the fifth one for age and cardiovascular diseases and diabetes; the sixth one for age and employment status at follow-up; and the final one, which was the full model, was adjusted for all the covariates.

The associations between insomnia symptoms and weight gain of at least five kilograms were examined in sub-study III using logistic regression analysis, and the odds ratios (OR) and their 95% confidence intervals (CI) were calculated. The models were adjusted as follows: the first one for age; the second for age and baseline BMI; the third one additionally for physical activity, smoking and alcohol consumption; the fourth one for age, baseline BMI, marital status, educational level and work arrangements; the fifth one for age, baseline BMI and baseline sleep duration, and the final one for age, baseline BMI and common mental disorders.

Variance analysis was used in sub-study IV to calculate the average age-adjusted weight in kilograms by the length of sleep duration, and logistic regression to examine the associations between sleep duration and weight gain of at least five kilograms. The odds ratios (OR) and their 95% confidence intervals (CI) were calculated. The first model was adjusted for age and the second one additionally for baseline BMI. Further models were additionally adjusted for physical activity, smoking and alcohol consumption (model 3) and marital status, educational level and work arrangements (model 4) and insomnia symptoms (model 5). The final model was adjusted for age, baseline BMI and common mental disorders.

The Statistical Analysis System (SAS) version 9.2 (SAS Institute Inc., Cary, NC, USA), the Statistical Package for the Social Sciences (SPSS) versions 15.1 and 18.1 (SPSS Inc. (IBM), Chicago, IL, USA) and the PASW statistical program, version 18 were used in conducting the analyses.

## **5.8 Ethical considerations**

The ethics committees of the Department of Public Health, the University of Helsinki and the health authorities of the City of Helsinki reviewed the study protocol. Data protection legislation and ethical regulations imposed by the data protection authorities were complied with.

## 6. RESULTS

### 6.1 Associations among insomnia symptoms and unhealthy behaviours

Sub-study I examined the associations among insomnia symptoms and unhealthy behaviours among women and men. At baseline 21 per cent of the women and 17 per cent of the men reported frequent insomnia symptoms, and the corresponding figures at follow-up were 26 and 20 per cent. Heavy drinking and binge drinking were more prevalent among women who reported frequent insomnia symptoms at baseline than among those who reported no or occasional insomnia symptoms. Moreover, smoking at follow-up was more prevalent among women with frequent insomnia symptoms. Physical inactivity at both baseline and follow-up was more prevalent among the women and men who reported frequent insomnia symptoms at baseline than among those who reported no or occasional insomnia symptoms (Table 1 in sub-study I).

Frequent insomnia symptoms at both baseline and follow-up were more prevalent among women who reported heavy and binge drinking at baseline, and frequent insomnia symptoms at follow-up were more prevalent among men who reported binge drinking at baseline. Among the women, frequent insomnia symptoms at baseline and follow-up were more prevalent among those who reported physical inactivity at baseline. Frequent insomnia symptoms at baseline were also more prevalent among the men who reported physical inactivity at baseline (Table 2 in sub-study I).

Figure 2 shows the extent of the association between insomnia symptoms at baseline and subsequent unhealthy behaviours among women following adjustment for age and unhealthy behaviours at baseline. Frequent insomnia symptoms were positively associated with subsequent heavy drinking (OR 1.34; 95% CI 1.06-1.69), smoking (OR 1.43; 95% CI 1.08-1.90) and physical inactivity (OR 1.38; 95% CI 1.17-1.62). There were no associations between frequent insomnia symptoms and subsequent binge drinking and unhealthy food habits among the women, and none among the men between insomnia symptoms and subsequent unhealthy behaviours following adjustment for age and unhealthy behaviours at baseline.

Full adjustments (age, corresponding unhealthy behaviours at baseline, marital status, occupational class, sleep duration and common mental disorders) slightly attenuated the associations between frequent insomnia symptoms and both subsequent heavy drinking and

physical inactivity among the women (data not shown). The association between frequent insomnia symptoms and subsequent smoking disappeared after full adjustment.

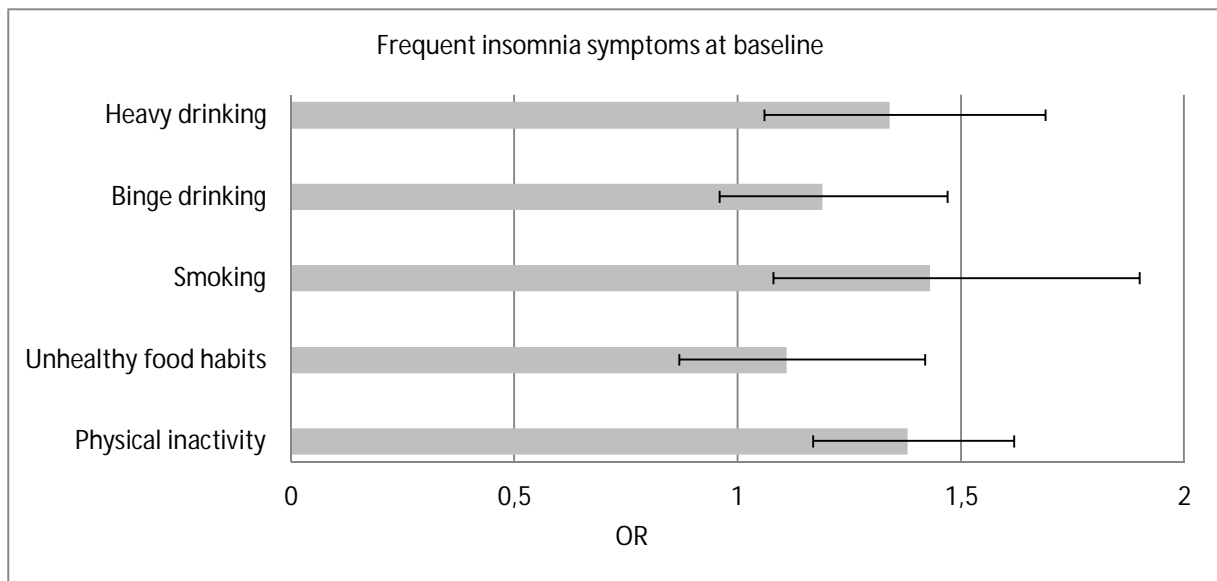


Figure 2. The associations between frequent insomnia symptoms at baseline and subsequent unhealthy behaviours at follow-up among women (n=5131-5248), adjusted for age and unhealthy behaviours at baseline (Odds ratios (OR) and 95% confidence intervals (CI): no or occasional insomnia symptoms served as a reference group (OR 1.00)

Figure 3 shows the associations between unhealthy behaviours at baseline and subsequent insomnia symptoms among women following adjustment for age and insomnia symptoms at baseline. Heavy drinking (OR 1.52; 95% CI 1.24-1.88), binge drinking (OR 1.29; 95% CI 1.09-1.53) and physical inactivity (OR 1.17 (1.00-1.35) were positively associated with subsequent insomnia symptoms. There were no associations between smoking and neither unhealthy food habits nor subsequent insomnia symptoms among the women, and none between unhealthy behaviours and subsequent insomnia symptoms among the men following adjustment for age and insomnia symptoms at baseline.

After full adjustments (age, insomnia symptoms at baseline, marital status, occupational class, sleep duration and common mental disorders), the associations between heavy and binge drinking and subsequent insomnia symptoms remained among the women (data not shown). The association between physical inactivity and subsequent insomnia symptoms disappeared after full adjustment.

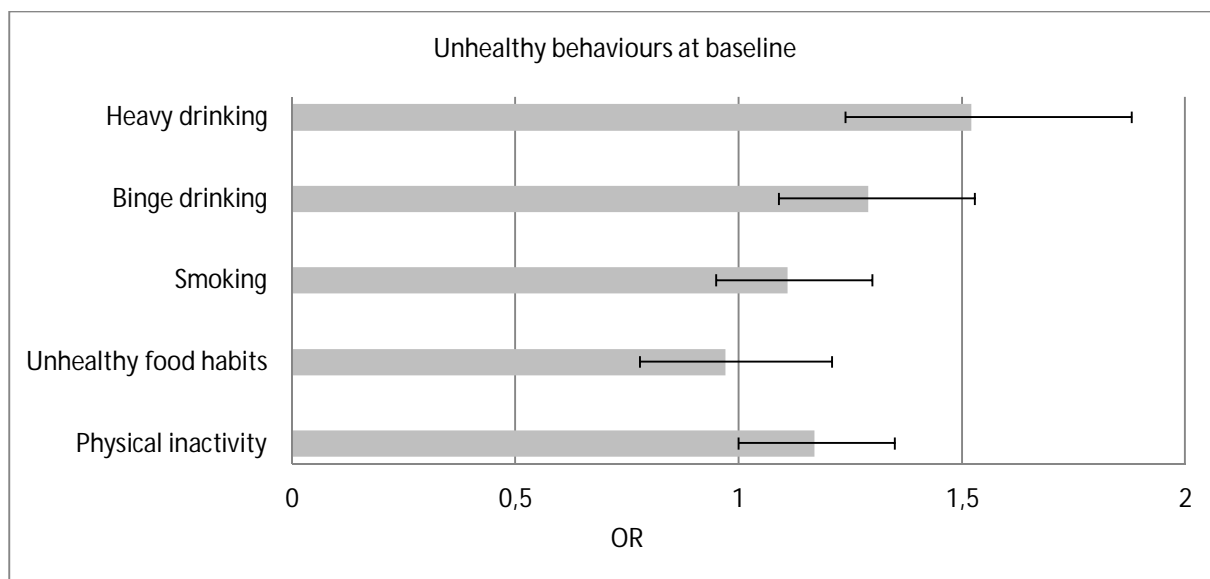


Figure 3. The associations between unhealthy behaviours at baseline and subsequent frequent insomnia symptoms at follow-up among women (n=5131-5248), following adjustment for age and insomnia symptoms at baseline (Odds ratios (OR) and 95% confidence intervals (CI)): healthier behaviours served as a reference group (OR 1.00)

The analyses also covered the pooled data, adjusted for gender as a covariate. Figure 4 shows the extent of the association between frequent insomnia symptoms at baseline and subsequent unhealthy behaviours following adjustment for age and unhealthy behaviours at baseline in the pooled data. Frequent insomnia symptoms were positively associated with subsequent heavy drinking (OR 1.35; 95% CI 1.09-1.66), smoking (OR 1.37; 95% CI 1.06-1.76) and physical inactivity (OR 1.37; 95% CI 1.18-1.58).

After full adjustment (age, corresponding unhealthy behaviour at baseline, marital status, occupational class, sleep duration and common mental disorders) the associations between frequent insomnia symptoms and subsequent heavy drinking and physical inactivity slightly attenuated but remained (Table 3 in sub-study I). The association between frequent insomnia symptoms and subsequent smoking disappeared following full adjustment.



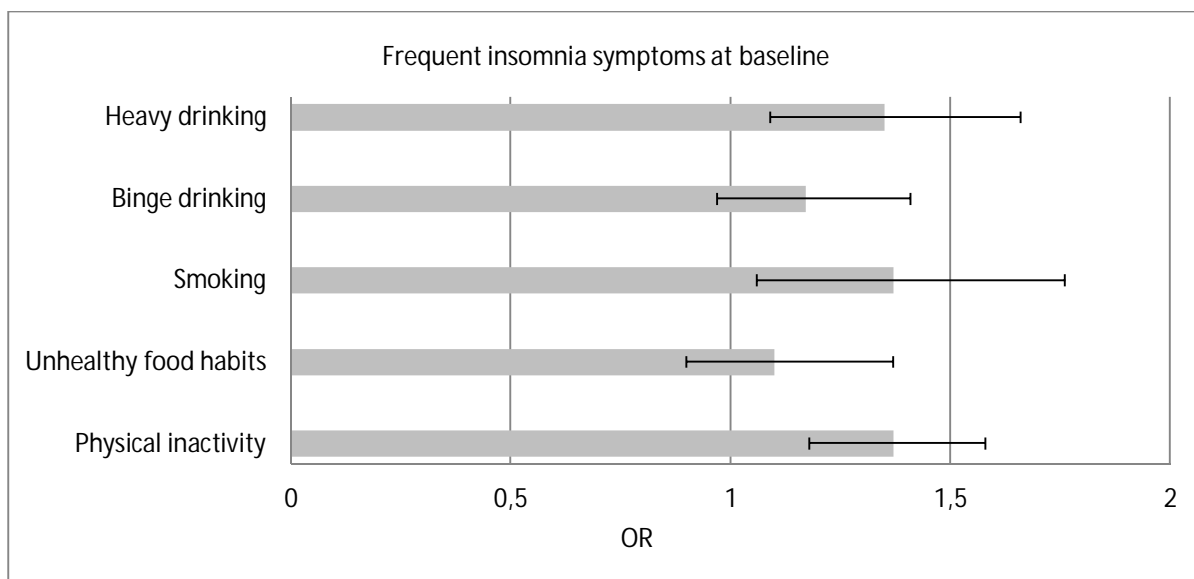


Figure 4. The associations between frequent insomnia symptoms at baseline and subsequent unhealthy behaviours at follow-up among women and men (n=6458), adjusted for age and unhealthy behaviours at baseline (Odds ratios (OR) and 95% confidence intervals (CI)): no or occasional insomnia symptoms served as a reference group (OR 1.00)

Figure 5 shows the extent of the association between unhealthy behaviours at baseline and subsequent insomnia symptoms following adjustment for age and insomnia symptoms at baseline in the pooled data. Heavy drinking (OR 1.51; 95% CI 1.24-1.83), binge drinking (OR 1.29; 95% CI 1.11-1.50) and physical inactivity (OR 1.17; 95% CI 1.02-1.34) were positively associated with subsequent insomnia symptoms.

Following full adjustment (age, insomnia symptoms at baseline, marital status, occupational class, sleep duration and common mental disorders), the associations between heavy and binge drinking and subsequent insomnia symptoms slightly attenuated, but remained (Table 4 in sub-study I). The association between physical inactivity and subsequent insomnia symptoms disappeared after full adjustment.

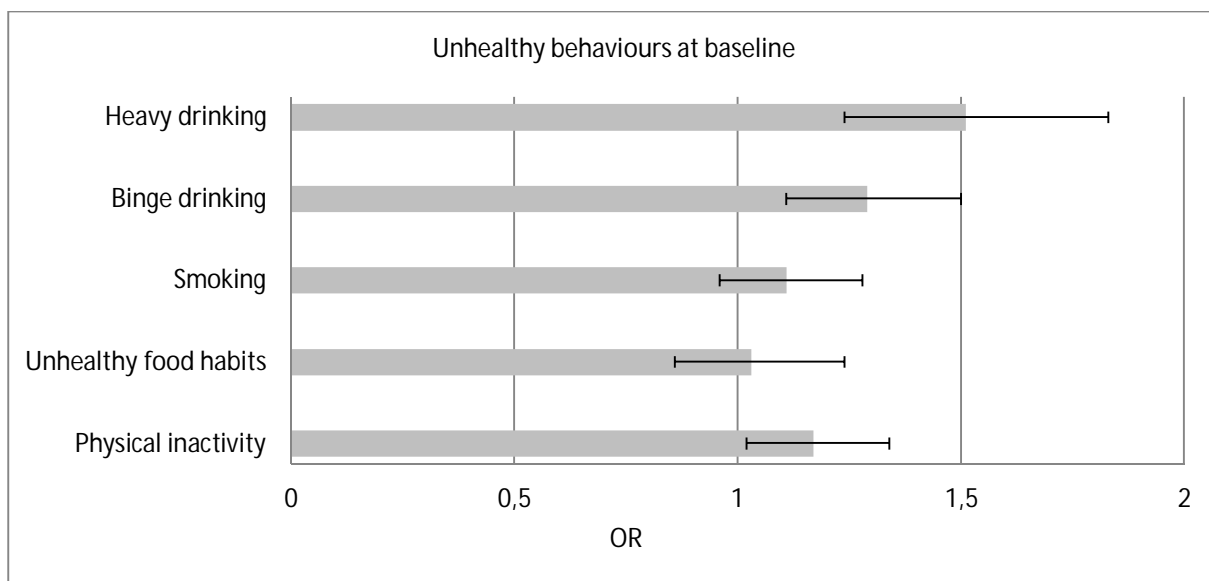


Figure 5. The associations between unhealthy behaviours at baseline and subsequent frequent insomnia symptoms at follow-up among women and men (n=6458), adjusted for age and insomnia symptoms at baseline (Odds ratios (OR) and 95% confidence intervals (CI)): healthier behaviours served as a reference group (OR 1.00)

## 6.2 The associations between body mass index and changes in insomnia symptoms

Sub-study II examined the associations between BMI and changes in insomnia symptoms among women and men. At baseline 48 per cent of the women and 40 per cent of the men reported normal weight, whereas 45 per cent of the women and 58 per cent of the men were at least overweight (see Table 1 in sub-study II). No or rare insomnia symptoms were reported by 29 per cent of the women and 34 per cent of the men at baseline and follow-up. Over the follow-up 25 per cent of the women and 26 per cent of the men reported at least occasional persistent insomnia symptoms, and nine and seven per cent of the women and men, respectively, reported an increase in insomnia symptoms; the corresponding figures for incident insomnia symptoms were 19 and 16 per cent. Six per cent of the women and five per cent of the men reported partial remission, and 12 per cent of both genders reported full remission. Insomnia symptoms varied by BMI at baseline: persistent occasional and frequent insomnia symptoms were more prevalent among the obese women, and persistent frequent insomnia symptoms among the obese men, than among those of normal weight.

Figure 6 shows the age-adjusted associations between BMI and changes in insomnia symptoms among women during the follow-up. Women with severe obesity were more likely

than women of normal weight to report both partial (OR 2.52; 95% CI 1.32-4.79) and full (OR 1.77; 95% CI 1.02-3.09) remission of insomnia symptoms. Obesity (OR 1.48; 95% CI 1.05-2.09) and severe obesity (OR 2.97; 95% CI 1.75-5.06) were positively associated with an increase in insomnia symptoms, whereas underweight (OR 1.43; 95% CI 1.05-1.96) and severely obese (OR 1.43; 95% CI 1.05-1.96) women were more likely to report incident insomnia symptoms. Overweight (OR 1.28, 95% CI 1.04-1.57) and obese (OR 1.72, 95% CI 1.27-2.33) women were more likely than women of normal weight to report persistent occasional insomnia symptoms, and overweight (OR 1.31, 95% CI 1.06-1.62), obese (OR 1.84, 95% CI 1.35-2.50) and severely obese (OR 2.33, 95% CI 1.36-4.00) women were also more likely to report persistent frequent insomnia symptoms.

Almost all the associations remained following full adjustment (age, marital status, occupational class, alcohol consumption, physical inactivity, common mental disorders, cardiovascular diseases, diabetes and employment status at follow-up).

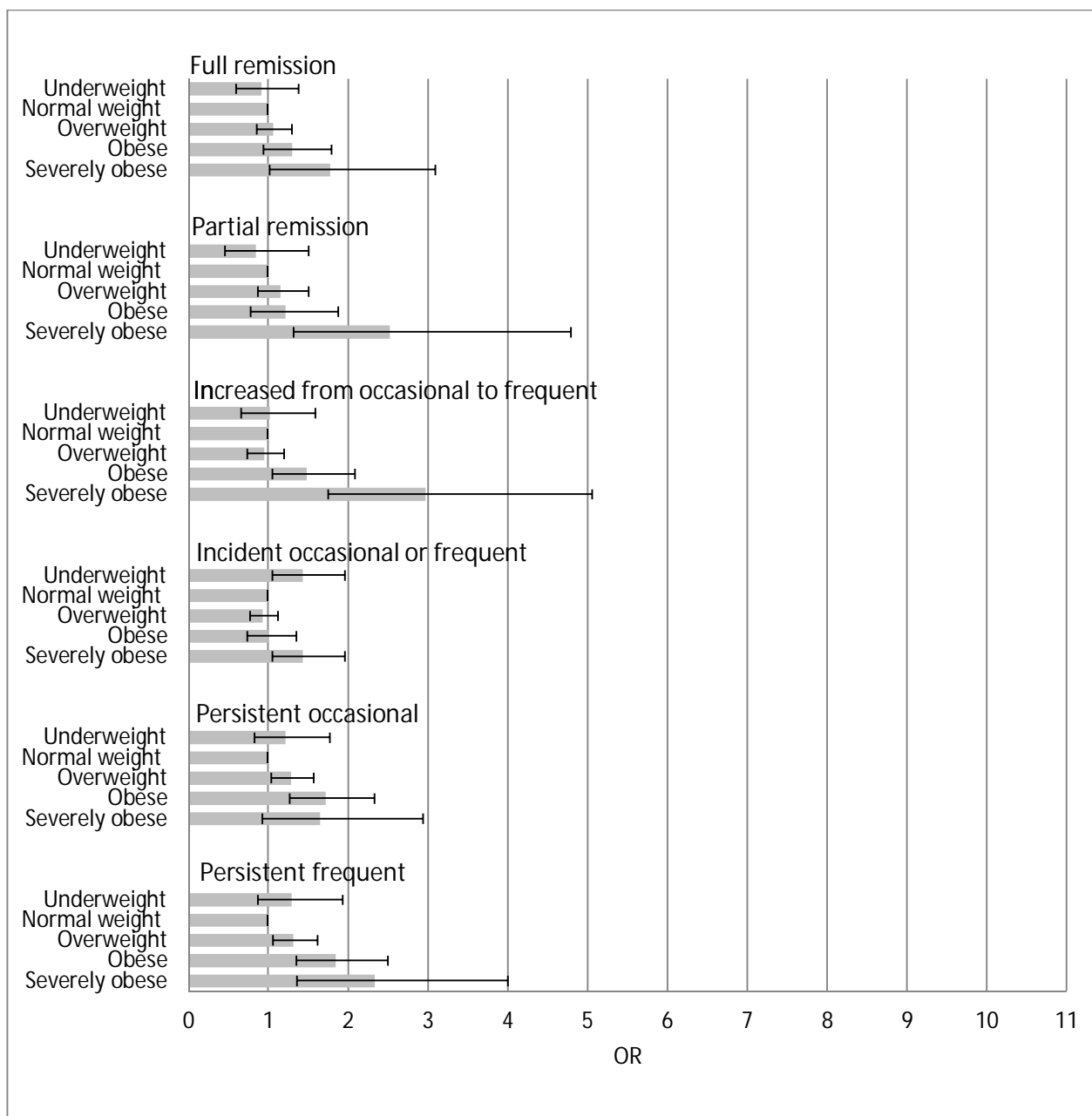


Figure 6. Age-adjusted associations between BMI at baseline and changes in insomnia symptoms during the follow-up among women (n=5273) (Odds ratios (OR) and 95% confidence intervals (CI)); normal weight served as a reference group (OR 1.00)

Figure 7 shows the age-adjusted associations between BMI and changes in insomnia symptoms among men. Severely obese men were more likely to report full remission of insomnia symptoms (OR 2.84; 95% CI 1.09-7.36), and to report an increase in insomnia symptoms (OR 3.47, 95% CI 1.17-10.3). Overweight was positively associated with incident insomnia symptoms (OR 1.53; 95% CI 1.05-2.23), and overweight and obesity with

persistent frequent insomnia symptoms (OR 2.04, 95% CI 1.26-3.32 and OR 2.59, 95% CI 1.37-4.90).

Among the men, the association between severe obesity and full remission of insomnia symptoms disappeared following full adjustment (age, marital status, occupational class, alcohol consumption, physical inactivity, common mental disorders, cardiovascular diseases, diabetes and employment status at follow-up) (Table 3 in sub-study II). Moreover, following full adjustment, the association between severe obesity and an increase in insomnia symptoms did not reach statistical significance; overweight remained similarly associated with incident insomnia symptoms; and overweight and obesity remained associated with persistent frequent insomnia symptoms, attenuating only slightly.

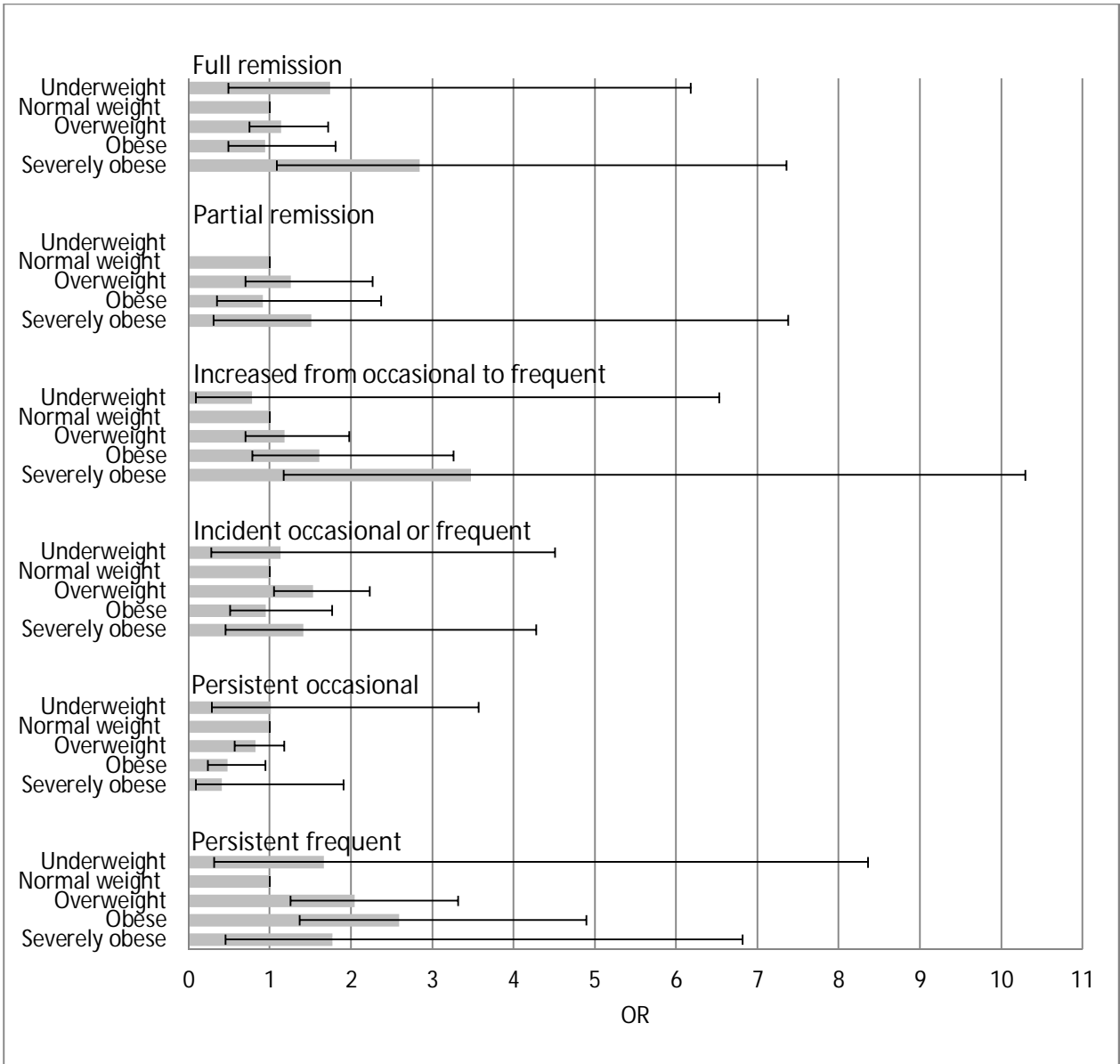


Figure 7. Age-adjusted associations between BMI at baseline and changes in insomnia symptoms during the follow-up among men (n=1215) (Odds ratios (OR) and 95% confidence intervals (CI)): normal weight served as a reference group (OR 1.00)

### **6.3 The associations between insomnia symptoms and weight gain**

Sub-study III examined the associations between insomnia symptoms and weight gain of at least five kilograms among women and men. Table 1 (in sub-study III) shows the responses to all four items concerning insomnia symptoms and a summary measure of insomnia symptoms at baseline. The most commonly reported insomnia symptom was “waking up several times per night”, and the least common was “having trouble falling asleep”, for both genders. The insomnia symptom frequency did not vary very much. The summary measure showed that half of the women and men reported at least occasional insomnia symptoms. Rare insomnia symptoms affected 35 per cent of the women and 33 per cent of the men, whereas 13 per cent of the women and 17 per cent of the men reported no insomnia symptoms.

Figure 8 charts weight gain of at least five kilograms according to insomnia symptoms among the women, following adjustment for age: 25 per cent of them gained five or more kilograms during the follow-up. Women who frequently had trouble falling asleep, woke up several times per night and had trouble staying asleep were more likely to have gained at least five kilograms than those without these insomnia symptoms. No differences in weight gain were observed among the women who reported waking up tired. According to the summary measure, about one third of the women with frequent insomnia symptoms gained five kilograms or more during the follow-up, whereas the corresponding figure for those with no insomnia symptoms was 22 per cent. Among the men there were no differences in weight gain between insomnia symptoms (Table 1 in sub-study III), but 25 per cent of them also gained five kilograms or more during the follow-up.

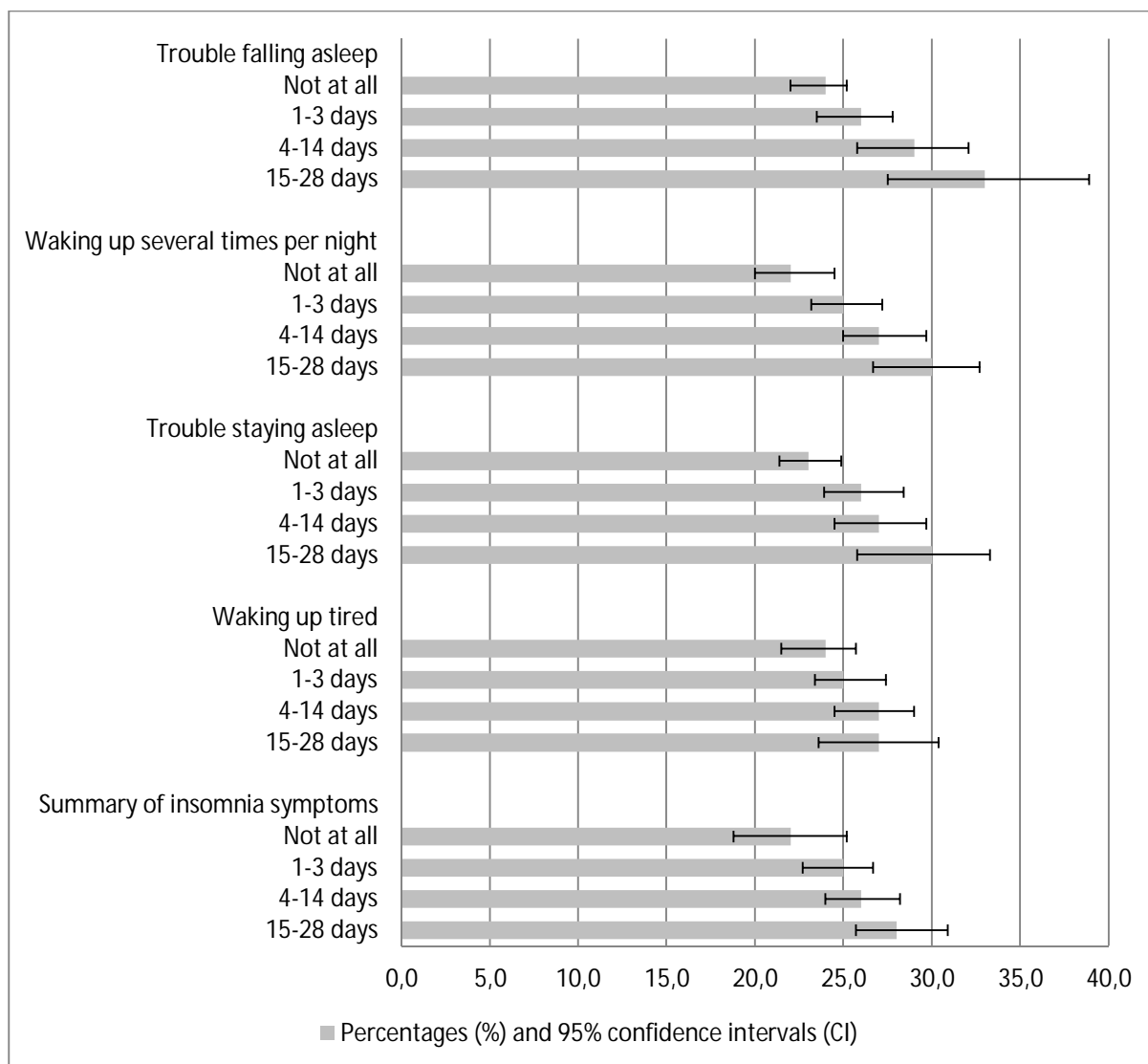


Figure 8. Weight gain of 5 kg or more over the follow-up according to insomnia symptoms at baseline among women (n=5273): age-adjusted prevalence with 95% confidence intervals (CI)

Women who frequently 1) had trouble falling asleep (OR 1.59; 95% CI 1.18-2.15), 2) woke up several times per night (OR 1.42; 95% CI 1.16-1.73) and 3) had trouble staying asleep (OR 1.37; 95% CI 1.10-1.70) were more likely to have gained five kilograms or more during the follow-up than women with no insomnia symptoms following adjustment for age and BMI at baseline (Figure 9). There were no associations between waking up tired and weight gain. The summary measure also indicates that frequent insomnia symptoms (OR 1.35; 95% CI 1.08-1.69) relate positively to weight gain among women. Similar analyses were conducted among men, but no associations with insomnia symptoms could be confirmed (data not shown).



Following adjustment for age, BMI at baseline and common mental disorders, the three above-mentioned insomnia symptoms remained positively associated with weight gain among women, although the associations attenuated slightly. The association between the summary measure and weight gain also attenuated following adjustment for age, BMI at baseline and common mental disorders (Table 3 in sub-study III). The associations between insomnia symptoms and weight gain attenuated most strongly following adjustment for common mental disorders (Table 4 in sub-study III).

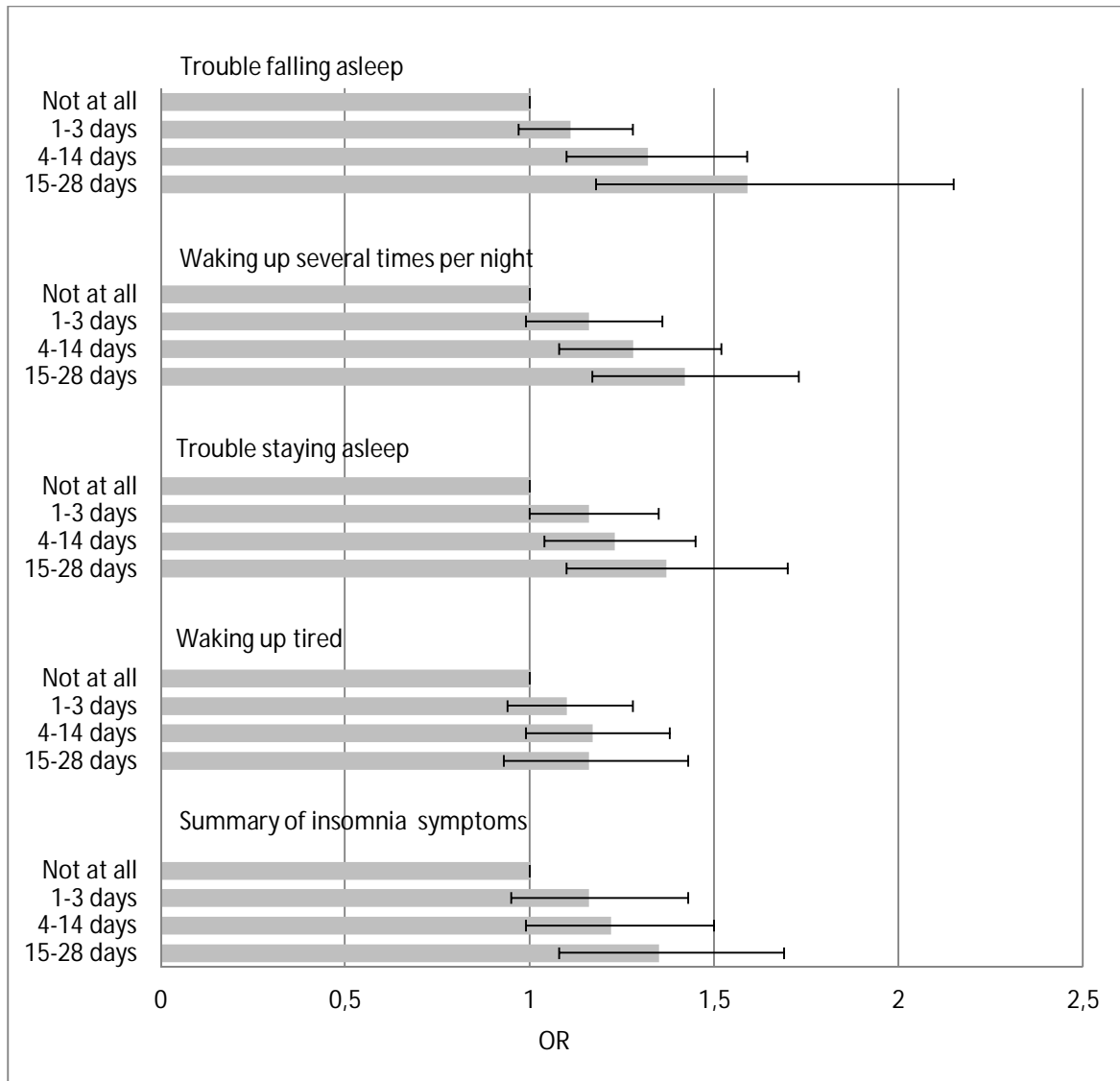


Figure 9. The associations between insomnia symptoms at baseline and weight gain of 5 kg or more among women (n=5273) during the follow-up (Odds ratios (OR) and 95% confidence intervals (CI)): adjusted for age and BMI at baseline. No insomnia symptoms served as a reference group (OR 1.00)

## 6.4 The associations between sleep duration and weight gain

Sub-study IV focused on the associations between sleep duration and subsequent weight gain of five kilograms or more among women and men. Table 1 in sub-study IV shows the average age-adjusted weight in kilograms by sleep duration. The association between sleep duration and weight (kg) tended to be U-shaped among women, both at baseline and follow-up. Among the men there were only slight indications of a U-shaped association (Table 1 in sub-study IV). The greatest weight gain was among women with short sleep duration (5 h or less) (Figure 10), but remained fairly constant among the other sleep-duration categories. There were no differences in weight gain by sleep duration among the men (sub-study IV).

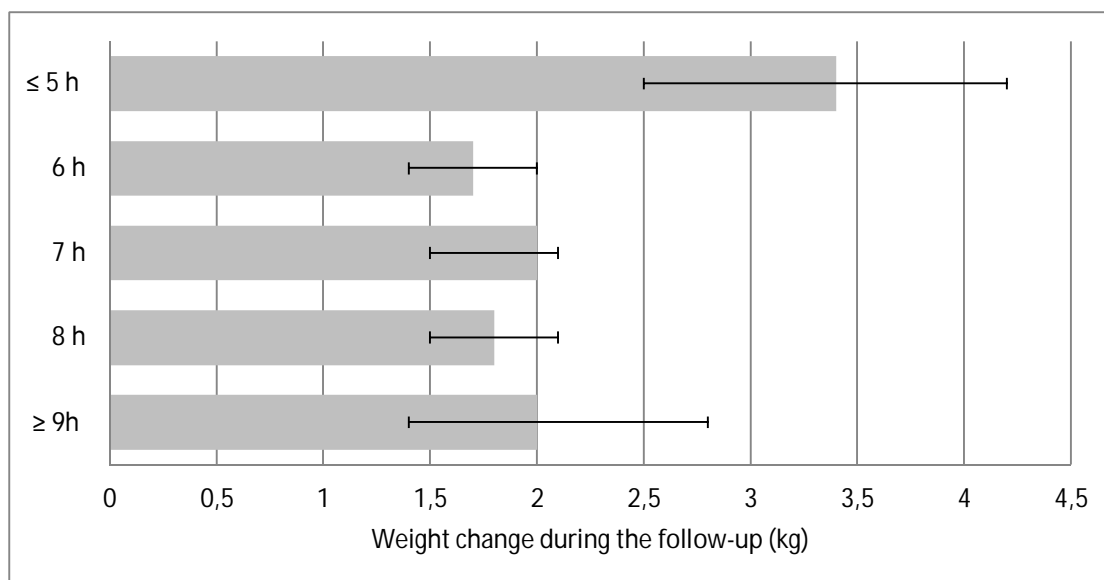


Figure 10. Weight change (kg) during the follow-up (95% confidence intervals (CI)) according to sleep duration among women (n=5279)

Women with sleep duration of five hours or less were more likely than those sleeping seven hours or more to have gained five kilograms or more in weight (OR 1.47; 95% CI 1.04-2.08) over the follow-up following adjustment for age and BMI at baseline (Figure 11). There were no associations between sleep duration and weight gain among the men (sub-study IV).

Adjusting for several covariates had only minor effects on the association between short sleep duration and weight gain among the women (Table 2 in sub-study IV).

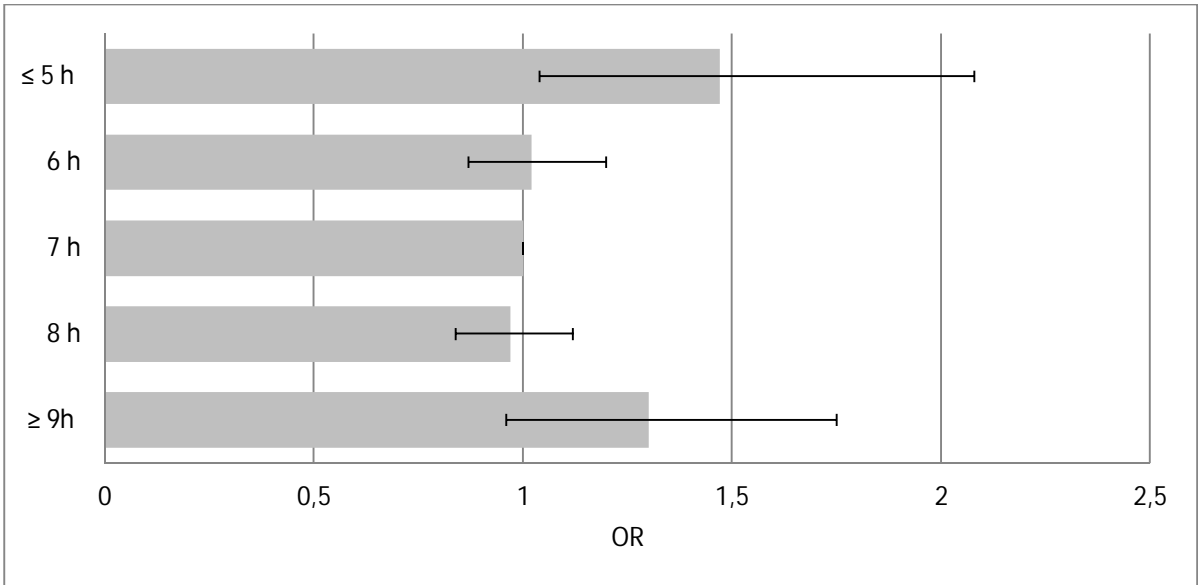


Figure 11. The associations between sleep duration at baseline and weight gain of 5 kg or more among women (n=5279) during the follow-up (Odds ratios (OR) and 95% confidence intervals (CI)): adjusted for age and BMI at baseline. Sleeping 7 hours served as a reference group (OR 1.00)

## 7. DISCUSSION

This thesis examined the associations of poor sleep with unhealthy behaviours and weight. The assessments were based on prospective cohort data on middle-aged female and male employees of the City of Helsinki, Finland.

The main results were:

- Insomnia symptoms and short sleep duration were associated with major weight gain in women.
- Body mass index was associated with changes in insomnia symptoms. In particular, overweight and obesity were associated with an increase in and the persistence of insomnia symptoms.
- There were few and mainly weak and inconsistent associations among insomnia symptoms and unhealthy behaviours. There was a bidirectional association among insomnia symptoms and heavy drinking. Also, insomnia symptoms were associated with subsequent physical inactivity and binge drinking was associated with subsequent insomnia symptoms.
- Overall, associations were observed among poor sleep and weight, and to some extent among insomnia symptoms and unhealthy behaviours.

### 7.1 Interpretations of the main findings

#### *Insomnia symptoms, short sleep duration and weight gain*

According to the results of the present study, insomnia symptoms and short sleep duration are associated with major weight gain in women, but not in men. However, none of the previous four prospective studies on insomnia symptoms and weight gain found any associations (Björkelund et al. 2005, Hasler et al. 2004, Lauderdale et al. 2009, Ross et al. 2011).

There were several differences between the previous prospective studies and the present one, which may explain the differences in findings. Both the 13-year prospective cohort study of young adults (Hasler et al. 2004) and the five-year cohort study among the middle-aged

(Lauderdale et al. 2009) produced similar results as in the present study, but had fewer participants (n=496, n=612), which might explain why the results did not achieve statistical significance. Björkelund et al.'s (2005) prospective study of women found no association between insomnia symptoms and weight gain at the four follow-up points, either. However, no data on insomnia symptoms or weight gain were available, and the article gave no information about the covariates. Thus, the results were not highly reliable. The one-year cohort study of the elderly (Ross et al. 2011) reported an inverse association compared to the present study. The mean age of the participants of that cohort was 81, which explains the differences in findings in that, generally, weight loss may be more of a problem in older people than weight gain.

According to a review, eight prospective studies found an association between short sleep duration and weight gain and five did not (Magee and Hale 2011). The follow-up times in the studies varied between one and 16 years, and the number of participants varied between 173 and 68,183. There were also differences between the studies that reported associations and those that did not. Most of the former did not adjust for insomnia symptoms: of the five studies that did make adjustments, only two were among those reporting an association between sleep duration and weight gain among women, one of which found only a modest association.

It appears from the review that the effect of short sleep duration on weight gain may attenuate over time, but the association is still inconsistent (Magee and Hale 2011). However, comparisons are limited on account of methodological differences between the studies in the numbers of participants, other population characteristics, the covariates included, the measurement of insomnia symptoms, the definition of short sleep and the measurement of weight.

According to one review there are no studies demonstrating that short sleep duration causes more than a very slow weight gain over time (Horne 2008). It may be that the period of short sleep started years before the study was conducted, and that the time at which short sleep duration was associated with weight gain fell beyond its scope (Magee and Hale 2010). Furthermore, the effects of short sleep duration on weight gain may decrease over time (Magee and Hale 2011). Thus, associations may exist, but they are difficult to detect due to the very long or very short follow-up time. The follow-up time in the present study was between five and seven years, and it may be that if the follow-up point had been two years

earlier, for example, the association would not exist. Moreover, if the follow-up point had also been two years later, the association would no longer exist. In other words, the onset and remission of short sleep duration may have occurred within the follow-up period. Thus, it may be that the length of follow-up time, be it too short or too long, may affect the presence or absence of previous evidence on insomnia symptoms and weight gain. It is not known how long people should suffer from short sleep duration until it leads to weight gain, or when weight gain begins due to short sleep duration. Additionally, proving the causal association between the two is complicated on account of several potential confounders and methodological problems (Nielsen et al. 2011, Magee and Hale 2011).

There are prospective studies on sleep duration and weight gain, and possible explanations have been proposed. One reason may be the association between short sleep duration and hormonal and metabolic changes. Some studies posit an association between short sleep duration and decreased leptin and increased ghrelin levels, corresponding to an increased appetite, which may lead to weight gain (Taheri et al. 2004, Spiegel et al. 2004). It has also been proposed that short sleep duration leads to the persistence of elevated levels of cytokines (such as IL-6 and TNF- $\alpha$ ), which are also linked to weight gain (Zimberg et al. 2012). Additionally, short sleep duration may lead to insulin resistance, which may explain the weight gain (Zimberg et al. 2012).

Another possible explanation is that short sleep duration may be associated with tiredness, which may reduce physical activity and lead to lower energy expenditure (Patel et al. 2006). However, it has been observed that physical activity explained only little of the association between short sleep duration and weight gain (Hasler et al. 2004, Patel et al. 2006). The findings of the present study do not support this explanation in that none of the several potential confounders such as socio-demographic factors, or health behaviours such as physical inactivity, smoking and alcohol consumption explained the associations between short sleep duration or insomnia symptoms and weight gain.

Moreover, tiredness may reduce one's willingness to engage in healthy food habits, which may lead to weight gain. It has also been hypothesised that insomnia symptoms may lead to weight gain because sufferers have more time to eat at night (Ross et al. 2011). However, dietary patterns only partially explained the association between short sleep duration and obesity (Nishiura et al. 2010). It is indeed possible that food habits explain the associations between short sleep duration and both insomnia symptoms and subsequent weight gain, but

proving it in epidemiological studies is a challenging task and needs further longitudinal research.

It was found in the present study that common mental disorders slightly attenuated the association between insomnia symptoms and weight gain. Because the other covariates did not affect the associations under investigation so much, it could be that there are links between insomnia symptoms and mental health in particular, which has been confirmed in other studies (Roth and Roehrs 2003). It must also be taken into account that some of the previous prospective studies did not include key covariates, which may be why no explanations for the associations have been found so far.

It is also possible that the underlying mechanisms among insomnia symptoms, short sleep duration and subsequent weight gain are quite similar, possibly due to the relationship between short sleep duration and insomnia symptoms. It has been observed that short sleepers have more insomnia symptoms than those who sleep for between seven and eight hours a night (Grandner and Kripke 2004). Thus, it may be that insomnia symptoms explain the association between short sleep duration and weight gain, and that short sleep duration explains the association between insomnia symptoms and weight gain. The present study found no supporting evidence in that adjusting for sleep duration and insomnia symptoms did not affect the associations. However, none of the previous studies on insomnia symptoms and weight gain adjusted for sleep duration, and only a few previous prospective studies on sleep duration and weight gain adjusted for insomnia symptoms. Further studies are needed, especially on the mechanisms driving the associations between short sleep duration and both insomnia symptoms and subsequent weight gain. The reasons why short sleep duration and insomnia symptoms might lead to weight gain remain unclear.

### *Body mass index and insomnia symptoms*

Overall, baseline BMI was associated with changes in insomnia symptoms. BMI has also been linked to changes in insomnia symptoms in previous prospective studies (Janson et al. 2001, Fernandez-Mendoza et al. 2012, Vgontzas et al. 2012). In the present study, overweight and obesity in particular were associated with an increase in and the persistence of insomnia symptoms.

Two prospective studies examining BMI and the persistence of insomnia (Gureje et al. 2011, Vgontzas et al. 2012) report results that are in line with those of the present study. One of them identified a trend among those with a higher-than-normal BMI to be at an elevated risk of persistence of insomnia symptoms (Gureje et al. 2011). However, the result did not reach statistical significance, possibly due to the small number of participants in the obese group (n=35). Moreover, comparisons should be made with caution because the reference group in that study comprised underweight persons. The main focus in the other study (Vgontzas et al. 2012) was on the possible association of sleep duration and mental health with the persistence of insomnia, and obesity was only a covariate in the analyses. There was an association, but it did not reach statistical significance, which could also have been due to the small number of participants with persistent insomnia (n=65) (Vgontzas et al. 2012). In spite of statistically non-significant results however, the findings of these studies and the present study were quite similar. No previous prospective studies have examined the association between BMI and an increase in insomnia symptoms.

Previous prospective studies have not adjusted for a broad variety of covariates similar to those adjusted for in the present study. Thus, there is also insufficient explanation of why overweight and obesity seem to increase and sustain insomnia symptoms over time. It may be that the associations are attributable to morbidity or medical care: overweight and obese people might be more likely to receive medical care, which in turn might lead to an increase in or the persistence of insomnia symptoms. However, medical care was equally prevalent among normal-weight and obese people in the present study. Moreover, several potential covariates such as health behaviours, physical health, common mental disorders and employment status did not explain the associations between overweight, obesity and the persistence of and increase in insomnia symptoms.



It is also possible that overweight and obesity have already modified the metabolism, which might lead to an increase in or the persistence of insomnia symptoms. One previous prospective study supports this hypothesis, suggesting that metabolic disorders associated with obesity could also be associated with changes in insomnia symptoms (Fernandez-Mendoza et al. 2012). One underlying mechanism may be sleep apnoea: an association between obstructive sleep apnoea and obesity has been observed (Lam et al. 2010). Given that that obstructive sleep apnoea interferes with sleep, it may lead to increased and persistent insomnia symptoms. However, it must be taken into account that obese people who do not suffer from sleep apnoea also have insomnia symptoms (Vgontzas et al. 2006). It is also possible that obese people have unhealthier food habits than normal-weight people, and such habits may offer one explanation for changes in insomnia symptoms. However, the present study did not support such a proposition, showing no associations among food habits and insomnia symptoms. Further studies are needed to examine in detail the different BMI groups and the respective associations with changes in insomnia symptoms, and to clarify the explanations.

#### *Insomnia symptoms and unhealthy behaviours*

Overall, the associations among insomnia symptoms and unhealthy behaviours found in the present study were weak and inconsistent. A bidirectional association with heavy drinking was identified. Two previous prospective studies report an association between alcohol consumption and subsequent insomnia symptoms (Crum et al. 2004, Singareddy et al. 2012), but any comparison should be made with caution because these earlier studies are limited to individuals with alcohol use disorder. Thus, the measurement of alcohol consumption differs from that used in the present study. Three other prospective studies found no associations (Fernandez-Mendoza et al. 2012, Singareddy et al. 2012, Vgontzas et al. 2012). However, the data comprised a randomly selected sample of women and men from various age groups, which may explain the difference in findings from the results of the present study.

Stein and Friedmann's (2005) review suggests an association among insomnia symptoms and alcohol consumption. However, the reviewed studies are quite old (1979-2001) and the results derived from cross-sectional analyses, thus it is not possible to assess causal relationships. Also, one clinical review supports the hypothesis, suggesting bidirectional

associations (Roehrs and Roth 2001). The present study identified only one bidirectional association among insomnia symptoms and unhealthy behaviour, but there was also an association between binge drinking and subsequent insomnia symptoms. One cross-sectional study among middle-aged and older adults (Canham et al. 2014) suggests an association between binge drinking and insomnia symptoms, but it may be affected by current smoking. Furthermore, insomnia symptoms were associated with subsequent physical inactivity. No previous studies have examined insomnia symptoms and subsequent physical inactivity.

There are several factors potentially affecting the associations among insomnia symptoms and unhealthy behaviours that could not be controlled for in the present study. However, there are some possible explanations as to why insomnia symptoms may lead to subsequent unhealthy behaviours, and vice versa. One explanation for the associations among insomnia symptoms and alcohol consumption, smoking, unhealthy food habits and physical inactivity, for example, could be related to mental health, and it is known that there are links between unhealthy behaviours and mental health (Swendsen et al. 1998, Fergusson et al. 2003, Sarlio-Lähteenkorva et al. 2004, Brown et al. 2005, Bots et al. 2008). Overall, common mental disorders may diminish interest in health, and further lead to seeking solace through alcohol drinking, smoking or unhealthy food habits. Sufferers may also have less energy to engage in physical activity or to adopt healthy food habits. However, according to the present study socio-demographic factors, sleep duration and common mental disorders do not explain the associations under investigation. Moreover, the explanations may vary depending on the type of unhealthy behaviour studied.

It is known that moderate alcohol drinking may even promote falling asleep (Stein and Friedmann 2005), thus drinking can be used as a sleep aid. In the longer-term this could lead to heavy drinking or insomnia symptoms. In fact, heavy drinking may lead to subsequent insomnia symptoms, because continued use diminishes the effect of alcohol, which may thus have an adverse effect on sleep (Stein and Friedmann 2005). It has also been shown that heavy drinking may lead to difficulties in sleep maintenance (Gann et al. 2004). One reason why heavy drinking may produce insomnia symptoms is that alcohol consumption is associated with snoring (Nagayoshi et al. 2011) and obstructive sleep apnoea (Lam et al. 2010). Excessive alcohol drinking may also cause movement disorders (Stein and Friedmann 2005), which in turn may interfere with sleep, but it was not possible in the present study to examine such mechanisms. It may be that the mechanisms underlying the association

between binge drinking and subsequent insomnia symptoms are quite similar to those linking heavy drinking to subsequent insomnia symptoms.

Little is known about the mechanisms that could explain why insomnia symptoms may lead to heavy drinking. One possible explanation is the use of alcohol as a sleep aid. In continuous use the amount of alcohol has to be increased to achieve the same effect (Stein and Friedmann 2005).

The present study also identified an association between insomnia symptoms and subsequent physical inactivity. There are no hypothesised reasons why this might be the case, but it may be that the tiredness caused by insomnia symptoms reduces the desire to be physically active.

Overall, it has been suggested that insomnia symptoms may predict unhealthy behaviours (Janson et al. 2001), and there is also weak evidence that unhealthy behaviours predict insomnia symptoms.

## **7.2 Methodological considerations**

The research reported in this thesis has certain strengths, including the large dataset and its prospective follow-up design. Its major strength lies in the opportunity to use longitudinal data and to examine the changes. All the questions were identical at baseline and follow-up, and the questionnaire also included a broad variety of covariates. Additionally, the data comprised both women and men.

However, there are also limitations that need to be acknowledged. The non-response rate at baseline was rather high (33%), and it is a potential source of bias. The rate at follow-up was lower. However, non-participation in the surveys has been examined. According to the non-response analyses we conducted (see e.g., Laaksonen et al. 2008, Lahelma et al. 2013), those who did not respond at baseline or at follow-up were somewhat younger, in lower occupational classes and had poorer health, but the differences were minor. Thus, it is unlikely that it substantially affected the associations under investigation. The differences between the responders and non-responders were smaller at follow-up (Lahelma et al. 2013). In terms of the variables used in the analyses, smoking and physical inactivity were slightly more common among those who did not respond at follow-up, as was unhealthy food habits (Seiluri et al. 2011). This selection may cause attenuated associations among insomnia

symptoms and physical inactivity, smoking and unhealthy food habits. The non-responders did not differ from the responders in terms of insomnia symptoms, sleep duration, BMI and or alcohol drinking.

The follow-up time was quite long, which may have led to bias due to several other factors and changes over the period that may have remained undetected or have influenced the studied associations. These potential sources of bias may diminish the likelihood of detecting associations. Furthermore, 80 per cent of the respondents were women, which corresponds to the target population. As a result, the number of men in the data were relatively small, thereby affecting the statistical power of the analyses for men. However, given that many employee studies focus mainly on men, the large number of female respondents could be considered an advantage.

The survey responses were all self-reported, which may have led to reporting bias and contributed to under-reporting or over-reporting depending on the variables. A commonly used valid and reliable instrument was employed to measure insomnia symptoms (Jenkins et al. 1988). However, there was no assessment of other sleep disorders such as restless legs, breathing disorders during sleep or some medical conditions that may be associated with insomnia symptoms (Ohayon 2002). A correlation of 0.45 has been observed between self-reported and measured sleep duration (Lauderdale et al. 2008), and self-reported sleep duration has been overestimated. Moreover, the question on sleep duration may have led to bias because the response alternatives included only full hours. Self-reported weight may also lead to bias (Visscher et al. 2006) due to under-reporting, for example. However, there may well be substantial agreement between self-reported and measured weight (Craig and Adams 2009).

Physical activity, and both heavy and binge drinking were assessed by means of standard, albeit simple questions (Kujala et al. 1998, Aalto et al. 1999). The maximum time of physical activity mentioned in each four question was four hours or more a week, and there were no questions on muscle-strengthening activity (Lahti 2011). These limitations may have resulted in underestimation. Although, the questionnaire we used has not been validated, an extensive review concluded that no physical-activity questionnaire was superior (van Poppel et al. 2010). However, alcohol consumption in particular may be under-reported. Moreover, grams of alcohol were determined based on self-reported portions, which limited the accuracy. The question on binge drinking, which included only six response alternatives, was restrictive

because it was not possible to use certain cut-off points. Food consumption is also liable to under- or over-reporting, and because of a lack of information on the amount of food consumed, the reliability of the data may be questioned. However, food habits were measured on a food frequency questionnaire (FFQ), which has not been validated but is widely used as a dietary-assessment tool in epidemiological studies (Erkkola et al. 2001). Additionally, biases may arise from changes in unhealthy behaviours, insomnia symptoms or weight during the follow-up, which may influence the associations under investigation. Furthermore, no information on the history of insomnia symptoms and unhealthy behaviours was available. Finally, it should be acknowledged that there are several potential factors that could affect the associations in question but were impossible to measure in this study.

However, it can be concluded that the data are broadly representative of the target population, and that the differences between responders and non-responders were relatively minor (Laaksonen et al. 2008). Overall, although there are limitations, it is unlikely that they severely biased the results concerning the associations among poor sleep, weight and unhealthy behaviours.

## 8. CONCLUDING REMARKS

This thesis complements previous findings on poor sleep, unhealthy behaviours and weight, and their associations among middle-aged employees. The current evidence confirms that poor sleep is common among employed middle-aged women and men, as are obesity and unhealthy behaviours. We used a cohort to examine the associations among insomnia symptoms and both unhealthy behaviours and weight.

The present study confirms the association of insomnia symptoms with short sleep duration and weight gain in women. Additionally, the BMI was associated with changes in insomnia symptoms. Thus, there are associations among poor sleep and weight, but it remains largely open to what extent poor sleep is an antecedent or a consequence of unhealthy behaviours. Most of the identified associations among insomnia symptoms and unhealthy behaviours were heterogeneous, for which there may be various reasons. It may be that differences in unhealthy behaviours might affect poor sleep differently. Alcohol drinking, physical inactivity, smoking and unhealthy food habits are different behaviours and have different predictors. It is commonly assumed that unhealthy behaviours are relatively persistent over time. However, there are still too few prospective studies on the associations among insomnia symptoms and unhealthy behaviours, and further research is needed among the middle-aged and other population groups.

Studies on the associations among poor sleep and weight are relatively more common. However, the results of previous prospective studies are inconsistent, and many possible explanations have been proposed. The associations among women are clear in the present study, but the reasons behind them need further research.

The present thesis concerns middle-aged, initially employed people from one large workplace and the results cannot therefore be directly generalised to all middle-aged people or other age groups. Neither can they be directly generalised to employees in other countries on account of the social and cultural differences. However, the findings are likely to describe Finnish employees of the same age in the public sector.

The associations among poor sleep and unhealthy behaviours and weight turned out to be complicated, and the complexity should be taken into account in health-promotion activities. Future prospective studies should further examine the associations among poor sleep and

overweight, obesity and unhealthy behaviours, all of which are significant risk factors in terms of public health and affect people of different ages. Future studies should therefore focus on different age groups. Poor sleep, unhealthy behaviours and obesity may have long-term effects. The problems to which poor sleep contributes may extend from childhood to adulthood and old age. The implications for public health, quality of life, productivity and performance are significant. Thus, from a public-health and political-economy perspective, it is necessary to fully clarify these associations.

In particular, there is a need for prospective studies on poor sleep and unhealthy behaviours. It would be useful to examine insomnia symptoms separately because they may be differentially related to certain unhealthy behaviours. Further studies could establish whether there are associations among other insomnia symptoms for example among daytime impairment and unhealthy behaviours and weight, and focus on unhealthy behaviours simultaneously in order to clarify whether the risk of insomnia symptoms increases if several are at play. Given the acknowledged relationship between insomnia symptoms and sleep duration, it would be useful to examine their joint association with unhealthy behaviours and weight, in order to establish which of the characteristics of sleep is dominant.

Health promotion at the workplace, focused on individual risk targets, may shed light on the complexity of the associations. Sleep, health behaviours and weight constitute a whole. For example, people who have healthy food habits, who are physically active, do not smoke or drink alcohol and are of normal weight are lacking an essential component of good health if they are poor sleepers. Thus, public-health interventions focusing on poor sleep, unhealthy behaviours and weight simultaneously are needed, given the mutual relationships among these factors. For example, focusing on unhealthy behaviours and obesity could lead to greater success in terms of preventive strategies, and help to alleviate insomnia symptoms. Conversely, promoting better sleep is likely to foster healthier behaviours.

Intervention studies on sleep or health behaviours could be useful in determining their role in weight and vice versa among people in high-risk groups. On the other hand, short-term interventions may help in clarifying the biological mechanisms affecting poor sleep, unhealthy behaviours and weight. There is also a need to examine epidemiological genetic links, given the lack of knowledge about the role of genetic factors in these associations. Currently, the most relevant prospective study on the associations among poor sleep, unhealthy behaviours and weight is a large observational epidemiological study.

More knowledge about sleep, weight and unhealthy behaviours is needed in order to prevent major chronic diseases and improve public health. The importance of maintaining normal weight and avoiding poor sleep and unhealthy behaviours should be emphasised throughout the population.

In sum, insomnia symptoms and short sleep duration were associated with weight gain among women, and BMI was associated with changes in insomnia symptoms. More specifically, overweight and obesity were associated with an increase in and the persistence of insomnia symptoms. Additionally, there was a bidirectional association among insomnia symptoms and heavy drinking. Insomnia symptoms were also associated with subsequent physical inactivity, and binge drinking was associated with subsequent insomnia symptoms.

The findings of this thesis could be used in occupational health care to alleviate insomnia symptoms and prevent weight gain, and to promote optimal sleep duration as well as healthier behaviours, thus improving health and well-being among employed and ageing people.



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**APPENDICES: Previous cross-sectional studies on insomnia symptoms and unhealthy behaviours and weight**

**Appendix 1.** Cross-sectional studies on the association among insomnia symptoms and alcohol consumption

<b>Author</b>	<b>Sample</b>	<b>Alcohol consumption/ Measure</b>	<b>Insomnia symptoms/ Measure</b>	<b>Methods/Covariates</b>	<b>Adjusted association (if available)</b>
Tachibana et al. 1996	Men, n=271  Age: Average 40.9	Alcoholic beverages consumption per week. The cut-off point was use on four days or more per week/ Self-reported	Difficulty falling asleep, mid-sleep awakenings, early-morning awakening in the last month/ Self-reported	Multiple logistic regression/  Unadjusted	Frequent alcohol consumption was associated with insomnia symptoms (OR 2.6 95% CI 1.18-5.72).
Fabsitz et al. 1997	Men, n=8870  Age: Average 40.5	Heavy drinking (>12 drinks in previous 2 weeks)/ Self-reported	The Jenkins Sleep Questionnaire/ Self-reported	Logistic regression/  Adjusted for paired observations of twins	Heavy drinking was associated with a higher risk of having trouble falling asleep (OR 1.18 95% CI 1.03-1.36), waking often (OR 1.49 95% CI 1.30-1.70), having trouble staying asleep (OR 1.52 95% CI 1.32-1.74) and waking up tired (OR 1.21 95% CI 1.06-1.38).
Härmä et al. 1998	Men, n=3020  Age: 45-60	Quantities and the amount of pure alcohol (centilitres per year). The cut-off point was 250 grams or more per year/ Self-reported	Difficulty falling asleep, waking up in the middle of sleep or difficulties falling asleep again, nightmares, non-restorative sleep, waking up too early, disturbed or restless sleep/ Self-reported	Stepwise logistic regression analysis	Alcohol consumption predicted insomnia symptoms (Chi-square 5.7, p=0.017).
Owens et al. 1998	Women, n=521  Age: 42-50	Paffenbarger Physical Activity Questionnaire/ Self-reported	Hours of sleep needed each night, amount of sleep needed now compared to before, any trouble sleeping, trouble falling asleep, Average time to fall asleep, waking during the night, average	Analyses of variance/  Unadjusted	Alcohol consumption was not associated with insomnia symptoms (prospective study, but here cross-sectional results).



			time awake during the night, waking earlier than desired, napping during the day, length of nap / Self-reported		
Janson et al. 2001	Men, n=2602 Age: 30-69	Dependence by the CAGE questionnaire/ Self-reported	Difficulties falling asleep, difficulties maintaining sleep/Self-reported	Multiple logistic regression/ Age, medical disorder, BMI, change in BMI, baseline insomnia, smoking, physical inactivity, alcohol dependence	Alcohol dependence (OR 1.75 95% CI 1.20-2.54) was associated with the risk of insomnia symptoms (prospective study, but here cross-sectional results).
Poikolainen 2005	Men and women, n=28472 Age: 17-65	Never drinkers and light drinkers (<70 g of alcohol per week)/ Self-reported	The Jenkins Sleep Questionnaire/ Self-reported	Logistic regression/ Gender, age-group, marital status, income and the interaction of gender with marital status	Insomnia symptoms were less common among never-drinkers than among light drinkers. Never drinkers had frequent insomnia symptoms and undisturbed sleep as often as light drinkers but occasional insomnia symptoms less often.
Wallander et al. 2007	Men and women, n=12437 Age: 20-79	Excessive consumption (more than 42 units per week)/ Self-reported	Insomnia, hypersomnia, sleep disturbance/ Self-reported	Logistic regression/ Age, gender, number of visits to the physician in the previous year	Excessive alcohol consumption (OR 1.70, 95% CI 1.50-1.90) was associated with an increased risk of insomnia symptoms.
Ohayon and Bader 2010	Men and women, n=1209 Age: 19-75	Never, sometimes, daily/ Self-reported	Difficulty initiating or maintaining sleep, non-restorative sleep accompanied with sufficient sleep/ Self-reported	Multivariate analyses/ Marital status, occupation, city size, child < 6 years of age, easily irritated, depressive mood, extroverted personality, anxious mood	Alcohol drinking sometimes (OR 1.40 95% CI 1.00-1.90) or daily (OR 4.60 95 CI 1.70-12.40) was associated with non-restorative sleep, but not with other insomnia symptoms.
Jaussent et al. 2011	Men and women, n=9294 Age: ≥ 65	<12 g/day, 12-36 g/day and >36 g/day (high alcohol intake)/ Self-reported	Having difficulty initiating sleep, waking up several times during the night, early morning awakening/ Self-reported	Multinomial logistic regression/ Socio-demographic, behavioural, clinical and sleep variables	High alcohol intake was protective of three insomnia symptoms (OR 0.22 95% CI 0.09-0.58).

**Appendix 2.** Cross-sectional studies on the association among insomnia symptoms and smoking

<b>Author, study design</b>	<b>Sample</b>	<b>Smoking/ Measure</b>	<b>Insomnia symptoms/ Measure</b>	<b>Methods/Covariates</b>	<b>Adjusted association (if available)</b>
Wetter and Young 1994	Men and women, n=3516  Age:20-69	Never, former, current/ Self-reported	Difficulty initiating sleep, waking up during the night and having a hard time getting back to sleep, waking up repeatedly during the night, early morning awakening, non-restorative sleep/Self-reported	Logistic regression/  Age, education	Smoking was associated with difficulty initiating sleep (men OR 2.32 95% CI 1.04-5.16, women OR 1.88 95% CI 1.09-3.23) and difficulty waking up (men OR 2.34 95% CI 1.25-4.39, women OR 2.37 95% CI 1.51-3.72).
Fabsitz et al. 1997	Men, n=8870  Age: Average 40.5	Current/ Self-reported	The Jenkins Sleep Questionnaire/ Self-reported	Logistic regression/  Adjusted for paired observations of twins	Smoking was associated with reduced problems of waking often (OR 0.76 95% CI 0.67-0.86) and trouble staying asleep (0.82 95% CI 0.72-0.94).
Janson et al. 2001	Men, n=2602  Age: 30-69	Non-smoker at baseline and follow-up, smoker at baseline and non-smoker at follow-up, smoker at baseline and follow-up/ Self-reported	Difficulties falling asleep, difficulties maintaining sleep/ Self-reported	Multiple logistic regression/  Age, medical disorder, BMI, change in BMI, baseline insomnia, smoking, physical inactivity, alcohol dependence	Smoking at baseline and follow-up was not associated with the risk of insomnia symptoms at follow-up (prospective study, but here cross-sectional results).
Kageyama et al. 2005	Women, n=522  Age: 18-59	Non-smokers, ex-smokers, current smokers/ Self-reported	Presence of subjective sleep-related problems, difficulty in falling asleep, intermittent waking, premature early waking, feeling of light	Multiple logistic analysis/  Age, marital status, number of night shifts in the last 3 months, support from colleagues and	Insomnia symptoms were associated with a high risk of current smoking (OR 1.86 95% CI 0.97-3.57).

			overnight sleep, sleep disruption/Self-reported	superiors, job control	
Strine et al. 2005	Men and women, n=82918 Age: ≥18	Never, former, current/ Self-reported	Sleep impairment/ Self-reported	Logistic regression/ Age, gender, race/ethnicity, education, employment status, and marital status	Smokers were more likely to report frequent insomnia symptoms (OR 1.60, 95% CI 1.50-1.80).
Wallander et al. 2007	Men and women, n=12437 Age: 20-79	Non-smoker, ex-smoker, smoker/ Self-reported	Insomnia, hypersomnia, sleep disturbance/Self-reported	Logistic regression/ Age, gender, number of visits to the physician in the previous year	Smoking (OR 1.40, 95% CI 1.30-1.50) was associated with an increased risk of insomnia symptoms.
Mehari et a. 2014	Men and women, n=4677 Age: ≥20	Never, former, current and cigarettes smoked per day/ Self-reported	Trouble falling asleep, waking up at night with trouble falling back to sleep, waking up too early, feeling tired during the day, sleepiness during the day, not get enough sleep/ Self-reported	Multiple logistic regression/ Age, race/ethnicity, marital status, educational level, any vs. no alcohol consumption, any vs. no caffeine intake, BMI	Current smokers had significantly higher odds of insomnia symptoms (OR 1.38, 95% CI 1.09-1.74) compared to never smokers.

**Appendix 3.** Cross-sectional studies on the association among insomnia symptoms and physical activity

<b>Author, study design</b>	<b>Sample</b>	<b>Physical activity/ Measure</b>	<b>Insomnia symptoms/ Measure</b>	<b>Methods/Covariates</b>	<b>Adjusted association (if available)</b>
Owens et al. 1998	Women, n=521  Age: 42-50	Paffenbarger Physical Activity Questionnaire/Self-reported	Hours of sleep needed each night, amount of sleep needed now compared to before, any trouble sleeping, trouble falling asleep, average time to fall asleep, waking during the night, average time awake during the night, waking earlier than desired, napping during the day, length of nap /Self-reported	Analyses of variance/  Unadjusted	Physical activity level was not associated with insomnia symptoms (prospective study, but here cross-sectional results).
Fabsitz et al. 1997	Men, n=8870  Age: Average 40.5	1) Light activity: climbing stairs instead of taking the elevator, walking instead of riding short distances, parking away from a destination in order to walk more, walking on a lunch break or after dinner, getting off the bus early to walk to the destination, extra walking or stair climbing for exercise. 2) Strenuous activity (last 3 months regularly); running or jogging at least 10 miles per week, playing strenuous racket sports at least 5 h a week, playing other strenuous sports, riding a bicycle at least 50 miles per week, or	The Jenkins Sleep Questionnaire/ Self-reported	Logistic regression/  Adjusted for paired observations of twins	Light (OR 0.93 95% CI 0.89-0.96) and strenuous (OR 0.78 95% CI 0.62-0.98) physical activity was associated with reduced problems of waking up tired.

		swimming at least 2 miles per week/Self-reported			
Härmä et al. 1998	Men, n=3020 Age : 45-60	The 4-point Gothenburg scale. In this study the scale was dichotomized/ Self-reported	Difficulty falling asleep, waking up in the middle of sleep or difficulties falling asleep again, nightmares, non-restorative sleep, waking up too early, disturbed or restless sleep/Self-reported	Stepwise logistic regression analysis/  Unadjusted	Physical activity predicted insomnia symptoms (Chi-square 10.1, p=0,001).
Sherrill et al. 1998	Men and women, n=722  Age: Average, Men 54.1 and women 59.9	Walking more than 6 blocks per day at a brisk pace (approximately 4.8-6.4 km/h), walking more than 6 blocks per day at a casual or average pace (<4.8 km/h), vigorous activity (sports, jogging, sustained swimming, brisk walking or bicycling) more than 1 hour per day/Self-reported	Trouble falling asleep, trouble staying asleep, not enough sleep, too much sleep, early morning awakening, falling asleep during the day, nightmares/ Self-reported	Logistic regression/  Age, gender, use of medications or alcohol to help sleep, any respiratory trouble	Regular physical activity was associated with a reduced risk of any insomnia symptoms (OR 0.71 95% CI 0.50-0.99).
Janson et al. 2001	Men, n=2602  Age: 30-69	An increasing level of physical activity (4 categories) during leisure time. Physical inactivity is defined as e.g., spending most of the time in front of the television, reading and engaged in other sedentary activities/ Self-reported	Difficulties falling asleep, difficulties maintaining sleep/ Self-reported	Multiple logistic regression/  Age, medical disorder, BMI, change in BMI, baseline insomnia, smoking, physical inactivity, alcohol dependence	Physical inactivity (OR 1.43 95% CI 1.03-1.97) was associated with the risk of insomnia symptoms (prospective study, but here cross-sectional results).
Fogelholm et al. 2007	Men and women, n=8028  Age: ≥ 30	The questions: 1) Physically inactive (reading, watching TV, carrying out activities that are not physically strenuous), 2) Regular lifestyle activity (walking, cycling and moving in other such exercise modes at least 4 h weekly, 3) Regular exercise training (at least 3 h per weekly and/or competitive sports regularly several	Sleeping disorders, insomnia, daytime tiredness, sleep apnoea/ Self-reported	Multivariable generalised logistic regression/  Age, mental health, smoking and education, OSA, physical inactivity	Regular lifestyle activity was protective of insomnia symptoms (with short sleep) (OR in men 0.74 95% CI 0.58-0.96, in women OR 0.75 95% CI 0.60-0.90 and also in men (with 7-8 h of sleep) OR 0.54 95% CI 0.40-0.75). Regular exercise or training activity was protective of insomnia symptoms (with long sleep and 7-8 h of sleep, men OR 0.38 95% CI 0.18-0.80, OR 0.55 95% CI

		times per week (during leisure)/ Self-reported			0.34-0.88 and women OR 0.25 95% CI 0.13-0.49, OR 0.56 95% CI 0.36-0.91) and also, men (with short sleep), OR 0.64 95% CI 0.48-0.87).
Chasens and Yang 2011	Men and women, n=958  Age: ≥ 20	Objectively measured by an ActiGraph™ activity monitor/ Measured	Sleep apnoea, insomnia, restless leg syndrome, other insomnia symptoms/ Self-reported	Regression analysis/  Unadjusted	Fewer insomnia symptoms were associated with higher numbers of steps walked daily ( <i>B</i> -275.49 95% CI -518.56-(-32.44).
Chang et al. 2013	Men and women, n=1258  Age: ≥ 18	Regular physical activity was defined as exercise for a total of 30 minutes per day at least 5 days a week. Intensity and frequency was measured by asking the number of days they did moderate or vigorous physical activities. Moderate activity included brisk walking, bicycling, vacuuming, gardening or anything else causing large increases in breathing or heart rate/ Self-reported	Having trouble falling asleep, wake up during the night and have difficulty getting back to sleep, waking up too early in the morning and are unable to get back to sleep / Self-reported	Multivariate binary logistic regression/  Age, gender, marital status, education, a composite indicator of chronic disease	Regular physical activity was associated with decreased odds of insomnia symptoms (POR 0.37 95% CI 0.14-0.99) among participants with under or normal body weight.  Also, regular physical activity was associated with decreased odds of each individual insomnia symptom (difficulty falling asleep POR 0.39 95% CI 0.24-0.64, sleep continuity disturbances POR 0.53 CI 0.30-0.94, early morning awakening POR 0.46 95% CI 0.18-0.14).

**Appendix 4.** Cross-sectional studies on the association among insomnia symptoms and weight

<b>Author, study design</b>	<b>Sample</b>	<b>Weight/ Measure</b>	<b>Insomnia symptoms/ Measure</b>	<b>Methods/Covariates</b>	<b>Adjusted association (if available)</b>
Owens et al. 1998	Women, n=521  Age: 42-50	Weight, BMI/ Measured	Hours of sleep needed each night, amount of sleep needed now compared to before, any trouble sleeping, trouble falling asleep, average time to fall asleep, waking during the night, average time awake during the night, waking earlier than desired, napping during the day, length of nap /Self-reported	Analyses of variance/  Unadjusted	No associations between weight, BMI, change in BMI and insomnia symptoms (prospective study, but here cross-sectional results).
Ito et al. 2000	Men, n=255 Women, n=263  Age: 65	BMI/ Self-reported	Difficulty falling asleep, waking at night, non-restorative sleep/ Self-reported	Logistic regression/  Irregular bedtime, cardiovascular disease, arthritis or joint pain, prostatic hypertrophy, sleeping-pill use, depression, life-satisfaction index	BMI was not associated with insomnia symptoms.
Kim et al. 2000	Men, n=1482 Women, n=1548  Age :>20	Weight/ Self-reported	Difficulty initiating sleep, difficulty maintaining sleep, early morning awakening/ Self-reported	Multiple logistic regression/  Age, gender, education, marital status, occupation, somatic and psychological symptoms	Weight loss was associated with an increased risk of insomnia (OR 2.00, 95% CI 1.20-3.30).
Patterson et al. 2004	Men, n=35998, Women, n=37005  Age: 50- 76	BMI/ Self-reported	Trouble falling asleep, waking at night, or waking too early/ Self-reported	Logistic regression/  Age, race/ethnicity, education, smoking	Chronic insomnia was associated with BMI (overweight OR 1.50, obese OR 2.20, severe obese OR 3.5, p= <0.001).
TwoRoger et al. 2005	Women, n=73	BMI/ Measured	Objectively measured sleep quality and self-reported	Linear regression/	BMI was associated with poorer actigraphic measures (total wake time (min) OR 1.00 95% CI 0.05-2.00, wake

	Age: 20-40		insomnia symptoms on the Pittsburgh Sleep Quality Index questionnaire/ Measured and self-reported	Intervention status, exposure order, measurement period, night, external sleep disruptions, exercise in the previous month, age, alcohol servings, and perceived stress	after sleep onset (min) OR 0.80 95% CI 0.00-1.60, $p \leq 0.05$ ). Self-reported insomnia symptoms were not associated with BMI (data not shown).
Fogelholm et al. 2007	Men and women, n=8028  Age: $\geq 30$	Abdominal obesity, BMI/ Measured	Sleeping disorders, insomnia, daytime tiredness, sleep apnoea/ Self-reported	Multivariable generalised logistic regression/  Age, mental health, smoking and education, OSA, physical inactivity	Moderate insomnia symptoms were associated with obesity (men OR: 1.27 95% CI 1.04-1.55, women OR 1.82 95% CI 1.53-2.16), overweight (women OR 1.34 95% CI 1.09-1.64) and abdominal obesity (women OR 1.41 95% CI 1.15–1.73). Severe insomnia symptoms were associated with obesity (men OR 3.16 95% CI 1.91-5.22, women OR 2.42 95% CI 1.69-3.47) and overweight (women OR 1.67 95% CI 1.09-2.54). Abdominal obesity was associated with insomnia symptoms (with long sleep, women OR 0.46 95% CI 0.24-0.88).
Van Den Berg et al. 2008	Men and women, n=983  Age: 57-97	BMI/ Measured	Sleep fragmentation/ Objectively measured	Multiple linear regression analyses/  Age, gender, educational attainment, smoking, alcohol consumption, alcohol consumption squared, napping during the daytime and depressive symptoms	Fragmentation index had an association with higher BMI: BMI (increased with 0.59 kg m <sup>-2</sup> per s.d. of fragmentation, 95% CI: 0.34–0.84). Higher fragmentation index was associated with obesity (OR 1.36 95% CI 1.17–1.57).
Bidulescu et al. 2010	Men and women, n=1515,  Age: 30-65	BMI, obesity/ Self-reported	The Pittsburgh Sleep Quality Index (PSQI) scale/ Self-reported	Multiple logistic regression/  Age, physical activity, smoking status, education and history of hypertension, hypercholesterolemia, diabetes and myocardial infarction  When sleep quality was examined, additionally adjusted for gender, total family income and financial stress	A higher insomnia-symptom score was associated with an increased likelihood of obesity, among women (OR 1.56 95% CI 1.24-1.97).  Sleep quality was also associated with obesity among women (OR 1.08 95% CI 1.03-1.12).
Jaussent et al. 2011	Men and women, n=9294	BMI/ Self-reported	Having difficulty initiating sleep, waking up several times during the night, early morning awakening/ Self-reported	Multinomial logistic regression/  Socio-demographic, behavioural, clinical and sleep variables	In women, obesity was protective of two or three insomnia symptoms (OR 0.71 95% CI 0.52-0.98, OR 0.55 95% CI 0.39-0.78). In men, obesity was associated with a higher risk of having difficulty in initiating sleep



	Age: ≥ 65				(OR 2.70 95% CI 1.15-6.34).
Yan et al. 2011	Men and women, n=660  Age : >90	BMI/ Measured	The Pittsburgh Sleep Quality Index (PSQI) scale/ Self-reported	Multiple logistic regression/  Waist circumference, blood pressure, serum lipid/lipoprotein, blood sugar, uric acid, smoking, alcohol, tea, exercise, age, gender, daytime napping, cognitive function	There was no association between BMI and sleep quality.