Public Health Promotion Unit, Department of Public Health Solutions,
Finnish Institute for Health and Welfare

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University of Helsinki

ASSOCIATIONS OF PERCEIVED WORK STRESS AND WORK SCHEDULE WITH DIETARY HABITS

Katri Hemiö

ACADEMIC DISSERTATION

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Supervised by

Adjunct Professor Jaana Lindström
Department of Public Health Solutions
Finnish Institute for Health and Welfare
Helsinki, Finland

Adjunct Professor Sampsa Puttonen
Research and Service Centre of Occupational Health
Finnish Institute of Occupational Health
Helsinki, Finland

Reviewed by

Adjunct Professor Marjaana Lahti-Koski
Department of Public Health
University of Helsinki
and
Finnish Heart Association
Helsinki, Finland

Professor Saija Mauno
Faculty of Social Sciences
University of Tampere
Tampere, Finland
and
Department of Psychology
University of Jyväskylä
Jyväskylä, Finland

Opponent

Professor Kimmo Räsänen
Institute of Public Health and Clinical Nutrition
University of Eastern Finland
Kuopio, Finland

ABSTRACT

Work conditions can have a substantial impact on workers' lifestyles and thus, on the development of chronic diseases. One important determinant of the risk of chronic disease is diet.

The aim of this thesis was to examine the role that perceived work stress and work schedule may play in workers' dietary habits in a shift-work intensive workplace. In order to facilitate reliable evaluation of workers' dietary habits, a brief food intake questionnaire (FIQ) was also validated.

This thesis is based on data from a screening and prevention programme for chronic diseases implemented in a Finnish airline company between 2006 and 2008. The programme consisted of a health assessment of the participants and a discussion on the health assessment results with an occupational health physician or nurse. The assessment involved measurements of height, weight, waist circumference and blood pressure; blood tests; comprehensive questionnaires covering work, work schedule, sleep, perceived stress, stress symptoms, diseases, medication, lifestyle habits; the type 2 diabetes risk score FINDRISC; and a fasting glucose measurement. An FIQ was filled in by the participants whose risk of type 2 diabetes was elevated and by the participants who took part in the FIQ validation study.

The follow-up study was carried out in 2009 to 2010. The health assessment was similar to that at baseline except that the study questionnaire was extended to include the FIQ and more detailed work-related questions.

Cross-sectional data were used for the FIQ validation study (n=77); the shift schedules and dietary habits study (n=1478); and the recovery from work, sleep and dietary habits study (n=1342). The effect of work stress changes on dietary habits was evaluated in a prospective design, with a 2.4-year follow-up (n=366).

The relative validity of the FIQ, using a seven-day food diary as a reference method, was shown to be acceptable for estimating participants' food intake. Based on the FIQ answers, nutrient intake models were created separately for men and women; for proportions of energy from fat, saturated fat and sucrose; as well as for amount of fibre, vitamin C, iron, and vitamin D. These models were used to calculate the estimated nutrient intakes of the workers in the study cohort.

The dietary habits of the work schedule groups differed and were better among the day workers. Male shift workers' fruit and vegetable consumption was lower than that of male day and in-flight workers. Older age was associated with higher vegetable and fruit consumption among both men and women. The quality of fat in the day workers' diets was better than that in the shift or in-flight workers' diets. Poor recovery from work and sleep problems were associated with many unhealthy dietary habits, including more eating

occasions, higher fast food and sweet consumption, and lower fruit and vegetable consumption among men; and more eating occasions, higher fast food, desserts, and sweet consumption among women. During over two years of follow-up, an increase in stress and decrease in work ability were associated with an increase in fat and saturated fat intake among men, as well as an increase in night shifts was associated with increased fat and saturated fat intake among women.

In conclusion, shift schedule, higher perceived stress, poor recovery from work, sleep problems, and reduced work ability were associated with worse dietary habits, especially among men. The effects were seen as reduced consumption of fruit and vegetables as well as a higher fat and saturated fat intake. Shift workers' risk of coronary heart diseases has already been proven, and this effect may be partly mediated by poor diet. The increase in saturated fat in parallel with increased work stress observed in this study may increase this risk among shift workers. Therefore, occupational health services should incorporate diet quality assessment into routine health examinations, together with dietary counselling targeted especially towards workers with high levels of stress.

TIIVISTELMÄ

Työympäristö voi vaikuttaa työntekijän elintapoihin, jolloin sairastumisen riski kroonisiin kansansairauksiin voi kasvaa. Terveellisillä ruokatottumuksilla tätä riskiä voidaan pienentää.

Tämän väitöskirjan tavoitteena oli selvittää vaikuttaako työn aiheuttama stressi tai työvuorojärjestelmä työntekijän ruokatottumuksiin työpaikassa, jossa suuri osa työntekijöistä työskentelee vuorotyössä. Tavoitteena oli myös tutkia, voiko tutkimuksessa käytetyllä ravitsemuskyselyllä arvioida työntekijöiden ruoankäyttöä ja ravintoaineiden saantia luotettavasti.

Väitöstutkimuksessa on käytetty suomalaisen lentoyhtiön työterveyshuollon toteuttaman Kroonisten sairauksien seulonta ja ehkäisy – hankkeen lähtötason (2006-2008) ja seurantavaiheen (2009-2010) terveystarkastusten aineistoja. Työntekijät osallistuivat hankkeen aikana terveystarkastukseen sekä sen tulosten läpikäymiseen työterveyslääkärin tai -hoitajan vastaanotolla. Terveystarkastuksessa mitattiin työntekijän pituus, paino, vyötärönympärys ja verenpaine sekä otettiin verikoe ja pyydettiin työntekijää täyttämään laaja kyselylomake, jolla kartoitettiin työhön liittyviä tekijöitä, työvuoroja, unta, koettua stressiä, stressin oireita, sairauksia, lääkitystä ja elintapoja. Diabeteksen riskitekijöitä arvioitiin tyypin 2 diabeteksen riskitestillä (FINDRISC) sekä paastoglukoosiarvolla. Osallistujia, joiden tyypin 2 diabeteksen riski oli suurentunut tai jotka osallistuivat ravitsemuskyselyn validointitutkimukseen, pyydettiin lisäksi täyttämään ravitsemuskysely.

Seurantatutkimus oli samansisältöinen kuin alkuvaiheen terveystarkastus paitsi, että kyselylomake oli laajempi sisältäen lisäksi ravitsemuskyselyn sekä tarkempia työhön liittyviä kysymyksiä. Poikkileikkausaineistoa käytettiin ravitsemuskyselyn validointitutkimukseen (n= 77), työvuorojärjestelmän (päivätyö, vuorotyö ilman lentotyötä tai lentotyö) vaikutuksia ruokatottumuksiin ja ravintoaineiden saantiin arvioivaan tutkimukseen (n=1478) sekä työstä palautumisen ja unen vaikutuksia ruokatottumuksiin arvioivaan tutkimukseen (n=1342). Pitkittäisellä aineistolla arvioitiin stressin ja yötyön muutosten vaikutuksia työntekijöiden ravintoaineiden saannin muutoksiin 2,4 vuoden seurannan aikana (n=366).

Tutkimuksessa käytetyn ravitsemuskyselyn avulla voitiin arvioida työntekijöiden ruoankäyttöä luotettavasti. Ravitsemuskyselyn vastauksista muodostettiin lineaarisen regression avulla laskentakaavat ravintoaineiden saanneille, jotka vastasivat samojen henkilöiden (n=77) ruokapäiväkirjoista laskettuihin ravintoaineiden saanteihin. Laskentakaavat muodostettiin rasvan, tyydyttyneen rasvan ja sakkaroosin osuuksille energiasta sekä kuidulle, C- ja D-vitamiinille ja raudalle.

Ravitsemuskyselyn perusteella työntekijöiden ruoankäyttö ja ravintoaineiden saanti erosivat eri työaikamuotojen välillä

päivätyöntekijöiden eduksi. Vuorotyötä tekevien miesten vihannesten ja hedelmien käyttö oli vähäisempää kuin päivä- tai lentotyötä tekevillä miehillä. Vanhemmat miehet ja naiset näyttivät käyttävän vihanneksia ja hedelmiä enemmän kuin nuoret työntekijät. Päivätyöntekijöiden ruokavalion rasvan laatu oli parempi kuin vuoro- tai lentotyöntekijöillä. Työntekijöiden ruokavalion laatua heikensi riittämätön palautuminen työstä sekä uniongelmat. Miehillä syömiskertojen määrä sekä pikaruokien, makeisten, viljatuotteiden ja alkoholin käyttö näytti tuolloin lisääntyvän ja vihannesten ja hedelmien käyttö vähentyvän. Naisilla huono palautuminen työstä ja uniongelmat näyttivät olevan yhteydessä lisääntyneeseen syömiskertojen määrään sekä pikaruokien, makeisten ja jälkiruokatyyppisten ruokien lisääntyneeseen käyttöön. Yli kahden vuoden seurannan aikana miehillä koetun stressin lisääntyminen ja työkyvyn alentuminen näyttivät lisäävän rasvan ja tyydyttyneen rasvan saantia ja naisilla saman sai aikaan yövuorojen lisääntyminen.

Tässä väitöstutkimuksessa havaittiin työvuorojärjestelmän, stressin, uniongelmien, riittämättömän työstä palautumisen ja alentuneen koetun työkyvyn olevan yhteydessä ruoan valintaan ja ravintoaineiden saantiin erityisesti miehillä. Vaikutukset näkyivät vihannesten ja hedelmien vähentyneenä kulutuksena sekä tyydyttyneen rasvan lisääntyneenä saantina. Tyydyttyneen rasvan kuten myös vuorotyön tiedetään lisäävän työntekijöiden riskiä sairastua sydän- ja verisuonisairauksiin, siksi työterveyshuollon tulisi sisällyttää työntekijöiden terveystarkastuksiin ravitsemusohjausta yhdessä stressioireiden kartoittamisen kanssa.

CONTENTS

LIST OF ORIGINAL PUBLICATIONS

This thesis is based on the following publications:

I Hemiö K, Pölönen A, Ahonen K, Kosola M, Lindström J. A Simple Tool for Diet Evaluation in Primary Health Care: Validation of a 16-Item Food Intake Questionnaire. Int J Environ Res Public Health. 2014;11:2683-97.

II Hemiö K, Puttonen S, Viitasalo K, Härmä M, Peltonen M, Lindström J. Food and nutrient intake among workers with different shift systems. Occup Environ Med. 2015;9:96-104.

III Hemiö K, Lindström J, Peltonen M, Härmä M, Viitasalo K, Puttonen S. High need for recovery from work and sleep problems associate with workers' unhealthy dietary habits. Public Health Nutr 2020, 1-10. doi:10.1017/S1368980020000063

IV Hemiö K, Lindström J, Peltonen M, Härmä M, Viitasalo K, Puttonen S. Association of work stress and night work with nutrient intake. A prospective cohort study. SJWEH 2020 online first. doi:10.5271/sjweh.3899

The publications are referred to in the text by their roman numerals.

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ABBREVIATIONS

AHEI	Alternate Healthy Eating Index
BDQ	brief dietary questionnaire
BMI	body mass index
CHD	coronary heart diseases
DASH	Dietary Approaches to Stop Hypertension
E%	proportion of energy
ESS	Epworth sleepiness scale
FFQ	food frequency questionnaire
FIQ	food intake questionnaire
HPA	hypothalamic-pituitary-adrenal system
Kappa	weighted Kappa coefficient
µg	microgram
M	arithmetic mean
mg	milligram
MUFA	monounsaturated fatty acids
n	number
NFR	Need for recovery
NPV	negative predictive value
PPV	positive predictive value
PUFA	polyunsaturated fatty acids
R^2	coefficient of determination
r	Spearman correlation coefficient
SAFA	saturated fatty acids
SAM	sympatho-adrenal-medullary
SD	standard deviation
T2D	type 2 diabetes

1 INTRODUCTION

Workers' good work ability is the result of a balance between human resources and work demands (Ilmarinen 2006). The factors that form the basis of work ability are workers' good health and functional capacity (Figure 1). Workers' skills, knowledge and attitudes, as well as work-related factors also influence work ability. For both employers and society, it is important to maintain work ability so that workers can work for longer and have a healthy life beyond their working careers. Sickness absences can be seen as an indicator of workers' reduced work ability and have shown to predict disability retirement (Salonen et al. 2018). The cost related to short-term sickness absences is estimated to be 10% to 30% higher when workers have a poor lifestyle (Kanerva et al. 2018). Thus, encouraging workers to adopt a healthy lifestyle is worthwhile for employers.

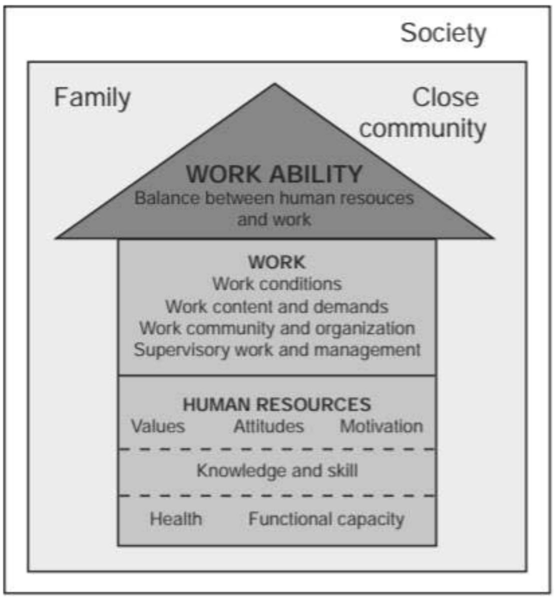

Figure 1 The determinants of good work ability (Ilmarinen 2006)

One work-related factor affecting workers' health is shift work, which is work done outside a regular daytime schedule. Working in shifts affects workers' circadian rhythms, and alters the regularity and timing of sleeping and eating times, causing a misalignment of the physiological functions of the body (Scheer et al. 2009). Moreover, shift work is known to increase the risk of cardiovascular diseases (Vyas et al. 2012; Vetter et al. 2016; Torquati et al. 2018), metabolic syndrome (Esquirol et al. 2009; De Bacquer et al. 2009; Pietroiusti et al. 2010), and type 2 diabetes (T2D) (Gan et al. 2015; Hansen et al. 2016; Vetter et al. 2018). Dietary habits play a significant role in preventing chronic diseases and maintaining good health (WHO 2003). Therefore, the work-related factors that associate with dietary habits should be assessed in order to prevent chronic diseases in the work environment.

The Finnish adult population's food and nutrient intakes are monitored regularly by the National FinDiet Surveys. The most recent survey was conducted in 2017. Comparison of the results with the national food and nutrient intake recommendations (National Nutrition Council 2014) revealed several unhealthy dietary habits in the Finnish population (age 18 to 74 years) (Valsta et al. 2018). The recommended amount of vegetables, fruit and berries (500 grams) was only consumed by 14% of men and 22% of women. The saturated fat intake recommendation was fulfilled by only 5% and the fibre recommendation by 30% of the population. Vitamin A and D, folate, and thiamin intakes were more often inadequate than those of other micronutrients. A clear difference between men's and women's food and nutrient intakes was observed. Women's dietary habits are shown to be better than men's. These results reflect that there is much to improve in the dietary habits of the Finnish population.

The present thesis investigated the association between work-related factors and workers' dietary habits in shift work-intensive workplace. The work-related factors studied were work schedules, sleep problems, recovery from work, work ability, and perceived stress. In addition, a new valid method for estimating nutrient intakes was also developed.

2 REVIEW OF THE LITERATURE

2.1 WORK STRESS

2.1.1 TRENDS AND PREVALENCE OF WORK STRESS

Trends in working conditions and worker's health in the EU have been followed since 1975 by a survey called 'European Working Conditions', organized by the European Foundation for the Improvement of Living and Working Conditions (Eurofound). The report currently includes work-related information from all the 28 EU countries (Eurofound 2019). The reports show that working life has changed in Europe. Workers' weekly working hours have decreased from 40.5 to 37.5 over a period of 20 years that is up till 2010 (Eurofound 2012). Work intensity, measured using ten work-related parameters, has slightly increased between 2010 and 2015 (Eurofound 2017). In addition, atypical working hours have become more common; for example, the prevalence of shift work increased from 17% to 21% between 2005 and 2015 (Eurofound 2017), and shift workers were more likely to report higher work intensity than workers without atypical working hours (Eurofound 2012). The highest rates of irregular working hours are reported in the agriculture and transport sectors.

In 2005, 22% of European workers experienced stress and one third reported working at very high speed and to tight deadlines for most of their working time (EU 2009). Five years later, 25% of workers experienced stress most of the time (Eurofound 2014). In Finland, a study showed that the prevalence of high or relatively high stress, evaluated using high mental workload, was 28% (Kivekäs and Ahola 2013). Emotional demands at work have also increased in Europe (Eurofound 2017). Changes in work characteristics have led to workers experiencing more work-related stressors, which can be detrimental to health in the long term.

2.1.2 DEFINITION AND CAUSES OF WORK STRESS

Work stress has been defined in several different ways. The European Commission has defined work stress as a 'pattern of emotional, cognitive, behavioral and physiological reactions to adverse and noxious aspects of work content, work organization, and work environment. It is a state characterized by high levels of arousal and distress and often by feelings of not coping' (European Commission 2000). In a recent report of the International Labour Organization, the definition of stress emphasizes inconsistency between individuals' work stressors and recovery: a 'harmful physical and emotional response caused by an imbalance between the perceived demands and the perceived resources and abilities of individuals to cope with those demands' (ILO 2016). Thus, in certain circumstances, stress can also be experienced as a positive phenomenon that can improve worker's efficiency at work in the short term. This thesis approaches stress as a negative impact on workers' health.

Several theories about work stressors have been proposed. The most studied theory is founded on the assumption that high job demands and low decision latitude cause work stress (Karasek and Theorell 1990). Another theory, known as the 'Effort-reward imbalance model' assumes that stress is caused when workers' efforts at work are not recognized or rewarded (Siegrist 1996). A review of seven prospective work stress studies revealed that high job demands, low job control, low co-worker support, low supervisor support, low procedural justice, low relational justice, and a high effort-reward imbalance predicted the incidence of stress-related disorders (Nieuwenhuijsen et al. 2010).

2.1.3 MEASURING WORK STRESS

Work stress can be measured on the basis of the body's physiological and biological responses to stress, workers' perceived work and work environment-related stressors, or as workers' reactions to the stressors of work (Hurrell et al. 1998). Because there are many ways to measure stress, this chapter focuses on the methods that measure subjective stress and only briefly discusses biological methods.

A biological indicator of stress is the hypothalamic–pituitary–adrenal-derived hormone cortisol, which can be measured from saliva (Fries et al. 2009). Cortisol concentration has strong diurnal variation and changes in concentration may predict the stress level of an individual. Higher work-related stress is associated with a higher cortisol response to awakening (Maina et al. 2009; Marchand et al. 2014; Li et al. 2018), and cortisol concentration has also shown to increase during working days compared with days off (Marchand et al. 2013). A sex difference was reported in an experimental study in which men's cortisol response to stress was stronger than that of women (Stephens et al. 2016). Due to different reactions to multiple neural mechanisms mostly related to the HPA axis, individual differences in resilience and susceptibility to stress have been observed (Franklin et al. 2012). Stress level can also be assessed using heart rate, blood pressure and immune system measurements (Hurrell et al. 1998).

In large epidemiological work stress studies, biological measurements can be difficult to carry out and therefore methods that rely on validated questionnaires are more often used (Hurrell et al. 1998; Tabanelli et al. 2008). Indirect methods assess stress level using subjective ratings of the negative impact of work-related issues, which are summed for a stress score. In a review of 33 work stress assessment questionnaires, the number of questions ranged from 15 to 232 (Nieuwenhuijsen et al. 2010). In addition to comprehensive stress questionnaires, a single stress symptoms question about the respondent's tense, restless, nervous and anxious feelings as well as sleep problems has shown to predict work stress at group level (Elo et al. 2003). The stress question correlates with psychological stress symptoms such as exhaustion, mental health and vitality, as well as sleep disturbances among both men and women in different age groups.

Questionnaires for assessing severe work stress symptoms such as anxiety and burnout have also been developed, as well as more general questionnaires that measure psychological distress; for example fatigue and insomnia (Hurrell et al. 1998). Rather strong evidence supports a link between work stress and sleep problems (Åkerstedt 2006; De Lange et al. 2009; Linton et al. 2015; Chazelle et al. 2016; Åkerstedt et al. 2017; Omholt et al. 2017), insomnia (Yang et al. 2018) and fatigue (Åkerstedt et al. 2002; Dahlgren et al. 2005; Omholt et al. 2017). An association between fatigue and altered cortisol secretion has also been reported, showing a connection between stress and fatigue (Kumari et al. 2009). One experimental study found that a high stress level negatively affected sleep quality, i.e. sleep efficiency and fragmentation. This effect was stronger among participants who were vulnerable to stress (Petersen et al. 2013).

Early symptoms of work stress may occur soon after the work shift when a worker may need time to recover from the stressors of work. The concept of the need for recovery from work (NFR), referring to this phenomenon, has been defined and can be assessed using a validated questionnaire (van Veldhoven and Broersen 2003). Insufficient recovery from work has shown to associate with workers' fatigue (van Veldhoven and Broersen 2003; Sonnentag and Zijlstra 2006). Studies have found that irregular work, three-shift work (including morning, evening and night shifts), overtime and a higher number of working hours predict a greater NFR (Jansen et al. 2003), as does older age (Kiss et al. 2008).

Atypical work schedules, as a work stressor, are associated with sleep problems, reflecting an increase in stress. Shift work, including two (morning and evening shifts), three and irregular shifts, as well as night work, predicted more sleep complaints than day work (Härmä et al. 1998). Three-shift work was associated with insomnia (Flo et al. 2013) and overtime, and hectic work with fatigue (Åkerstedt et al. 2002; Åkerstedt et al. 2017).

In summary, there are several ways to measure work stress. The selection of stress or stress symptom questionnaires should depend on the intended purpose of measuring stress. Sleep quality and quantity have been associated with stress, and therefore sleep measurements can be used as indicators of stress. This thesis measures stress by the reactions experienced by workers. It also examines shift work as one of the stressors in the work environment.

2.1.4 WORK STRESS AND HEALTH

Figure 2 illustrates a conceptual framework for the association between work stress and health (Eurofound 2010; Cohen et al. 2016). In this model, work stress is caused by workers' insufficient recovery from the working day due to the excessive demands of work. Negative emotional responses caused by stress may have an effect on workers' lifestyle and/or they may activate stress-induced physiological reactions. In the long term, these behavioural and physiological responses may increase the risk of several diseases.

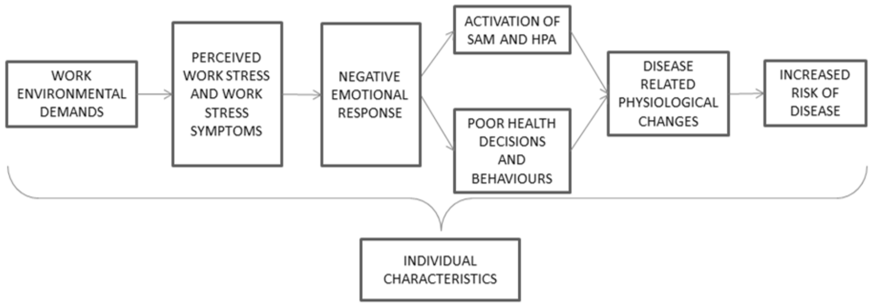

Figure 2 Model for the association between work stress and impaired health. Adapted from Cohen et al. 2016 and Eurofound 2010. SAM = sympatho-adrenal-medullary mediators. HPA = hypothalamic–pituitary–adrenal system.

Another model emphasizes two stages of recovery from work that affect workers' health (Geurts and Sonnentag 2006). In the first stage, workers' inadequate recovery from a working day increases their compensatory efforts to ensure adequate work ability the next working day. As a result, the psychophysiological systems of stress remain activated, unlike in optimal recovery. If the adverse outcomes of the first stage accumulate, workers may eventually develop chronic health problems.

Several prospective studies have reported relations between work stress and health. In a Swedish longitudinal study, high job strain in late midlife predicted self-reported complex health problems after over 20 years of follow-up (Nilsen et al. 2014). Most studies of work stress and health have focused on coronary heart diseases (CHD). In a meta-analysis of 14 prospective CHD studies including over eighty thousand employees, work stress was assessed on the basis of job strain, effort-reward balance or organizational justice. The age and gender-adjusted analyses showed that stress associated with CHD (high vs low job strain OR 1.43, 95% CI 1.15-1.84; high efforts and low rewards vs low efforts and high rewards OR 1.58, 95% CI 0.84–2.97; organizational injustice vs justice OR 1.62, 95% CI 1.24–2.13) (Kivimäki et al. 2006). This study did not control for lifestyle factor results. In contrast, Chandola et al. showed that lifestyle factors (fruit, vegetable, and alcohol consumption, physical activity, smoking) and metabolic syndrome played a role in the association between stress and the risk of CHD in a 12-year follow-up (Chandola et al. 2008). A more recent multicohort study consisting of over 100 000 workers showed that among men with cardiometabolic disease at baseline, high job strain associated with a risk of mortality (HR 1.68; CI 1.19-2.35) after an almost 14-year follow-up (Kivimäki et al. 2018). In this study, the association was independent of age, smoking status, physical activity, alcohol consumption, BMI, and socioeconomic status. Possible mediating factors such as diet (except alcohol) were not taken into account. In summary, according to several prospective studies, work stress seems to moderately increase the risk of CHDs. However, only some of the studies adjusted the results for lifestyle factors, which may influence the interpretation of the results.

Workers' occupational stress has shown to predict weight gain. In a prospective study investigating the association between work-related stress and obesity, low decision latitude at baseline was associated with weight gain over a 20-year follow-up (OR 1.29, 95% CI 1.13-1.47). The result remained after adjusting for diet quality (calculated from food frequency questionnaires), social job support, physical activity, smoking, marital status, academic education, and BMI (Klingberg et al. 2019). In a nine-year follow-up study, psychosocial stress concerning job demands, lack of skill discretion, and decision authority were associated with weight gain among men who had a higher BMI at baseline. In the same study, high job demands at baseline associated with weight gain among overweight women (Block et al. 2009). The analyses were adjusted for several covariates, but diet-related variables were not included. This study showed that overweight workers seem to respond to stress more than workers of normal weight. This finding is also supported by a prospective study in which elevated hair cortisol concentration, indicating a higher stress level, was associated with obesity (Jackson et al. 2017).

In recent years, associations have been observed between work stress and cognition. High midlife work stress was associated with lower global cognition function after a 25-year follow-up (Sindi et al. 2017). Perceived work stress predicted cognitive impairments after one year and a change in stress level associated with a change in cognition (Eskildsen et al. 2017). An 11-year prospective study found that high job strain increased workers' adverse cognitive outcomes (Dong et al. 2018).

To summarize, prospective cohort studies provide evidence of an association between work stress and multiple adverse health outcomes in later life. The definition and indicators of work stress vary as does the handling of confounding and possible mediating factors such as diet. Diet can influence chronic disease incidence and therefore, results that have not controlled for diet should be interpreted with caution.

2.2 ASSOCIATION BETWEEN STRESS AND DIETARY HABITS

Very few studies have specifically assessed the connection between work-related stress and dietary habits and therefore this chapter also explores studies on the association between non-work-related stress and diet. Because stress and sleep problems are closely related, the effect of sleep problems on dietary habits is also discussed, as well as shift work, which is a risk factor for stress and sleep problems.

2.2.1 STRESS AND DIETARY HABITS

A review of the relationship between stress, dietary habits and weight, published in 2007, concluded that chronic stress can influence dietary habits even though some of the studies included in the review had limitations due to study designs (Torres and Nowson 2007). As this review only very briefly discussed the associations between work stress and diet, no conclusions can be drawn. Some studies on the association between work stress and dietary habits have been published more recently and are presented here and in Table 1.

Higher work stress was associated with poorer overall diet quality in two cross-sectional studies (Gibson et al. 2018; Muniz et al. 2019). Isasi et al. found no associations between chronic stress and diet quality, but their study measured work stress among other stressors and therefore no conclusion between work stress and diet quality can be drawn (Isasi et al. 2015).

Some studies have investigated the association between work stress and healthy food intake. Higher work stress has been associated with lower fruit and vegetable consumption among men and women (Chandola et al. 2008; Bauer et al. 2012; Nagler et al. 2013), but another study of male trucking workers found no such association (Buxton et al. 2009). In addition, worker's high perceived stress and habits of doing other things while eating associated with lower fruit and vegetable intake than among workers who did nothing else while eating (Barrington et al. 2012). Although the study participants were workers, work stress-specific questions were not included in the stress assessment. Nagler et al. and Buxton et al. investigated the factors that associated with fruit and vegetable consumption. Situations at work such as lack of healthy food choices, time pressure, fatigue, stress, longer working hours, and bringing fewer meals from home to work were associated with lower fruit and vegetable intake (Buxton et al. 2009; Nagler et al. 2013). Thus, it seems that work-related stress associates with lower fruit and vegetable intake.

Table 1 *Studies reporting associations with stress and dietary habits*

Reference and country	Study design and population	Stress assessment	Dietary assessment	Results
Chandola T et al. 2008, Great Britain	Prospective n=4358, men and women civil servants age range 35–55	Job Content Questionnaire	- alcohol intake - frequency of consumption of fruit and vegetables	Higher stress - alcohol ↑ - fruit and vegetables ↓
Buxton et al. 2009, USA	Cross-sectional n=542 men motor freight workers mean age 48.6 years	Job Content Questionnaire (13 items) Work-related questions	Food servings: -fruit and vegetables (6 items) -drinks with added sugar - sugary snacks	Higher job strain - drinks with added sugar ↑ - sugary snacks ↑
Barrington et al. 2012, USA	Cross-sectional n=621 workers men=264, women= 357 age range 18–65 years	Perceived Stress Scale (10 items)	- 7-question fruit and vegetable assessment tool - fast food meals - soft drinks	High stress and doing something else while eating - fruit and vegetables ↓ - fast food ↑
Bauer et al. 2012, USA	Cross-sectional n=2143 workers men=877, women=1266	Work-life stress (3 items)	- fruit and vegetables (2 items), sugar-sweetened beverages (1 item), fast food (5 items)	Highest stress category - fruit and vegetables ↓ - fast food ↑
Mouchacca J et al. 2013, Australia	Cross-sectional, Study 1: n=4349 women age range 18-46 years Prospective, Study 2: n=1382 women age range 18 to 46 Participants worked full- or part-time or were unemployed	Perceived Stress Scale (4 items)	FFQ: potato crisps or salty snack food; chocolate or lollies; cake, doughnuts or sweet biscuits; pies, pasties or sausage rolls; fast foods; pizza; non-diet soft drinks	Study 1 and study 2: Higher stress - fast food ↑

Nagler et al. 2013, USA and Canada	Cross-sectional n=1555 - construction labourers, motor freight workers	Job Content Questionnaire (13 items) and 4 questions about reasons for some dietary habits connected to work	-7-question fruit and vegetable assessment tool	Lower fruit and vegetable intake: - no opportunity - no time - tired or stressed
Barrington et al. 2014, USA	Cross-sectional n=65 235 men =32 355, women =32 880 age range 50–70+ years	Single item (stress at home and work)	FFQ: number of eating occasions, servings of fruit and vegetables, high-fat snacks, fast food items, and sweetened drinks	Higher stress - high-fat snacks ↑ - fast food ↑ - less eating occasions
Isasi et al. 2015, USA	Cross-sectional n=5077 men=1936, women=3141 age range 18-74 years Hispanic/Latino adults	Perceived Stress Scale (10 items) Chronic stress burden (8 items, including work stress)	two 24-h recalls (calculated AHEI-2010 score) meals outside	Higher perceived stress scale - lower AHEI-2010 score Chronic stress - no associations
Gibson et al. 2018, Great Britain	Cross-sectional n=5527 police men=3333, women=2194 mean age men 42.4 years, women 39.5 years	Job Content Questionnaire (six items) Working hours	7-day food records - DASH score were calculated	Higher strain among men -poor diet Long working hours among men - poor diet
Muniz et al. 2019, Brazil	Cross-sectional n=478 men=311, women=167 mean age 44.3 workers at university: faculty professionals and non-faculty staff	Job Content Questionnaire (17 items)	FFQ: fruit, vegetables, sugar-sweetened beverages and fish included in score	High strain - poor diet

FFQ, food frequency questionnaire; AHEI, Alternative Healthy Eating Index; ↑ associate with higher intake, ↓ associate with lower intake

Some studies have investigated the association between work stress and unhealthy food intake. High job strain was associated with higher sugary snacks and drinks consumption among male motor freight workers in one study (Buxton et al. 2009). In other studies, when stress at work and home was taken into account, no associations with sugary drinks were found (Bauer et al. 2012; Barrington et al. 2014) and in a study in which stress was assessed without work stress (Mouchacca et al. 2013). In addition to associations between stress and the consumption of sugar-containing foods and drinks, associations between stress and the consumption of high fat-containing foods have been studied. Higher levels of perceived stress due to home and work situations have been associated with a greater intake of high-fat snacks (Barrington et al. 2014) and higher fast food consumption (Bauer et al. 2012; Barrington et al. 2014), with no sex differences. In addition, higher stress without work stress assessment predicted higher fast food consumption in cross-sectional (Barrington et al. 2012; Mouchacca et al. 2013) and prospective study designs (Mouchacca et al. 2013) Higher work stress predicted higher alcohol intake in a prospective study of civil servants (Chandola et al. 2008). Barrington et al. reported that participants who were sensitive to the effects of stress had less eating occasions (Barrington et al. 2014). In conclusion, higher perceived stress and work stress seems to associate with the consumption of high fat foods and sugary snacks and drinks.

Only a few studies have investigated the relationship between workers' stress and nutrient intakes (Table 2). A higher level of perceived stress was associated with higher energy, fat and saturated fat intake as well as lower carbohydrate intake (Hellerstedt and Jeffery 1997; Ng and Jeffery 2003; Barrington et al. 2014; Isasi et al. 2015). A large Japanese study found several but weak and inconsistent associations between job strain, worksite support and nutrient intake (Kawakami et al. 2006).

To summarize, studies on stress and food intake have rather consistently shown that higher perceived stress is associated with worse dietary habits, such as increased fast food and decreased fruit and vegetable consumption. This is mostly shown in studies with a cross-sectional design. Only a few stress studies have comprehensively investigated a persons' diet; instead, studies have mostly focused on selected dietary habits that are a priori expected to change because of stress. As a consequence, possible other associations between stress and dietary habits may have been neglected. Furthermore, only a few studies have investigated the impact of stress on nutrient intake. A modest link has been seen between stress and fat intake, but no firm conclusions regarding this can be drawn.

Table 2 *Studies reporting associations with stress and nutrient intake*

Reference	Study design and population	Stress assessment	Dietary assessment	Results
Hellerstedt and Jeffery 1997, USA	Cross-sectional n=3843 men=1872, women=1971	Job Content Instrument	18-item FFQ - fat intake	High job demands - fat intake in men ↑
Ng and Jeffery 2003, USA	Cross-sectional n=12 110 workers men=5490, women=6620 mean age 40 years	Perceived Stress Scale (4 items)	Block Fat screener - fat intake	Higher stress - fat intake ↑
Kawakami et al. 2006 Japan	Cross-sectional n=25 104 men=15295, women=2853 mean age: men 40.8 years, women 36.3 years	Job Content Questionnaire	Dietary history questionnaire	Weak associations: High job strain among men - fat, vitamin E, cholesterol, PUFA, MUFA. All ↑ High worksite support: Men: - energy, fibre, retinol, carotene, vitamin A, C and E, cholesterol, SAFA. All ↑ Women: - energy, protein, vitamin E, PUFA. All ↑
Barrington et al. 2014, USA	Cross-sectional n=65 235 men =32 355, women =32 880 age range 50–70+ years	Single item (stress at home and work)	FFQ	High stress ↑ - fat intake ↑ - carbohydrate intake ↓
Isasi et al. 2015, USA	Cross-sectional n=5077 men=1936, women=3141 Age range 18–74 year Hispanic/Latino adults s	Perceived Stress Scale Chronic stress burden (8 items, including work stress)	two 24-h recalls (calculated AHEI-2010 score) meals outside	Higher perceived stress scale - energy intake ↑ - SAFA intake ↑ Chronic stress - energy intake ↑

PUFA, polyunsaturated fatty acids; MUFA, monounsaturated fatty acids; SAFA, saturated fatty acids,
↑ associate with higher intake, ↓ associate with lower intake

2.2.2 SLEEP, SHIFT WORK AND DIETARY HABITS

Studies on the relation between sleep and diet have usually focused on the impact of sleep duration on diet, and other aspects of sleep, such as sleep quality, have been studied far less. In a review of 16 sleep and diet studies, short sleep duration was associated with higher caloric intake, higher intake of fat, and potentially with lower fruit intake and lower quality diet (Dashti et al. 2015). A recent review concluded that people who sleep 7–9 hours per day are likely to consume more fruit and vegetables than those with shorter or longer habitual sleep duration (Noorwali et al. 2019). Sleep quality has also been associated with dietary habits and one cross-sectional study has shown that the associations of sleep duration and sleep quality with diet differ (Mossavar-Rahmani et al. 2017). Some studies have investigated the association between sleep quality and diet quality scores. In women, the lower Alternative Healthy Eating Index (AHEI score) (McCullough et al. 2002) is associated with reduced sleep quality (Stern et al. 2014). Sleep quality has also been associated with the Mediterranean diet among normal and overweight, but not obese adults (Godos et al. 2019). A large study of Latinos revealed that both optimal sleep duration and sleep quality were associated with a better healthy eating index (Mossavar-Rahmani et al. 2017). Thus, a link seems to exist between good sleep quality and a healthy diet.

Some studies have found associations between sleep quality and particular food items. Optimal sleep duration was associated with higher nut and legume intake and better sleep quality with higher whole fruit and lower sodium intake (Mossavar-Rahmani et al. 2017). Another large cross-sectional study of middle-aged women concluded that women's poor sleep was associated with lower consumption of vegetables and higher consumption of confectionaries, energy drinks and sugar-sweetened beverages as well as irregular eating and skipping breakfast (Katagiri et al. 2014). A study of male motor freight workers found that higher job strain predicted higher consumption of sugar-sweetened drinks and sugary snacks, but when sleep was taken into account, these associations were attenuated (Buxton et al. 2009). Workers with restorative sleep had higher fruit and vegetable intake and lower sugar-sweetened drinks and sugary snacks intake when confounding factors including age, education, race, night work, and packed lunches were taken into account (Buxton et al. 2009). In conclusion, workers with good sleep quality were more likely to eat more fruit and vegetables and less sugar-containing foods and drinks than workers with sleep disturbances.

Day workers' dietary habits seem to be better than shift worker's. A recent systematic review consisting of 33 studies of shift work and dietary habits concluded that shift work can somewhat alter workers' dietary habits (Souza et al. 2019). The findings were rather consistent as regards to shift workers' higher saturated fat intake and higher sugar-sweetened beverage consumption than that of day workers. Findings regarding fruit and vegetable intake were mixed: of the ten studies measuring fruit and vegetable consumption, four found it to be higher among day workers, three among shift workers and three found no differences between workers with different schedules (Souza et al. 2019). Daily distribution of energy has shown to differ between day and shift workers (Lennernäs et al. 1995) and shift workers more often eat at night than day workers, which is expected (Souza et al. 2019). The review found no differences between the number of meals eaten by day and shift workers (Souza et al. 2019). However, shift workers may more often eat snacks instead of main meals than day workers (De Assis, M A A et al. 2003; Waterhouse et al. 2003; Li et al. 2011).

In summary, a consistent association between short sleep duration and unfavourable dietary habits has been observed. Sleep quality and shift work seem to affect dietary habits, but more research is needed to confirm these findings. As only a few prospective studies have examined sleep or shift work and diet, it is difficult to know whether changes in sleep or work schedules also affect diet. In addition, some evidence has been found that the association between sleep and diet may be reciprocal; so a healthy diet may promote good sleep quality (St-Onge et al. 2016b).

2.3 DIETARY INTAKE ASSESSMENT

When evaluating the associations between diet and disease or impaired health, reliable and accurate dietary intake assessment is required. As no absolute dietary intake assessment method exists, several methods to approximate dietary intake have been developed. These include food records, 24-hour dietary recalls, food frequency questionnaires (FFQ), dietary history (Willett 2013) and biomarkers (Ostan et al. 2018). When choosing the dietary intake assessment method for a study, the objectives of the study and the advantages and limitations of these methods should be taken into account (Willett 2013). Of the possible methods, the FFQ has been established as the main method of habitual dietary intake assessment in epidemiological studies (Willett 2013). Dietary assessment methods are time-consuming, require sophisticated data management systems and updated nutrient databases, as well as adequate financial resources. Therefore, these methods are not suitable for practical dietary counselling and assessing and monitoring diet quality in a health care setting. For this reason, to complement comprehensive diet quality assessment tools, brief dietary questionnaires (BDQs) have been developed and validated (Calfas et al. 2000; England et al. 2015). BDQs have been used, for example, to assess obesity-related dietary behaviours (Greenwood et al. 2012), the nutritional risk of chronic diseases (Rifas-Shiman et al. 2001) or diet quality (Schröder et al. 2012).

From here onwards, I focus on BDQs that concern the whole diet approach.

2.3.1 CONTENT OF BRIEF DIETARY QUESTIONNAIRES

The main purpose of BDQs is to reliably, cost-effectively and quickly estimate the respondent's usual diet quality or the quality of certain components of their diet. Dietary questionnaires are considered short or brief when they consist of less than 35 (England et al. 2015) or 50 (Calfas et al. 2000) items. BDQs can be constructed in several different ways. They can be developed to fulfil the need for a certain type of questionnaire by experts who have knowledge of that particular field (Rifas-Shiman et al. 2001). They can be compiled from questions in an existing questionnaire (Greenwood et al. 2012) or by adapting previously validated questionnaires or parts of them for a new questionnaire (Shatenstein and Payette 2015). A new approach to developing a BDQ involves supervised learning to categorise dietary patterns and identify foods that predict diet quality using the regression tree approach (CART) (Lafrenière et al. 2019). Using this method, the best indicators of low and high diet quality can be identified from a list of foods and selected for the questionnaire.

The content of a new BDQ should be directed by the aim of the study. The questionnaire items can be chosen on the basis of the consumption of the most popular foods in national surveys, identifying foods from an appropriate dietary dataset by statistical analyses or knowledge of a possible association between nutrients and health (Cade et al. 2004). The contents of BDQs can be comprised of food frequency questions with open-ended, predefined frequency categories (semi-quantitative) and of dietary quality questions. For predefined frequency categories, portion sizes or examples of portion sizes can be included, or the respondent can describe their own portion sizes (Cade et al. 2002).

The results of the BDQs can be interpreted in several different ways. The most often used method is to score the questionnaire answers on the basis of nutrition recommendations, with the sum of the scores denoting diet quality. This method is quick and easy to use and can therefore be a practical tool for screening individuals with unhealthy dietary habits and supporting dietary counselling in a health care setting.

2.3.2 ESTIMATING THE VALIDITY OF BRIEF DIETARY QUESTIONNAIRES

The validation of BDQ examines whether the questionnaire is suitable for its intended use. The validity of a BDQ can be tested by comparing it with a reference method. However, a reference method that optimally measures absolute food and nutrient intakes is not available. In nutrition studies, food records are considered the 'gold standard' and have the greatest degree of demonstrated validity among dietary assessment methods, provided that a sufficient number of days is collected (Willett 2013). In addition, the reference method should be independent of the test method. Therefore, comprehensive FFQ should not be used as the reference method because both BDQ and FFQ rely on memory. The validity of the BDQ has to be tested within the population of interest and therefore the participants of the validation study should reliably represent the main study population (Cade et al. 2002). The recommended number of participants is 100 to 200, depending on the nutrients of interest (Willet and Lenart 2013). The time periods covered by the BDQ and the reference method should overlap.

The aim of the relative validation of a BDQ is to test whether the BDQ ranks the participants according to their food and nutrient intake in a similar way to the reference method. This relative validity of BDQs can be tested using the same methods that are used when comprehensive FFQs are validated. The questionnaires are usually evaluated using correlation coefficients, weighted Kappa values, Bland Altman analyses, the *t*-test or Wilcoxon signed-rank test, classifying the same or opposite thirds and mean percentage differences from the reference method (Lombard et al. 2015). Comprehensive FFQ validity evaluation requires results from more than three statistical tests (Lombard et al. 2015). Of the methods, Spearman's rank correlation coefficients above 0.5 and weighted Kappa values above 0.4 are regarded as sufficient agreement, or if at least 50% of the participants are correctly classified in the same thirds and less than 10% are classified in the opposite thirds (Masson et al. 2003).

When a validation study is evaluated, some aspects of measurement errors of food intake have to be taken into account (Gleason et al. 2010). Measurement errors can occur within one participant or between participants. Within-participant measurement error can occur when food intake recording does not represent the true variation of the participant's diet. Therefore, the number of days needed to encompass day-to-day food consumption variation plays a key role in reliably and accurately estimating the participant's usual diet. One study showed that correlations between nutrient intakes estimated using the test and reference method were greater when one-week food records were collected twice (Willett et al. 1985). Some other within-participant measurement errors may also occur. If the participant does not succeed in accurately estimating portion sizes, their nutrient intake may be under- or overestimated. Therefore, tools such as scales or a picture booklet of portion sizes are recommended for recording habitual food intake. Agreement between FFQ and the reference method has shown to be greater when participants describe their own portion size or portion size is included in the questionnaire, compared with a questionnaire without portion sizes (Cade et al. 2004). Measurement error might also occur if participants changes their habitual dietary habits or for some reason omits to record all consumed foods. Between-participant measurement errors may occur if participants' habitual diets are not correctly estimated, which may result in an inaccurate mean dietary intake for the group (Willett 2013).

Validated BDQs that assess respondents' overall diet quality are scarce. Using the inclusion criteria of evaluating validity among healthy adults, measuring overall diet quality (more than three different components of a diet) and the questionnaire being feasible for nutrition counselling in a health care setting, eight BDQs were found (Rifas-Shiman et al. 2001; Murphy et al. 2001; Svilaas et al. 2002; Laviolle et al. 2005; Gans et al. 2006; Greenwood et al. 2012; Schröder et al. 2012; Lafrenière et al. 2019). The overview of the nine validation studies (one BDQ validated by two studies) is presented in Table 3. The methods were compared in several different ways: food and nutrient intakes calculated from BDQs were compared with the estimations from a reference method (Rifas-Shiman et al. 2001), BFQ items were scored and the sum of the score or sub-scores were compared with the reference method (Murphy et al. 2001; Svilaas et al. 2002; Laviolle et al. 2005; Gans et al. 2006; Schröder et al. 2012), questionnaire items were tested against all nutrients calculated using the reference method (Greenwood et al. 2012), and a predictive model (CART) was used to choose foods that predict diet quality (Lafrenière et al. 2019). The BDQs contained 6 to 39 food items. The number of participants varied from 44 to 1040 and the studies included both men and women, except for one study. Of the nine studies, four evaluated validity by comparing BDQs with FFQs, two studies used 24h recall, two studies used food records, and one study used dietary history. Three of the studies evaluated the validity of the BDQ against biomarkers and a reference method. Five tested validity using three or more different statistical tests. In all but one study, validity was tested using the Spearman or Pearson correlation. Correlation coefficients ranged from 0.49 to 0.73 for diet quality, from 0.03 to 0.82 for foods, from 0.28 to 0.74 for nutrients, and from 0.21 to 0.53 for biomarkers. Four studies tested the agreement between the methods. The proportion of participants who were categorized into the same class as in the reference method ranged from 0.37 to 0.88.

***Table 3**: Studies reporting brief dietary questionnaires' validation results*

Reference Tool name Country	Aim	Content	Population, age	Reference method	Results and authors' conclusions
Rifas-Shiman S et al. 2000 PrimeScreen USA	To assess nutritional risk of chronic diseases in primary care setting	25 items: 18 food or food groups (18 items), vitamins and supplements (7 items); fruit, vegetables, whole and low-fat dairy products, whole grains, fish and red meat, as well as other foods that are major contributors to the intake of saturated and trans-fat. Food and 13 nutrient intakes were calculated.	n=160 (m=69, w=91) age range 19–65 years	• 131-item FFQ • biomarkers (vitamin E, β-carotene, lutein/zeaxanthin)	Spearman correlation: • foods r=0.36-0.82; nutrients r=0.43-0.74; biomarkers r=0.33-0.43 To identify respondents who eat daily: • vegetables less than 5 portions (FFQ) vs. vegetables 3 servings (PrimeScreen): sensitivity 0.73, specificity 0.67, PPV 0.67, NPV 0.73 • SAFA 10E% or more (FFQ) vs. SAFA 10E% (PrimeScreen): sensitivity 0.81, specificity 0.66, PPV 0.66, NPV 0.80 *PrimeScreen ranks individuals reasonably well by intake of foods and nutrients.*
Murphy et al.2001 Food Behavior Checklist (FBC) USA	Nutrition education program	39 items:1. Fat/ cholesterol intake (14 items);fruit/ vegetable intake (11 items); fibre intake (1 item); dairy products (2 items); dietary quality (6 items); food security (2 items); food expenditures (2 items); salt (1 item) Each item scored and summed for each topic area.	n=100 (w=100) mean age 33 years	• three 24h recalls • biomarker serum carotenoids for 59 subjects	Spearman correlation: 22 items were correlated with 24h recalls: diet quality r=0.61, fat and cholesterol r=0.28, fruit and vegetables r=0.79, dairy items r=0.67 • with serum carotenoids: diet quality 0.32, fat and cholesterol r=0.28, fruit and vegetables r=0.48 *FBC should be limited to 22 items that show adequate validity.*
Svilaas et al.2002 Norway	To assess habitual diet in clinical use, health educational tool	15 items: milk, dairy products, grain products, fat on bread, cheese, meat on bread, fish on bread, mayonnaise on bread, meat, fish, fatty fish, fat in cooking, vegetables, fruit, snacks. Each item was scored for three diet quality or frequency categories. The sum of the scores indicates diet quality.	n=101 (m=39, w= 62) age range 28–82 years	• 7-day food records	• Food groups: reproducibility 0.93, agreement 0.73 (from 0.38 to 0.88), Kappa 0.14-0.73 Pearson correlation: • Diet quality score r= 0.73, diet quality score vs SAFA r=-0.59 *Can assess usual dietary intake. Valid for estimated dietary fat and fibre intake.*

Laviolle B et al.2005 France	Cardiovascular disease prevention	14 items: 1. SAFA intake: cheese, red meat, delicatessen, pies and pizzas, cookies, cakes and pastries, butter. 2.MUFA, n-3 and n-6 PUFA intake: fish, nuts, vegetable fats. 3. Fruit and vegetables, 3 items Summary scores were calculated for each of the categories.	n=49 (m=21, w=28) age range 47–58 years Biomarkers n=181 (m=154, w=27)	• 7-day dietary history • biomarkers (plasma folate, SAFA, n-3 fa)	Spearman correlation (same quartile %): • Fruit and vegetables vs. folate r=0.47 (37%); fruit vs vitamin C intake r=0.50 (31%); SAFA r=0.51 (37%); n-3 fa r=0.48 (39%) • Biomarkers: fruit and vegetables vs folate r=0.39 (41%); SAFA r=0.21 (30%); n-3 PUFA r=0.53 (41%) *Questionnaire is valid for dietary pattern assessment.*
Gans K et al.2006 Rapid Eating and Activity Assessment for Patients (REAP) USA	Nutrition assessment and counselling	24 items: whole grains, calcium-rich foods, fruit and vegetables, fat, saturated fat and cholesterol, sugary beverages and foods, sodium, alcoholic beverages, food shopping and preparation, special diets, food limitations, and willingness to change eating habits. REAP was scored and total scores and subscores were calculated for some nutrients	1. study n=44 students 2. study n=94 (m=40, w=54) mean age 43.2 years	1. Study • 3-day food records and HEI calculated from them 2. Study • FFQ	Correlations (1. Study, 2. Study): • Total score 0.49, - ; fat 0.55, -0.47; SAFA 0.41, -0.44; cholesterol 0.33, -0.43; sodium 0.27, -0.18; grains 0.25, -; vegetables 0.03, 0.45; fruit 0.50, 0.30; dairy 0.25, -; meat (high intake) -0.47, -. *REAP is a valid method of nutrition assessment in primary care practices.*
Greenwood et al.2012 Healthy Eating Vital Sign (HEVS) USA	To assess obesity-related dietary behaviours, screening tool for use in primary care clinics	10 items: 1. Eating out last week 2. Eating out usually Consumption of: 3. soda day before 4 soda usually 5 juice day before 6 juice usually 7 vegetables day before 8 vegetables usually 9 fruit day before 10 fruit usually Correlations between HEVS questions and food and nutrient intakes estimated from FFQ	n=60 (m=4, w=56)	• >100-item FFQ	Results are shown as: Item of HEVS, Pearson correlation, FFQ: 1. r=0.3 Fat, SAFA 1-2. r=0.3-0.4 MUFA, trans-fat, grain product 3-4. r=0.3-0.4 Fat, SAFA, MUFA, 4. r=0.3-0.4 Energy, cholesterol, sugar, trans-fats, sweets/desserts, grain products 5-6. r=0.3-0.4 Energy, SAFA, cholesterol, sugar 7-8. r= 0.3-0.4 Fibre, fibre-rich vegetables and fruit, vegetables, fruit and fruit juices 8. r=0.3-0.4 fibre-rich beans, r=-0.3 Trans-fats 9. r=0.3-0.4 fibre, fibre-rich beans, fibre-rich vegetables and fruit 9-10. r=0.4 Fruit and fruit juices Cronbach alfa 0.49 *Results support the criterion validity and internal reliability of the HEVS.*

Schröder H et al.2012 Short diet quality screener (sDQS) Spain	To assess diet quality in a primary care setting	18 items: bread, vegetables, fruit, dairy products, rice and pasta, vegetable oils (2 items), alcohol, cereals, meat, sausages, cheese, pastry, animal fat, fast food, fish, legumes, nuts. Each item was scored for three frequency categories. The sum of the scores indicated diet quality.	n=102 (m=52, w=50) mean age 58.6 (SD 12.1) years	• ten 24h recalls	Diet quality: • Pearson correlation: r=0.61 • Same tertile 48.5%, opposite tertile 3.9% • Fat, ratio of SAFA to unsaturated fat, cholesterol, trans-fat, fibre, vitamin C, folic acid, magnesium, potassium and flavonoids differ between sDQS diet quality score tertiles *Reasonably accurate assessment of food-based dietary indices and rank subjects.*
Lafrenière J et al.2019 The Brief Diet Quality Assessment Tool Canada	To assess diet quality (low or high) in a clinical setting	Processed meat, soft drinks, 2% milk, apples, onions, nuts, fruit juice, French fries, fish, hummus, whole wheat bread, pasta, broccoli, peanut butter, salad, tea and coffee CART approach identified best diet quality predictors	n=1040 (m=504, w=536) age range 18–72 years	• 136-item online FFQ from which AHEI was calculated (cut-off point 65)	Identified low diet quality: • Agreement 0.87, sensitivity 0.88, specificity 0.85, PPV 0.90, NPV 0.84, ROC curve 0.92 *The tool identified subjects with low quality diet using six items.*

n=number, m=men, w=women, FFQ=food frequency questionnaire, PPV=Positive predictive value, NPV=Negative predictive value, SAFA= saturated fatty acids, E%=proportion of energy, Kappa=Weighted Kappa coefficient, MUFA=Monounsaturated fatty acids, n-3, n-6 PUFA=Polyunsaturated fatty acids, fa= fatty acid, HEI=Healthy Eating Index, SD=standard deviation, AHEI=Alternative Healthy Eating Index

Only a few validation studies reported correlation coefficients for food groups. One study reported correlation coefficients for fish (r=0.57) and meat dishes (r=0.63) (Rifas-Shiman et al. 2001). The correlation coefficients for vegetables varied greatly, ranging from 0.03 to 0.70 (Rifas-Shiman et al. 2001; Murphy et al. 2001; Gans et al. 2006). The highest correlation coefficient was reported for carrots (Rifas-Shiman et al. 2001) and the lowest for the consumption of vegetables, estimated using one question (Gans et al. 2006). Cook et al. showed that using five different vegetable questions improved the positive predictive value of vegetable consumption estimation compared with one question only, whereas the consumption of fruit could be assessed with only one question (Cook et al. 2015). BDQs ranked consumption of fruit rather well, with correlation coefficients ranging from 0.30 to 0.65 (Rifas-Shiman et al. 2001; Murphy et al. 2001; Gans et al. 2006). Milk product correlation coefficients ranged from 0.25 to 0.71 (Rifas-Shiman et al. 2001; Murphy et al. 2001; Gans et al. 2006) and for sweet bakery products one study found a correlation coefficient of 0.48 (Rifas-Shiman et al. 2001).

One study found the nutrients' correlation coefficients between BDQ and FFQ to be 0.59 for SAFA, 0.58 for fibre, 0.71 for vitamin C, 0.58 for calcium and 0.43 for iron (Rifas-Shiman et al. 2001).

To conclude, validation studies of BDQs have varied greatly in their study designs, but have in general been scientifically justified. The main objective of BDQs is to assess respondents' overall diet quality in a health care setting, and for this, the validity of BDQs can be interpreted as reasonably good.

3 AIMS

The aim of this thesis was to examine the role that perceived work stress, recovery, and work schedule may play in workers' food and nutrient intake. In order to facilitate a reliable evaluation of workers' dietary habits, a brief food intake questionnaire (FIQ) was validated as part of the thesis.

The specific aims were as follows:

1. To ascertain the relative validity of a brief FIQ for measuring food and nutrient intake that are relevant in the prevention of chronic disease risk among workers (I)
2. To examine whether workers with differing work schedules differ in their food and nutrient intake (II)
3. To explore the associations of workers' recovery from work and sleep problems with food intake (III)
4. To study how change in work stress symptoms and night work associate with changes in nutrient intake during a two-and-a-half-year follow-up (IV)

4 METHODS

This thesis is based on data from a screening and prevention programme for chronic diseases, implemented in a Finnish airline company, in which 67% of the employees worked in shifts.

4.1 STUDY DESIGN AND PARTICIPANTS

The occupational health services of the Finnair airline company conducted a chronic disease screening and prevention programme among three fifths of the workforce during 2006 to 2008. The content of the prevention programme focused on shift work-related issues. The impact of the programme was evaluated an average of two and a half years later by the follow-up health assessment study. A detailed description and the results of the programme have been published earlier (Viitasalo et al. 2012; Viitasalo et al. 2015). A flowchart of the study depicts the data used in this thesis (Figure 3).

The programme consisted of the participants' health assessments and a discussion on the health assessment results with an occupational physician or nurse. In addition, lifestyle counselling was offered to the participants at an increased risk of T2D. The health assessment included height, weight, waist circumference and blood pressure measurements; blood tests; comprehensive questionnaires with items on work, work schedule, sleep, stress, diseases, medication, lifestyle habits; and the diabetes risk score FINDRISC (Lindström and Tuomilehto 2003). Risk of T2D was assessed using the FINDRISC score (value over 9 indicating an increased risk) and fasting plasma glucose (value from 6.1 to 6.9 mmol/l indicating increased risk) or a two-hour oral glucose tolerance test (two-hour plasma glucose value after the 75 g oral glucose load from 7.8 to 11.0 mmol/l indicating increased risk).

The participants at an increased risk of T2D based on their FINDRISC score were asked to fill in an FIQ during the baseline health assessment visit. They were also offered 1–3 face-to-face lifestyle counselling sessions with a nutritionist or diabetes nurse. The participants with impaired fasting glucose or impaired glucose tolerance were asked to fill in the FIQ during an appointment with a physician or nurse.

At baseline, 4169 workers were invited to the health assessment according to their year of birth and of these, 2312 (55%) participated in the programme. The FINDRISC score or glucose measurements showed an elevated risk of T2D among 657 participants and of these, 350 participated in additional lifestyle counselling. The participants were not invited to the follow-up study if they had T2D(n=40) or if their fasting glucose measurement (n=72) or

FINDRISC score (n=1) was missing. The eligible 2199 participants were invited to a follow-up health assessment which was identical to that at baseline except that the questionnaire was supplemented with the FIQ and the NFR from work questionnaire and some other work-related questions. Of the invited 2199 eligible participants, 1523 (69%) completed the follow-up questionnaire. Some participants were excluded from the study because they had stopped working for the company (n=172) or the FIQ they filled in was unreliable (n=7). Study II was based on the data of the participants who were working and had completed the FIQ at follow-up (n=1344) and of those who did not take part in follow-up but had completed the FIQ at baseline (n=134). Thus, the final sample of Study II consisted of 1478 participants.

Study III was based on the cross-sectional data of the participants who completed the study questionnaire at follow-up (n=1523). Of these, 179 were excluded from the study for the same reasons as those excluded from Study II. In addition, two participants were excluded due to an incomplete NFR questionnaire. The final sample of Study III consisted of 1342 participants.

Study IV was based on prospective data on the participants who completed the FIQ at baseline (the participants whose risk of T2D was elevated or who took part in the FIQ validation study) and at follow-up (n=408). The participants who no longer worked for the company were excluded from the data (n=42). The final sample of Study IV consisted of 366 participants.

Study I was a validation study of the FIQ. This sub-study was carried out during 2007 and 2008. During the participants' baseline health assessments, a subgroup was invited to take part in the validation study. They were asked to complete the FIQ during the health assessment and afterwards to record their food intake for seven consecutive days. In-flight workers were excluded from the validation study because the limited number of food options on the plane during their working days may have reduced the variability of their food intake, leading to different food choices than on their free days. However, one flight attendant was included because she had no working days during the administration of the food record. Altogether 98 men and women were invited, 89 agreed to participate and of these, 77 completed the sub-study.

All the procedures involving the research study participants were approved by the Ethics Committee of the Hospital District of Helsinki and Uusimaa. Written informed consent was obtained from all participants.

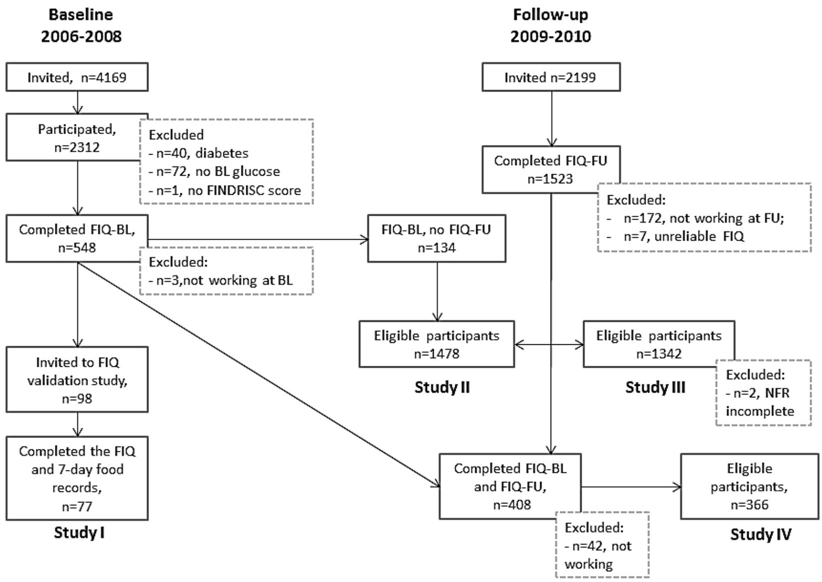

Figure 3. Flowchart of the study. FIQ=food intake questionnaire, BL=baseline, FU=follow-up, n=number, NFR=need for recovery from work questionnaire

4.2 DIETARY INTAKE ASSESSMENT

4.2.1 FOOD INTAKE QUESTIONNAIRE

Dietary intake was assessed using an FIQ that was originally developed for the DEHKO T2D prevention programme (FIN-D2D) in Finland (Saaristo et al. 2007). This FIQ asked respondents to estimate their usual consumption of certain foods and beverages. The questionnaire items were chosen on the basis of scientific evidence of a healthy diet, foods relevant to the prevention of chronic diseases, cultural eating habits, and experts' practical experience of chronic disease prevention. The purpose of the FIQ was to assess both overall quality and quality of fat and carbohydrates in the diet, because these components are regarded as important for the prevention of chronic diseases. Its content was planned by nutritionists, nurses and physicians and it was tested among FIN-D2D programme workers. The FIQ consisted of 38 questions covering 16 food groups. Frequency questions with semi-quantitative portion sizes were used for estimating the consumption of fast food, vegetables, fruit and berries, desserts (e.g. bakery items, ice cream, puddings, and chocolate) and sugar and sweets. Open-ended questions were used to estimate the number of meals and snacks, the number of main dishes (fish, sausage, poultry, meat and vegetable dishes), consumption of dairy products (classified according to fat content), cheese (classified according to fat content), bread and breakfast cereals (classified according to fibre content), cold cuts (classified according to fat content) and non-alcoholic (sugar-sweetened and non-sugar sweetened) and alcoholic beverages. Further, the quality of fat in the diet was estimated using questions on fat or cream used for cooking, spread used on bread, and type of typically consumed salad dressing. Altogether, the FIQ contained frequency questions with semi-quantitative portion sizes (5 items), open-ended numerical questions (28 items), questions on quality of fat (4 items) and a question on the number of meals and snacks typically consumed daily.

The consumption of foods was calculated by multiplying the frequency by the weight of an average serving size. The intakes of fat, saturated fat, protein, carbohydrate, sucrose, fibre, alcohol, vitamin D, vitamin C, calcium, and iron were calculated using a nutrient composition table (National Institute for Health and Welfare 2008). For the questions covering several foods (e.g. desserts), the nutrient intakes were calculated using a combination of typical foods from that category. The daily consumption of spread on bread was estimated by multiplying an average serving size of spread by the number of bread slices consumed daily, for those who reported using spread on bread. Fat used for cooking was estimated by the number of meals eaten per week. For those who reported using salad dressing, one serving was added to the calculated daily food intake.

Energy contents (kJ) for macronutrients were calculated by multiplying fat grams by 37; carbohydrate, sucrose, and protein grams by 17; and alcohol grams by 29. The energy intake from each macronutrient was divided by the total energy and multiplied by 100 in order to calculate the proportion of energy (E%) for each of the macronutrients.

4.2.2 FOOD RECORDS

The FIQ validation study participants were asked to fill in food records for seven consecutive days, starting from the following day. A nutritionist instructed the participants on how to record their consumption of foods and beverages in detail. To minimise measurement errors, the participants were given mechanical scales and a picture booklet of food portion sizes (Haapa et al. 1985) to help them estimate their portions. The completed food records were checked and the participants were asked to clarify missing or unclear information. Daily food and nutrient intakes were calculated using in-house software based on the Finnish food composition database (National Institute for Health and Welfare 2008). Intake in grams was calculated for the following groups: fish, sausage, chicken, meat and vegetable dishes, fast foods, vegetables, fruit and berries, milk products, rye bread, multigrain bread, white bread, porridge, breakfast cereals, cheeses, cold cuts, desserts, sweets, tea, coffee, soft drinks, sugar-sweetened juices, fruit juices, beer, wine, and distilled spirits. In addition, intakes of energy (kJ), fat (proportion of energy, E%), saturated fat (E%), protein (E%), carbohydrate (E%), sucrose (E%), fibre (grams), calcium (mg), vitamin D (µg), vitamin C (mg), iron (mg), and alcohol (E%) were calculated. Finally, food and nutrient intakes were calculated as a mean of the seven days.

4.3 WORK AND STRESS-RELATED VARIABLES

4.3.1 WORK SCHEDULES

Work schedules were categorized into three groups. Participants with working hours between 6:00 am and 18:00 pm were considered day workers. In-flight shift work included that of pilots and flight attendants with irregular working hours. Finally, the ground crew shift work group included all other participants (Study II). A night shift was when work was performed for at least three hours between 11:00 pm and 6:00 am (Study IV). The regularity of work shifts was assessed using the following question: Do you work a regular shift schedule? The response options were 'yes' or 'no'.

4.3.2 SLEEP AND FATIGUE

Six questions from the Nordic Sleep Questionnaire defined participants' sleep problems during the past three months (Partinen and Gislason 1995). The questions were: 'Have you had difficulties falling asleep?', 'How often do you awaken during the night?', 'Do you feel tired during the daytime?', 'Have you suffered from an irresistible tendency to fall asleep while at work?', 'How often have you awakened during the night without being able to fall asleep again?' and 'How often have you felt that your sleep is not restorative during the past three months?'. The responses had a five-scale rating (never or less than once a month to daily or almost daily). The sum of the questions' responses was used as an indicator of sleep problems (Study III). In addition, the sum of three questions was used as a covariate (Study II): 'Have you had difficulties falling asleep?', 'Do you feel tired during the daytime?' and 'How often do you awaken during the night?'.

Sleepiness was assessed using the Epworth sleepiness scale (ESS) which consists of eight questions rated on a four-point Likert type scale: 0=would never doze, 1=slight, 2=moderate, 3=high chance of dozing (Johns 1991) (Study IV).

Work-related fatigue was assessed by the statement: 'I feel exhausted from work', rated on a four-point scale: 0=not at all, 1=some, 2=rather much, 3=very much (Study IV).

Sleep apnoea was assessed by asking 'Has a physician diagnosed you with sleep apnoea?' The response options were 'yes' or 'no'.

4.3.3 STRESS, WORK ABILITY, AND RECOVERY FROM WORK

Stress level was assessed by the statement: 'A stressed person may feel strained, restless, nervous and/or distressed or they may have difficulties falling asleep. I feel this kind of stress'. The four response alternatives ranged from 'not at all' to 'very much' (Study IV).

Predicted work ability was assessed by asking: 'Do you believe that with regard to your health you could work in your current job in two years' time?' The question was rated on a three-point scale: 0=rather sure, 1=not sure, 2=hardly (Ilmarinen 2007) (Study IV).

The NFR scale was assessed using a validated 11-item questionnaire (van Veldhoven and Broersen 2003). The scale measures workers' ability to recuperate from work at the end of the working day or during free time before the next shift. The items were scored on a four-point scale (1=never, 2=sometimes, 3=often, 4=always). Higher scores indicate a greater NFR (Study III).

4.4 CLINICAL AND BACKGROUND VARIABLES

Participants' characteristics included age, education, marital status, BMI, blood test results (triglyceride, cholesterol, high-density and low-density lipoprotein), stress, physical activity, smoking, sleep, and shift work-related variables. These varied depending on the study in question.

Age was used as a continuous variable, except in Study III, in which age was categorized into three groups: under 40, 40 to 49, and over 49 years. Education was categorized into three groups: low (comprehensive school), intermediate (secondary education) or high (polytechnic or university). Marital status was categorized into living alone or living with a partner. Body mass index (BMI) was calculated by dividing weight (kg) by height (m) squared. Physical activity was assessed using four response alternatives: 'I don't exercise much during leisure time', 'I walk, cycle or do other exercise that does not cause sweating for at least 4 hours a week', 'I exercise rather strenuously for at least three hours a week', 'I train for a competition several times a week'. Sedentary lifestyle was defined when one of the first two alternatives was chosen. Smoking was categorized into two groups: smoking and not smoking (including former smokers). Occupations were categorized into maintenance, customer service, in-flight work, office work, and management.

4.5 STATISTICAL METHODS

The common statistical methods for background variables were the t-test for continuous variables, the χ^2-test for categorical variables or the Kruskal-Wallis test for non-normally distributed continuous variables, as appropriate. Differences were considered significant if $p<0.05$. Study I analyses were conducted using the SAS statistical package (SAS Institute Inc., Cary, NC, USA, version 8.2) and R version 2.13.1. In Studies II–IV the analyses were conducted using the statistics package Stata 11.2 (II) or 16.0 (III–IV).

4.5.1 FOOD INTAKE QUESTIONNAIRE VALIDATION (I)

The validation of the FIQ was conducted by comparing the respondents' FIQ answers to their food and beverage consumption in the food record. Initially, we investigated how similarly the intakes measured using two different methods ranked the respondents. We used Spearman correlation analysis to compare the food intake frequencies estimated from the FIQ with the food and beverage intakes calculated in grams in the food records.

In addition, the nutrient intakes calculated from the FIQ and food records were compared using the Spearman correlation coefficient and Weighted Kappa statistics. The agreement between the two methods was evaluated by cross-classification of the participants by nutrient intake estimates into exact and opposite tertiles and by calculating the agreement (%) between the methods.

4.5.2 MODELS FOR NUTRIENT INTAKE ESTIMATES (I)

Simple linear regression was used to model the average daily intake of fat, saturated fat, sucrose, fibre, iron, vitamin C, and vitamin D from the questionnaire responses. The modelling used nutrient intake estimates from the food records as the dependent variables and sum variables from the questionnaire and sex as the independent variable. The questionnaire items that were relevant to the intake of the nutrient in question were included in the models. Each questionnaire item was then weighted with a multiplier. The multipliers were determined in a loop in which we tested whether increasing or subtracting the multiplier of the questionnaire item by one increased the model's coefficient of determination (R^2). If R^2 increased, the multiplier was further increased/subtracted until R^2 no longer increased. The next questionnaire item was processed in the same way. This loop was worked through the questionnaire items until none of the multipliers in the model changed. When necessary, the response variable was base *e* log-transformed to improve the normality and homoscedasticity of the residuals. Back-transformation of the logarithmic values after model-fitting introduces bias into estimates. This is corrected by including the multiplicative bias correction factor exp(MSE/2) in the models, where MSE is the mean squared error (Newman 1993).

Differences between nutrient intake estimates from the food records and from the models were compared using the Spearman correlation coefficient, mean percent difference and agreement into exact and opposite tertiles. In addition, the coefficients of determination were calculated for each nutrient intake model.

4.5.3 FOOD AND NUTRIENT INTAKES AND WORK SCHEDULES (II)

Food and nutrient intake analyses of work schedule groups (day work, non-flight shift work, in-flight shift work) were stratified by sex. In addition, nutrient intake analyses were performed for two age groups, divided by mean age. The results were presented as proportions (%) or means and standard deviations.

Analysis of variance was used for continuous variables and the χ^2-test for categorical variables to evaluate the food and nutrient intake differences between the work schedule groups. The analyses were adjusted for education, stress, sleep, and participating in the lifestyle intervention offered during the programme. Age was also included in the analyses that were not age stratified. Skewed nutrient intake distributions were normalized by Box-Cox power transformation. Post hoc analyses were carried out by linear and logistic regression. For logistic regression analyses, 95% confidence intervals were calculated.

4.5.4 NEED FOR RECOVERY FROM WORK, SLEEP PROBLEMS, STRESS LEVEL AND DIETARY HABITS (III)

The NFR scale, sleep problem score or stress level differences of the sex, age and work schedule groups were assessed using analysis of variance. Pearson's correlation analyses were used to compare the NFR scale, sleep score, and stress level associations. Ordered logistic regression was performed to evaluate the association between NFR or sleep problems and eating occasions or food intake stratified by sex. In the analyses, eating occasions or food group were the dependent variables, and NFR scale, sleep problem score or stress level were the independent variables. Dependent variables were used as categorical variables in the ordered logistic regression analyses, in which the ORs denote the odds of falling into a higher consumption category by a one-point increase in the NFR score, sleep problem scale or stress level.

The analyses were adjusted for potential confounders: age (continuous variable), education (three groups), marital status (two groups), work schedule (day work vs shift work), full- vs part-time work, and occupational category (five groups). The results were presented as ORs and 95% confidence intervals for NFR and sleep problems.

4.5.5 PROSPECTIVE ASSOCIATIONS BETWEEN WORK STRESS SYMPTOMS AND NUTRIENT INTAKE (IV)

Work stressors and stress symptoms were depicted by perceived stress, work-related fatigue, work ability, sleepiness and number of night shifts. Associations between changes in work stress, work stress symptoms or number of night shifts and nutrient intake during a 2.4-year follow-up were analysed using multiple linear regression. The change from baseline to follow-up was calculated by subtracting the baseline value from the follow-up value. Work stress, work stress symptoms or number of night shifts were the independent variables, and nutrient intakes were the dependent variables in the models. The analyses were adjusted for baseline nutrient intake and participation in the lifestyle intervention. In addition, we further adjusted the analyses for potential covariates: age (continuous), education (three groups), work schedule (day vs shift work), full- vs part-time work, occupation (five groups), and marital status. The covariate work schedule was not included in the analyses of night shift work and nutrients.

We also compared the nutrient intake changes of the lifestyle intervention participants and the non-participants as well as men and women, from baseline to follow-up, using the paired student's t-test. Linear regression was used to analyse the differences between the nutrient intake of the lifestyle intervention participants and non-participants during follow-up.

5 RESULTS

5.1 PARTICIPANT CHARACTERISTICS

The characteristics of the participants are shown in Table 4. The proportion of men was higher than that of women in all the studies. The participants' mean age was the highest in Study IV (M 48.2, SD 7.0) and the lowest in Study I (M 44.2, SD 9.1) as expected. One fourth of the participants lived alone. Most of the participants had completed intermediate education. Compared with Study I participants, the study samples differed statistically significantly in terms of sex (Studies II and III), age and occupation.

Table 4. *Characteristics of study samples in Studies I–IV and differences between validation of participants in Study I and Studies II–IV.*

	Study I n=77	Study II n=1478	Study III n=1342	Study IV n=366	p^a	p^b	p^c
Men, %	68	55	55	58	0.03	0.03	0.12
Age, years (SD)	44.2 (9.1)	47.8 (8.3)	47.3 (8.4)	48.2 (7.0)	<0.001	0.002	<0.001
Married or cohabiting, %	75	75	76	75	0.95	0.85	0.97
Education, %					0.37	0.37	0.27
low	7	10	9	13			
intermediate	80	73	73	75			
high	13	17	18	12			
Sedentary lifestyle[d], %	22	17	16	30	0.25	0.20	0.16
Shift work[e], %	49	59	59	51	0.09	0.16	0.78
Occupation, %					<0.001	<0.001	0.02
maintenance	47	32	31	38			
customer service	11	7	7	9			
in-flight work	1	22	22	11			
office work	36	29	30	32			
management	5	10	10	10			
BMI (kg/m^2) (SD)	26.8 (4.1)	26.4[f] (4.4)	26.1[g] (4.2)	28.9 (4.5)	0.44	0.16	0.002

n=number; SD, standard deviation

[a]p-values for difference between t-test and χ^2-test in Study I and Study II

[b]p-values for difference between t-test and χ^2-test in Study I and Study III

[c]p-values for difference between t-test and χ^2-test in Study I and Study IV

[d]Less than 4 h weekly leisure-time physical exercise not causing sweating

[e]Including ground crew and in-flight shift workers

[f]n=1418, [g]n=1282

5.2 VALIDITY OF FOOD INTAKE QUESTIONNAIRE (I)

The Spearman correlation coefficients (r_S) of the food group intakes, assessed by the FIQ and food records, varied from 0.08 for poultry dishes to 0.74 for wine. The correlation coefficients are shown in Figure 4. Of the 16 food groups, including 26 foods and beverages, only sausage dishes, poultry dishes and fast food did not correlate significantly between the two methods. Correlation coefficients were 'good' (r at least 0.5) for the following food groups: tea (r=0.75), wine (r=0.74), milk products (r=0.68), fruit and berries (r=0.65), porridge (r=0.65), breakfast cereals (r=0.63), beer (r=0.61), rye bread (r=0.59), coffee (r=0.58), desserts (r=0.57), fish dishes (r=0.57), and fruit juices (r=0.51).

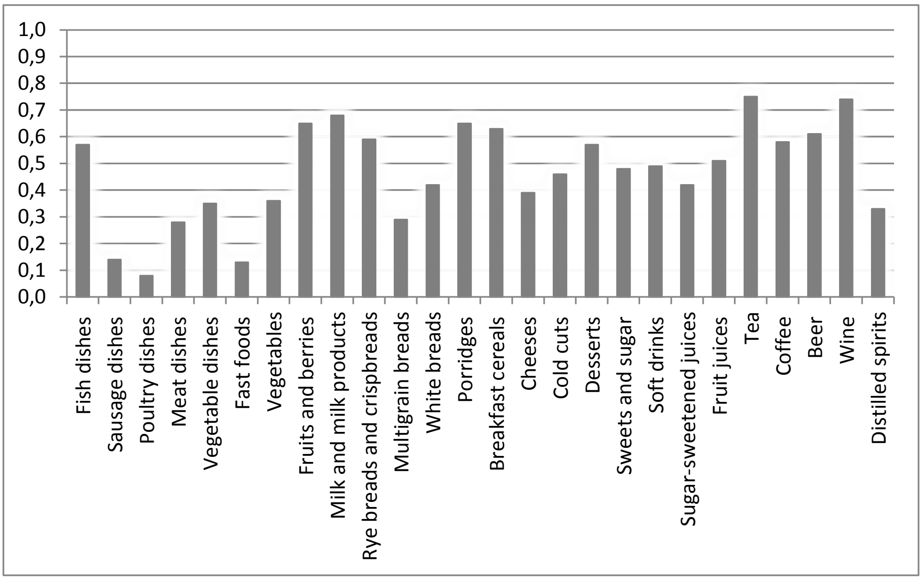

Figure 4. Spearman correlation coefficients for food groups estimated from food intake questionnaire and food records

The Spearman correlation coefficients for nutrients calculated from the FIQ and food records ranged from 0.30 for energy to 0.61 for sucrose. The correlation coefficients that exceeded 0.5 were those for carbohydrates, sucrose, fibre, alcohol, and vitamin C. Weighted Kappa values ranged from 0.15 for energy to 0.50 for alcohol. Kappa values were in agreement with the Spearman correlation coefficients but were at a lower level. Compared with food records, the FIQ classified over 50% of the participants correctly according to carbohydrates, sucrose, alcohol, vitamin C and D intakes, but misclassified 5.2% for alcohol to 15.6 % for iron intake into the opposite category. In conclusion, good validity was found for carbohydrates (E%), sucrose (E%), alcohol (E%) and vitamin C (mg) and acceptable validity was found for saturated fat (E%), fibre (g) and vitamin D, based on the results of the Spearman correlation, exact and opposite agreements, and the weighted Kappa statistics.

5.3 MODELS FOR PREDICTING NUTRIENT INTAKE (I)

Linear regression models for estimating daily nutrient intakes from the questionnaire answers were created separately for men and women for total fat (E%), saturated fat (E%), sucrose (E%), fibre (g), vitamin C (mg), iron (mg) and vitamin D (μg). Of the 38 questionnaire items, 22 had an impact on the final models. Table 5 shows the between-methods results of the statistical tests that compared the nutrient intakes calculated from food records and predicted by the models. The R^2 results ranged from 0.31 (iron) to 0.49 (fibre) and the Spearman correlation coefficient ranged from 0.47 (iron) to 0.60 (fibre). The models' mean percentage difference from the nutrient intake calculated from the food records showed good validity for fat, saturated fat, fibre and iron and poor validity for sucrose, vitamin D and C. The between-methods agreement showed that the models correctly classified the participants into the exact category ranging from 41% (sucrose) to 57% (vitamin D) and into the opposite category ranging from 3% (sucrose, vitamin C) to 9% (vitamin D, iron). The scoring of the FIQ and the models are presented in Appendix 1. In conclusion, based on the results shown in Table 5, the validity of the predicted nutrient intakes can be interpreted as good for fibre, fat, and saturated fat, and acceptable for sucrose, vitamin D, vitamin C, and iron.

***Table 5**. Summary of statistical test outcomes regarding nutrient intakes estimated from food records and predicted by linear regression models. Nutrient intakes are estimated from food records.*

						Agreement (%)				
	Mean (SD)	r_s	V[a]	Differ %	V[a]	Exact %	V[b]	Opposite %	V[b]	R^2
Fat, E%	33.6 (5.8)	0.56	3	2.1	3	48	1	4	3	0.33
Saturated fat, E%	12.6 (3.2)	0.57	3	4.5	3	46	1	4	3	0.34
Sucrose, E%	8.7 (3.8)	0.58	3	22.0	1	41	1	3	3	0.28
Fibre, g	20.5 (7.9)	0.60	3	5.3	3	55	3	8	3	0.49
Vitamin D, μg	6.1 (3.8)	0.55	3	22.3	1	57	3	9	3	0.34
Vitamin C, mg	84.4 (50.1)	0.48	2	34.2	1	47	1	3	3	0.24
Iron, mg	12.7 (3.6)	0.47	2	4.7	3	44	1	9	3	0.31

r_s, Spearman correlation coefficient; Differ %, mean percentage difference from the reference method; R^2, coefficient of determination; E%, proportion of energy;
[a]Validity: 1=poor (r_s<0.20, differ-%>20.0), 2=acceptable (r_s=0.2-0.49, differ-%=11.0-20.0), 3=good (r_s≥0.50, differ-%=0.0-10.9)
[b]Validity: 1=poor (exact <50%, opposite >10%) , 3=good (exact ≥50%, opposite ≤10%)

5.4 FOOD AND NUTRIENT INTAKES AMONG WORKERS WITH DIFFERENT WORK SCHEDULES (II)

Table 6 shows the characteristics of the participants of Study II, which varied according to work schedules. Day workers were the oldest. The participants' age range was 25 to 68 years. The ground grew shift workers' education level was lower than that of day or in-flight workers. The flight attendants' BMI and triglyceride values were lower and the high-density lipoprotein cholesterol measurements higher than among female day or shift workers.

***Table 6**. Characteristics of Study II participants (n=1478, mean (SD) or %)*

		Day work men=352 women=256	Ground grew shift work men=394 women=147	In-flight shift work men=69 women=260	p-value
Age	men	49.1 (8.7)	47.2 (8.6)	46.0 (7.5)	0.002
	women	48.5 (8.1)	46.5 (8.4)	47.4 (7.9)	0.04
Education high, %	men	23	3	22	<0.001
	women	23	14	27	0.007
Sedentary lifestyle, %	men	20	18	10	0.14
	women	21	17	10	0.001
Feeling stressed, %	men	11	9	7	0.41
	women	12	20	7	0.001
Sleep problems score	men	7.4 ((2.5)	7.9 (2.4)	7.5 (2.5)	0.02
	women	7.1 (2.4)	8.2 (2.6)	7.7 (2.3)	0.001
Shift work, years	men	1.0 (4.8)	21.7 (10.0)	20.8 (9.0)	<0.001
	women	0.4 (2.3)	18.9 (8.5)	22.4 (8.7)	<0.001
BMI (kg/m^2)	men	27.1 (3.9)	27.4 (4,1)	26.4 (3.7)	0.11
	women	26.5 (5.1)	26.5 (5.3)	23.5 (2.9)	<0.001
Triglyceride, mmol/l	men	1.5 (0.8)	1.6 (1.2)	1.4 (0.7)	0.33
	women	1.1 (0.5)	1.1 (0.6)	0.9 (0.4)	<0.001
HDL, mmol/l	men	1.34 (0.3)	1.31 (0.3)	1.40 (0.3)	0.04
	women	1.61 (0.4)	1.62 (0.4)	1.76 (0.4)	<0.001

Workers' food choices differed in the work schedule groups (Table 7). Shift working men were less likely to consume one portion or more per day of vegetables or fruit and berries (49%, 38%) than day (63%, 44%) or in-flight workers (64%, 52%) ($p<0.001$, $p=0.049$), respectively. Male and female in-flight workers less frequently chose vegetable oil-based spread on bread (57%, 54%) than day (75%, 67%) or shift workers (70%, 65%) ($p=0.007$, $p=0.009$), respectively. Older age associated with daily vegetable consumption among men (OR 1.63, 95% CI 1.22-2.18) and women (OR 1.51, 95% CI 1.02-2.26), as well as daily consumption of fruit was more common in the older age group of men (OR 1.70, 95% CI 1.27-2.27) and women (OR 1.58; CI 1.12-2.24).

Table 7. *Male and female workers' daily food consumption (alcohol per week) in work schedule groups (% or mean (SD)).*

	Regular day work	Ground grew shift work	In-flight shift work	p-value crude	p-value[a]
Men	n=352	n=394	n=69		
Vegetables daily, %	63	49	64	**<0.001**	
Fruit and berries daily, %	44	38	70	**0.049**	
Low fat milk products, dl	2.6 (3.1)	3.0 (3.1)	2.7 (2.9)	0.38	0.46
Milk products (≥2% fat), dl	0.8 (1.7)	1.2[b] (1.9)	0.8 (1.0)	**0.03**	0.13
Rye bread or crispbread, slices	3.2 (2.5)	3.4[c] (2.0)	2.6 (1.9)	**0.008**	**0.01**
Vegetable oil-based spread on bread, %	75	70	57	**0.007**	
Low fat cheese, slices	3.6 (5.9)	3.5 (5.0)	3.2 (4.7)	0.62	0.66
Sugar containing drinks, dl	1.4 (1.6)	1.5 (1.7)	1.5 (1.7)	0.56	0.55
Alcohol drinks, per week	7.9 (7.5)	7.4 (7.0)	7.6 (5.6)	0.27	0.09
Women	n=256	n=147	n=260		
Vegetables daily, %	81	76	81	0.40	
Fruit and berries daily, %	69	67	52	0.78	
Low fat milk products, dl	2.5 (2.0)	2.7 (2.6)	2.6 (2.1)	0.95	0.99
Milk products (≥2% fat), dl	0.7 (1.3)	0.9[b] (1.2)	1.0[b] (1.5)	**0.002**	**0.01**
Rye bread or crispbread, slices	2.5 (1.5)	2.5 (1.8)	2.5 (1.4)	0.55	0.35
Vegetable oil-based spread on bread, %	67	65	54	**0.009**	
Low fat cheese, slices	2.6 (2.7)	3.1 (3.2)	3.7 (6.9)	0.10	**0.04**
Sugar-containing drinks, dl	0.9 (1.3)	1.1 (1.5)	1.0 (1.2)	0.19	0.61
Alcoholic drinks, per week	3.9 (4.1)	3.6 (4.3)	4.2 (4.9)	0.17	0.28

m=men, n=women
[a]adjusted for age, education, sleep, stress, and participation in lifestyle intervention meetings
[a] $p<0.05$ compared with day work group
[b] $p<0.05$ compared with in-flight work group

Some nutrient intakes differed according to work schedule and work schedules stratified by age (Tables 8 and 9). Among men, shift workers' proportion of energy from fat (33.0 E%) was higher than that of day workers (32.5 E%) and in-flight workers (31.7 E%) (p=0.03). Similarly, saturated fat intake was higher among shift workers than among other work schedule groups (p=0.005), but the association attenuated when age, education level, sleep problems, stress, and participation in lifestyle intervention meetings were taken into account. Vitamin C intake was higher among male in-flight workers (94.4 mg) than among day (85.7 mg) or shift workers (84.6 mg), p=0.04.

Table 8. *Men's nutrient intake in work schedule groups*

Nutrient		Regular day work n=352	Ground grew shift work n=394	In-flight shift work n=69	p-value[1]
Fat, E%	All	32.5 (3.4)	33.0 (3.6)[ab]	31.7 (3.1)	**0.03**
	age<48	33.1 (3.5)	33.4 (3.8)	32.1 (3.3)	0.09
	age ≥48	32.0 (3.2)	32.5 (3.3)[b]	30.9 (2.7)	0.17
Saturated fat, E%	All	11.8 (1.7)	12.1 (2.0)[ab]	11.6 (1.8)	0.06
	age≤48	12.1 (1.9)	12.4 (2.1)[b]	11.8 (1.9)	0.11
	age >48	11.6 (1.6)	11.8 (1.7)	11.2 (1.4)	0.41
Fibre, g	All	22.1 (6.9)	21.7 (5.0)	21.3 (4.7)	0.83
	age≤48	21.1 (6.6)	21.0 (4.6)	20.3 (4.2)	0.63
	age>48	22.8 (7.1)	22.4 (5.2)	22.8 (5.2)	0.81
Sucrose, E%	All	8.4 (2.1)	8.3 (2.1)	8.3 (2.0)	0.66
	age≤48	8.4 (2.3)	8.4 (2.1)	8.5 (2.0)	0.53
	age>48	8.4 (2.0)	8.1 (2.0)	7.9 (2.0)	0.16
Vitamin D, µg	All	7.4 (4.3)	7.2 (2.6)	7.1 (2.6)	0.51
	age≤48	7.7 (6.2)	7.1 (2.1)	6.9 (2.4)	0.61
	age>48	7.3 (2.1)	7.2 (3.1)	7.4 (2.9)	0.85
Vitamin C, mg	All	85.7 (39.6)	84.6 (50.6)[b]	94.4 (47.8)[a]	**0.04**
	age≤48	82.1 (37.8)	82.1 (45.5)	95.5 (55.6)[a]	0.08
	age>48	88.3 (40.8)	87.5 (55.4)	92.6 (31.9)	0.32
Iron, mg	All	13.7 (2.1)	13.7 (1.9)	13.3 (1.6)	0.20
	age≤48	13.4 (2.2)	13.6 (1.8)[b]	13.0 (1.3)	0.06
	age>48	13.9 (2.0)	13.8 (1.9)	13.8 (2.0)	0.74

E%, proportion of energy
[1] education, age, sleep, stress, and lifestyle intervention meetings adjusted for in all analyses; education, sleep, stress, and lifestyle intervention meetings adjusted for in age group analyses
[a] p<0.05 compared with day work
[b] p<0.05 compared with in-flight work

Among women, the proportion of saturated fat intake from energy was higher among shift workers than among day workers. In addition, among older women (over 47.6 years), fat and saturated fat intakes were higher among shift and in-flight workers than among day workers (p<0.001). Among younger female in-flight workers, iron intake was higher than among day workers (p=0.02). Sucrose intake was higher among in-light workers than day workers (p=0.04), but the association attenuated when confounders were taken into account.

Table 9. *Women's nutrient intake in work schedule groups.*

Nutrient		Regular day work n=256	Ground grew shift work n=147	In-flight shift work n=260	p-value[1]
Fat, E%	All	32.8 (2.8)	33.5 (3.2)	33.1 (2.8)	0.1
	age<47.6	33.5 (2.8)	33.3 (3.0)	33.0 (2.5)	0.55
	age ≥47.6	32.3 (2.6)	33.9 (3.5) [a]	33.3 (3.2) [a]	**<0.001**
Saturated fat, E%	All	12.2 (1.5)	12.6 (1.9)[a]	12.5 (1.7)	**0.02**
	age≤47.6	12.5 (1.6)	12.5 (1.7)	12.3 (1.5)	0.87
	age >47.6	11.9 (1.4)	12.8 (2.0) [a]	12.6 (2.0) [a]	**<0.001**
Fibre, g	All	17.2 (2.7)	17.2 (3.5)	17.3 (2.7)	0.84
	age≤47.6	16.6 (2.8)	16.9 (2.6)	17.3 (2.8)	0.16
	age>47.6	17.8 (2.5)	17.6 (4.3)	17.2 (2.6)	0.32
Sucrose, E%	All	8.6 (1.9)	9.0 (2.3)	9.0 (2.0)[a]	0.17
	age≤47.6	8.9 (1.9)	9.2 (2.4)	9.2 (2.1)	0.66
	age>47.6	8.4 (1.9)	8.8 (2.0)	8.8 (1.9)	0.31
Vitamin D, µg	All	5.4 (1.6)	5.3 (1.6)	5.4 (1.6)	0.68
	age≤47.6	5.3 (1.5)	5.3 (1.5)	5.3 (1.5)	0.93
	age>47.6	5.5 (1.7)	5.3 (1.8)	5.5 (1.7)	0.64
Vitamin C, mg	All	95.8 (35.3)	95.7 (41.0)	95.5 (28.1)	0.67
	age≤47.6	97.2 (41.0)	98.7 (49.7)	96.9 (26.7)	0.70
	age>47.6	94.6 (29.7)	92.0 (27.2)	93.8 (29.7)	0.34
Iron, mg	All	10.9 (1.0)	11.0 (1.3)	11.0 (1.0)	0.08
	age≤47.6	10.7 (1.1)	10.8 (0.8)	11.0 (1.1) [a]	**0.02**
	age>47.6	11.0 (0.9)	11.2 (1.6)	11.0 (0.9)	0.97

E%, proportion of energy
[1] education, age, sleep, stress, and lifestyle intervention meetings adjusted for in all groups; education, sleep, stress, and lifestyle intervention meetings adjusted for in age group analyses
[a] p<0.05 compared with day work
[b] p<0.05 compared with in-flight work

5.5 SLEEP, RECOVERY AND STRESS FROM WORK, AND THEIR ASSOCIATION WITH WORKERS' DIETARY HABITS (III)

In Study III, men were less highly educated (men 13.6% vs women 23.2%, all education groups, p<0.001), more sedentary (18.1% vs. 14.4%, p<0.001), had a higher BMI (26.9 vs. 25.1, p<0.001), had a lower NFR score (27.8 vs. 31.1, p<0.001), and more often had sleep apnoea (5.2% vs. 1.3%, p<0.001) than women. Sleep problems did not differ between men and women (13.0 vs. 12.6, p<0.09). Rather or very much stress was reported by 9.6% of men and 11.7% of women (p-for sex difference=0.14). Men's food and beverage consumption indicated poorer dietary habits than that of women (Table 10).

***Table 10**: Food and beverages consumption among men and women (Study III)*

Food and intake	Men n=737	Women n=605	p-value
Vegetables daily, %	56.7	80.2	<0.001
Fruit and berries daily, %	42.1	68.8	<0.001
Fast food weekly, %	33.9	20.3	<0.001
Desserts daily, %	16.6	25.0	<0.001
Sweets daily, %	33.2	26.0	0.004
Grain products, portions per day, mean (SD)	3.9 (2.4)	3.1 (1.7)	<0.001
Sugary drinks, decilitres, mean (SD)	10.2 (11.6)	6.7 (9.0)	<0.001
Alcohol drinks, portions per week, mean (SD)	7.6 (7.0)	4.0 (4.5)	<0.001

The correlation coefficient of the NFR scale and sleep score was 0.57 (p<0.001), of the NFR score and stress 0.49 (p<0.001), and of the sleep score and stress 0.46 (p<0.001).

The NFR score was higher among shift-working than day-working men (M 29.3, SD ±14.4 vs. M 25.9, SD ±15.7, p=0.002) and women (M 33.7, SD±15.6 vs. M 26.9, SD ±15.1, p<0.0011). Among men, the mean sleep problem score was 12.5, SD ±4.4 among day workers, and 13.4, SD ±4.0 among shift workers (p=0.007). Among women, the mean sleep problem score was 11.8±3.8 among those in day work and 13.1, SD ±3.9 among those in shift work (p<0.001). Among men, rather or very much stress was reported by 10.2% of those in day work and 8.5% of those in shift work (p=0.14). Among women, rather or very much stress was reported by 12.0% of participants in day work and 11.6% in shift work (p=0.05).

All the following results were controlled for confounding factors (age education, marital status, work schedule, full vs part time work, and occupational category). Among men, poor recovery from work was associated with higher eating frequency (OR=1.03, 95% CI: 1.00-1.06), higher intake of fast food (OR=1.05, 95% CI: 1.02-1.08) and sweets (OR=1.05, 95% CI: 1.02-1.08), and lower intake of vegetables (OR=0.96, 95% CI: 0.93-0.98) and fruit (OR=0.96, 95% CI: 0.93-0.98). Among women, poor recovery from work associated with higher fast food (OR=1.06, 95% CI: 1.02-1.09) and dessert consumption (OR=1.04, 95% CI: 1.00-1.07) (Table 11).

__Table 11__. Association between Need for recovery from work score and dietary habits among men (n=737) and women (n=605)

		Men		Women	
		OR	95% CI	OR	95% CI
Meals and snacks	Model 1	1.02	0.99 - 1.05	1.02	0.99 - 1.04
	Model 2	1.03	1.00 - 1.06*	1.02	0.99 - 1.06
Vegetables	Model 1	0.95	0.93-.0.98***	1.00	0.97 - 1.03
	Model 2	0.96	0.93 - 0.98**	1.00	0.97 - 1.03
Fruit and berries	Model 1	0.96	0.94 - 0.99**	0.99	0.96 - 1.02
	Model 2	0.96	0.93 - 0.98**	0.99	0.96 - 1.02
Fast food	Model 1	1.03	1.01 - 1.06*	1.05	1.02 - 1.08**
	Model 2	1.05	1.02 - 1.08**	1.06	1.02 - 1.09**
Desserts	Model 1	1.01	0.98 - 1.04	1.04	1.01 - 1.07**
	Model 2	1.01	0.99 - 1.04	1.04	1.00 - 1.07*
Sweets	Model 1	1.04	1.02 - 1.07**	1.00	0.99 - 1.06
	Model 2	1.05	1.02 - 1.08***	1.03	1.00 - 1.06
Grain products	Model 1	1.00	0.98 - 1.03	1.00	0.97 - 1.03
	Model 2	0.99	0.97 - 1.02	1.00	0.97 - 1.03
Sugary drinks	Model 1	1.01	0.98 - 1.04	0.99	0.96 - 1.02
	Model 2	1.01	0.98 - 1.04	0.98	0.95 - 1.02
Alcoholic drinks	Model 1	1.00	0.97 - 1.03	1.01	0.98 - 1.04
	Model 2	1.00	0.97 - 1.03	1.01	0.98 - 1.04

Model 1, no adjustments
Model 2, adjusted for education, age, marital status, day work vs shift work, full or part time work, and occupation

***p<0.001, **p<0.01, *p<0.05

Among men and women, sleep problems were associated with higher eating frequency (men: OR=1.04, 95% CI:30 1.00-1.07, women: OR=1.06, 95% CI: 1.02-1.11) and consumption of fast food (men: OR=1.07, 95% 31 CI: 1.04-1.11, women: OR=1.06, 95% CI: 1.02-1.10) and sweets (men: OR=1.05, 95% CI: 1.01-32 1.08, women: OR=1.04, 95% CI: 1.00-1.08) (Table 12). In addition, sleep problems were associated with lower fruit and grain products and higher consumption of alcoholic drinks among men (Table 12).

***Table 12**. Association between sleep problems and dietary habits among men (n=734) and women (n=602)*

		Men		Women	
		OR	95% CI	OR	95% CI
Meals and snacks	Model 1	1.03	0.99 - 1.06	1.04	1.01 - 1.08*
	Model 2	1.04	1.00 - 1.07*	1.06	1.02 - 1.11**
Vegetables	Model 1	0.97	0.94 - 1.00	1.00	0.96 - 1.04
	Model 2	0.98	0.95 - 1.01	1.01	0.97 - 1.05
Fruit and berries	Model 1	0.96	0.93 - 0.99*	1.01	0.97 - 1.05
	Model 2	0.96	0.93 - 0.99**	1.01	0.97 - 1.05
Fast food	Model 1	1.06	1.02 - 1.09**	1.05	1.01 - 1.09*
	Model 2	1.07	1.04 - 1.11***	1.06	1.02 - 1.10**
Desserts	Model 1	1.01	0.98 - 1.05	1.03	0.99 - 1.07
	Model 2	1.01	0.98 - 1.05	1.03	0.99 - 1.07
Sweets	Model 1	1.04	1.01 - 1.08**	1.05	1.01 - 1.08*
	Model 2	1.05	1.01 - 1.08**	1.04	1.00 - 1.08*
Grain products	Model 1	0.98	0.95 - 1.01	1.00	0.96 - 1.04
	Model 2	0.97	0.93 - 1.00*	1.00	0.96 - 1.04
Sugary drinks	Model 1	1.02	0.98 - 1.05	1.01	0.97 - 1.05
	Model 2	1.02	0.98 - 1.05	1.01	0.97 - 1.05
Alcoholic drinks	Model 1	1.05	1.01 - 1.08	1.01	0.97 - 1.05
	Model 2	1.05	1.01 - 1.08	1.01	0.97 - 1.05

Model 1, no adjustments
Model 2, adjusted for education, age, marital status, day work vs shift work, full or part time work, and occupation

***p<0.001, **p<0.01, *p<0.05

Among men and women, stress was associated with higher consumption of fast food (men: OR 1.23, 95% CI 1.00-1.51, p=0.047, women: OR 1.44 95% CI 1.14-1.84, p=0.003). Among women, stress was associated with higher consumption of desserts (OR 1.30 95% CI 1.04-1.64, p=0.023) and sweets (OR 1.35 95% CI 1.08-1.68, p=0.008) (unpublished results).

5.6 ASSOCIATIONS BETWEEN CHANGES IN WORK STRESS SYMPTOMS OR NIGHT SHIFTS AND NUTRIENT INTAKES (IV)

Study IV included workers who had completed the FIQ at both baseline and follow-up, meaning that most participants were at an increased risk of T2D at baseline. In Study IV, 58% of the 366 participants were men. Shift work was common among both men (53%) and women (49%). Of the male shift workers, 44% worked night shifts and of these, 71% worked at least four nights per month. Of the female shift workers, 45% worked night shifts and of these, 37% worked at least four nights per month. Among men, the number of night shifts per month increased by 9% and among women by 19% during the follow-up. During the follow-up, 6% of men and 4% of women changed between shift work and day work schedules. Perceived stress was experienced by 53% of men and 57% of women, but only 16% of men and 7% of women felt that they would not be able to continue in their current work in two years' time. During the follow-up, 27% of men and 31% of women felt that their stress had increased. Two-thirds of the participants attended lifestyle interventions.

Among men, an increase in stress was associated with increased fat (β=0.59, CI 0.07 – 1.11, p=0.03) and saturated fat intake (β=0.31, CI 0.02–0.58, p=0.02) (Table 12). Reduced work ability associated with increased fat (β=1.31, CI 0.57–2.05, p<0.001) and saturated fat intake (β=0.52, CI 0.14–0.90, p=0.005) and a decrease in vitamin C intake (β=-9.2, CI -16.56- -1.84, p=0.03) among men. Moreover, sleepiness associated with an increase in saturated fat (β=0.07, CI 0.00–0.15, p=0.03). All the above results were controlled for confounders (age, education, work schedule, full- vs part-time work, occupation, and marital status).

Among women, an increase in night shifts associated with an increase in intake of fat (β=0.24, CI 0.00–0.47, p=0.02) and saturated fat (β=0.17, CI 0.04–0.29, p=0.02), and an increase in fatigue associated with an increase in alcohol consumption (β=7.50, CI 1.25-13.74, p=0.02) (Table 13) when confounders were controlled for.

Participants who took part in lifestyle counselling sessions changed their dietary habits during follow-up (see Appendix 2). Intake of sucrose, saturated fat, and vitamin C decreased (all p<0.01) and vitamin D, iron and alcohol (all p<0.03) intake increased. Among those who did not take part in lifestyle counselling sessions, fibre intake decreased (p=0.005). Sucrose intake decreased and alcohol intake increased among both men and women during the follow-up (all p<0.04). In addition, among men, saturated fat intake decreased (p=0.002) and among women, vitamin D intake increased, and vitamin C intake decreased (p<0.02).

Table 12. *Association between changes in work stress symptoms or number of night shifts and in nutrient intake during 2.4-year follow-up* among men (n=211) [β= regression coefficient; CI=confidence intervals].

Change in:		Feeling stressed[b]		Fatigue[b]		Work ability[b]		Epworth Sleepiness Scale[b]		Number of night shifts[b]	
		β [a]	95% CI	β [a]	95% CI	β [a]	95% CI	β [a]	95% CI	β [a]	95% CI
Sucrose, E%	Model 1 [c]	0.02	-0.32 - 0.35	0.17	-0.15 - 0.48	-0.17	-0.65 - 0.31	0.04	-0.06 - 0.13	0.04	-0.12 - 0.19
	Model 2 [d]	-0.07	-0.41 - 0.27	0.10	-0.22 - 0.42	-0.19	-0.68 - 0.30	0.04	-0.06 - 0.13	0.03	-0.12 - 0.19
Fat, E%	Model 1 [c]	0.58	0.07 - 1.08 *	0.08	-0.40 - 0.57	1.22	0.51 - 1.93 **	0.10	-0.05 - 0.24	-0.19	-0.47 - 0.08
	Model 2 [d]	0.59	0.07 - 1.11 *	0.11	-0.39 - 0.61	1.31	0.57 -2.05 ***	0.09	-0.05 - 0.24	-0.18	-0.46 – 0.10
Saturated fat, E%	Model 1 [c]	0.32	0.05 -0.58 *	0.08	-0.18 - 0.34	0.52	0.16 - 0.89 **	0.08	0.01 – 0.15 *	-0.03	-0.17 – 0.11
	Model 2 [d]	0.31	0.02 - 0.58 *	0.05	-0.22 – 0.32	0.52	0.14 – 0.90 **	0.07	0.00 – 0.15 *	-0.04	-0.18 – 0.11
Alcohol, g	Model 1 [c]	8.94	-4.93 – 22.81	4.44	-8.77 – 17.64	-3.01	-22.97 – 16.96	-0.10	-3.99 – 3.79	-0.87	-7.64 – 5.89
	Model 2 [d]	9.60	-4.90 – 24.09	3.94	-10.01 – 17.89	-5.23	-26.50 – 16.04	-0.21	-4.28 – 3.86	-1.52	-8.53 – 5.49
Fibre, g	Model 1 [c]	-0.18	-0.88- 0.53	-0.40	-1.13 – 0.34	-0.17	-1.19 – 0.86	-0.15	-0.37 – 0.07	0.16	-0.21 – 0.52
	Model 2 [d]	-0.11	-0.83 – 0.62	-0.27	-1.04 – 0.50	0.07	-1.00 – 1.15	-0.13	-0.36 – 0.10	0.26	-0.16 - 0.69
Vitamin D, µg	Model 1 [c]	-0.17	-0.48 – 0.14	0.21	-0.08 – 0.51	-0.10	-0.54 – 0.34	-0.09	-0.17 - -0.00 *	-0.14	-0.28 – 0.01
	Model 2 [d]	-0.18	-0.50 – 0.14	0.25	-0.06 – 0.57	-0.09	-0.56 – 0.38	-0.09	-0.18 - -0.00	-0.15	-0.39 - 0.10
Vitamin C, mg	Model 1 [c]	-5.03	-9.67 - -0.39 *	-3.01	-7.17 – 1.15	-8.01	-14.99 - -1.02 *	-1.32	-2.62 - -0.01 *	-1.33	-3.63 – 0.98
	Model 2 [d]	-4.63	-9.46 – 0.20	-2.88	-7.20 – 1.44	-9.20	-16.56 - -1.84 *	-1.21	-2.56 – 0.15	-2.00	-4.38 - 0.45
Fe, mg	Model 1 [c]	0.01	-0.23 – 0.23	-0.02	-0.29 – 0.24	0.29	-0.06 – 0.65	-0.04	-0.12 – 0.04	0.02	-0.11 – 0.15
	Model 2 [d]	0.05	-0.21 – 0.30	0.00	-0.28 – 0.28	0.31	-0.06 – 0.68	-0.03	-0.12 – 0.04	0.07	-0.08 - 0.21

[a] Positive slope indicates an increase and negative slope a decrease in nutrient intake when work stress symptoms have increased
[b] Change from baseline was calculated by subtracting the follow-up value from the baseline value. Change in stress levels ranged from -3 to 2, fatigue from -3 to 2, work ability from -2 to 2, Epworth Sleepiness Scale from -13 to 10, and number of night shifts from -10 to 10.
[c] Adjusted for participation in lifestyle interventions and baseline nutrient intake
[d] Further adjusted for age, education, work schedule, occupation, full- or part-time work at baseline or follow-up, and marital status
***p<0.001, **p<0.01, *p<0.05

Table 13. *Association between changes in work stress symptoms or number of night shifts and in nutrient intake during 2.4-year follow-up among women (n=155) [β= regression coefficient; CI=confidence intervals].*

Change in:		Feeling stressed[b]		Fatigue[b]		Work ability[b]		Epworth Sleepiness Scale[b]		Number of night shifts[b]	
		β [a]	95% CI	β [a]	95% CI	β [a]	95% CI	β [a]	95% CI	β [a]	95% CI
Sucrose, E%	Model 1 [c]	0.32	0.03 - 0.61 *	-0.03	-0.32 - 0.27	-0.07	-0.67 - 0.53	0.01	-0.08 - 0.10	0.06	-0.09 - 0.21
	Model 2 [d]	0.29	-0.01 - 0.60	-0.07	-0.38 - 0.23	-0.19	-0.80 - 0.43	0.01	-0.08 - 0.11	0.07	-0.08 - 0.22
Fat, E%	Model 1 [c]	-0.06	-0.53 - 0.41	-0.01	-0.48 - 0.46	0.22	-0.73 - 1.18	0.02	-0.12 - 0.17	0.21	-0.02 - 0.45
	Model 2 [d]	-0.15	-0.63 - 0.34	-0.08	-0.56 - 0.40	0.15	-0.81 - 1.12	0.02	-0.12 - 0.16	0.24	0.00 - 0.47 *
Saturated fat, E%	Model 1 [c]	0.01	-0.24 - 0.26	0.06	-0.20 - 0.31	0.05	-0.47 - 0.57	0.01	-0.07 - 0.09	0.15	0.03 - 0.28 *
	Model 2 [d]	-0.03	-0.29 - 0.23	0.03	-0.23 - 0.29	-0.00	-0.53 - 0.52	0.01	-0.07 - 0.09	0.17	0.04 - 0.29 *
Alcohol, g	Model 1 [c]	-0.62	-6.99 - 5.75	7.66	1.49 - 13.84 *	3.14	-9.31 - 15.60	1.11	-0.86 - 3.09	-1.03	-4.30 - 2.24
	Model 2 [d]	-0.73	-7.32 - 5.85	7.50	1.25 - 13.74 *	3.92	-8.61 - 16.45	0.86	-1.12 - 2.84	-1.50	-4.79 - 1.81
Fibre, g	Model 1 [c]	0.34	-0.17 - 0.84	-0.22	-0.73 - 0.30	0.86	-0.17 - 1.88	0.06	-0.09 - 0.22	-0.11	-0.37 - 0.14
	Model 2 [d]	0.28	-0.24 - 0.81	-0.25	-0.77 - 0.28	0.75	-0.28 - 1.79	0.08	-0.09 - 0.23	-0.14	-0.39 - 0.12
Vitamin D, μg	Model 1 [c]	-0.22	-0.49 - 0.05	0.04	-0.24 - 0.31	0.41	-0.14 - 0.96	0.01	-0.08 - 0.09	-0.11	-0.25 - 0.02
	Model 2 [d]	-0.20	-0.48 - 0.08	0.04	-0.24 - 0.32	0.46	-0.10 - 1.02	0.01	-0.08 - 0.09	-0.12	-0.26 - 0.02
Vitamin C, mg	Model 1 [c]	-1.34	-4.84 - 2.16	-2.76	-6.36 - 0.84	-1.32	-8.39 - 5.75	-0.48	-1.56 - 0.61	-0.77	-2.55 - 1.01
	Model 2 [d]	-1.98	-5.59- 1.62	-3.21	-6.83 - 0.41	-1.75	-8.90 - 5.40	-0.46	-1.54 - 0.62	-0.83	-2.61 – 0.95
Fe, mg	Model 1 [c]	0.14	-0.08 - 0.35	-0.03	-0.25 - 0.19	0.25	-0.18 - 0.68	0.05	-0.02 - 0.11	-0.02	-0.12 - 0.09
	Model 2 [d]	0.10	-0.12 - 0.33	-0.05	-0.27 - 0.17	0.21	-0.23 - 0.65	0.04	-0.02 - 0.11	-0.03	-0.14 - 0.08

[a] Positive slope indicates an increase and negative slope a decrease in nutrient intake when work stress symptom have increased
[b] Change from baseline was calculated by subtracting the follow-up value from the baseline value. Change in stress levels ranged from -3 to 2, fatigue from -3 to 2, work ability from -2 to 2, Epworth Sleepiness Scale from -13 to 10, and number of night shifts from -10 to 10.
[c] Adjusted for participation in lifestyle interventions and baseline nutrient intake
[d] Further adjusted for age, education, work schedule, occupation, full- or part-time work at baseline or follow-up, and marital status
*p<0.05

6 DISCUSSION

This thesis is based on data from a screening and prevention programme for chronic diseases, implemented in a Finnish airline company. The company operates around the clock and therefore two thirds of the company workers are shift workers. Shift work in the company is three times more common than in the Finnish workforce in general. Based on the findings presented in this thesis, additional stress caused by shift work and work-related factors has an impact on workers' dietary habits.

6.1 FOOD INTAKE QUESTIONNAIRE VALIDITY AND NUTRIENT INTAKE ESTIMATION USING THE MODELS

An FIQ is a practical tool for estimating diet quality in health care. The FIQ in this study was designed to assess the consumption of dietary components that have shown to influence the risk of chronic diseases as well as to evaluate overall diet quality.

The relative validity of FIQ was explored using several tests, with food records as the standard. The results showed that the FIQ reliably ranked participants according to their food and nutrient intakes. Furthermore, it seems that the participants were able to estimate their food intake with sufficient precision.

Overall, the correlations between the food groups in the FIQ and those in the food records were acceptable. Some lower correlations were found for portions of vegetables and slices of multigrain bread and cheese. The reason for this might be the participants' difficulties converting eaten food into portions according to the portion size examples in the FIQ or difficulties estimating the combined consumption of different kinds of vegetables. A review of 227 FFQ validation studies found a wide range of correlations for the dietary factors studied (Cade et al. 2004). For example, the correlations ranged from 0.16 to 0.72 (M 0.39) for vegetables and from -0.01 to 0.71 (M 0.49) for fruit (Cade et al. 2004), and the reported mean correlations are in agreement with the results of this study. Although in this study, the consumption of vegetables was evaluated using a single question, it seems that the participants were ranked as well as they were used questionnaires containing several questions on vegetables. Unexpectedly, in the present study, three food groups (sausage dishes, poultry dishes and fast food) showed a poor correlation. Detailed examination of the fast food data revealed misclassification of the Karelian pasty: the fast food category in the food database includes Karelian pasties, which are generally not considered fast food in local food culture. This may at least partly explain the discrepancy between the two methods.

Nutrient intakes were calculated from the FIQ and compared with the participants' nutrient intakes calculated from their food records. The results showed that the FIQ ranks participants according to their nutrient intakes rather well, but that intakes of energy, calcium, and iron were not consistent between the two methods. According to a Finnish national survey, the main sources of calcium at the time were milk products (men 65%, women 62%), grain, and bakery products (Paturi et al. 2008). As the present study inquired about the consumption of milk and cheese, the low correlation result for calcium was unexpected. A review article has reported mean correlations between the FFQ and the reference method of 0.47 for energy, 0.51 for fat, 0.49 for vitamin C, 0.39 for vitamin A, 0.55 for calcium and 0.45 for iron (Cade et al. 2004), indicating better consistency for calcium and iron than in our study. In general, a larger number of items in the FFQ increased the correlation but reliable estimates of only a few nutrients are possible with short FFQ or BDQ (Cade et al. 2004). The low correlation for energy intake was expected because the FIQ was not designed to estimate total energy intake and therefore some foods contributing to energy intake, such as starch-containing carbohydrates (e.g. potatoes and pasta), were not included. Somewhat unexpectedly, the correlation for carbohydrates was good, as was that for sucrose. Presumably, the correlation for carbohydrates actually measured the correlation for sucrose, because some of the main sources of carbohydrates were not included in the estimations.

The Spearman correlation coefficient was used to measure the association between the two methods. Cross-classification evaluates whether an FIQ can correctly identify low and high nutrient consumers. The present study found at least 50% agreement for the highest or lowest tertiles of carbohydrate, sucrose, alcohol, vitamin D and vitamin C intakes. Agreement between the methods has only been reported in a few BDQ validation studies: agreement for low diet quality 87% (Lafrenière et al. 2019), for diet quality in the same tertile 48.5% or in the opposite tertile 3.9% (Schröder et al. 2012), and for different food groups ranging from 38% to 88% (Svilaas et al. 2002). One comprehensive FFQ, compared with food records, classified 22% to 56% of respondents into the same third and 2% to 22% into opposite thirds among men and 35% to 78% into the same third and 0% to 30% into the opposite thirds among women (Masson et al. 2003). These results are in agreement with the present study's results and show that a BDQ can also classify individuals according to their food or nutrient intakes. In summary, a validation study requires multi-dimensional knowledge of food and nutrient databases, the design of the study, and the methods used in terms of high quality and reliable results. In this thesis, FIQ showed sufficient validity to estimate food and nutrient intakes.

The models for nutrient intake prediction based on the FIQ answers estimated the intake of fat, saturated fat, sucrose, fibre, vitamin C and D, and iron reasonably well. The method is not intended to accurately calculate nutrient intakes based on the nutrients in foods, but to predict nutrient intakes through individuals' dietary choices. For example, vegetable and fruit consumption predicted a lower saturated fat intake in the model. Presumably, the use of vegetables and fruit characterizes a person's eating habits more broadly. An eating style study showed that consumption of vegetables and fruit, breakfast eating, not eating fast food or snacking, personal estimation of high diet quality, and little emotional eating predicted lower BMI (Heerman et al. 2017). In a validation study of a BDQ, the use of soda correlated with energy, fat, SAFA, trans-fats, MUFA, cholesterol, and sugar intake, the result thus depicting a person's dietary habits more broadly than only sugar intake from sodas (Greenwood et al. 2012).

Only one study was found that used linear regression for estimating fruit, vegetable, fat, and fibre intake from a BDQ (Thompson et al. 2004). The developed regression model estimates from the BDQ were compared with 24-hour recalls, and validity was tested in four separate studies. When mean intakes were compared, the BDQ was able to predict servings of vegetables and fruit (in one study of two) and the proportion of fat from energy among men. The correlations between the models and the 24-hour recalls were 0.57 and 0.66 for servings of vegetables and fruit, 0.55 for the proportion of energy from fat and 0.54 for fibre intake. In the present study, the correlation between the models and food records for fat intake was 0.56 and for fibre 0.60, which is consistent with the study by Thompson et al.

The majority of BDQs are used to evaluate diet quality by scoring the questionnaire items, and thus, obtaining a sum score that reflects diet quality. In our method, several components of the diet can be evaluated. The FIQ estimated nutrient intakes reliably. Therefore, it can be used as a screening tool to identify people in need of dietary counselling and to facilitate and monitor the effect of dietary counselling in primary health care, as well as in research, in which group-level information on diet is needed when more laborious methods to collect food intake data are not feasible.

6.2 WORKERS' FOOD AND NUTRIENT INTAKE

In the present study, we compared two rather different shift-worker groups' dietary habits to those of day workers. One shift-work group consisted of lower educated ground crew shift workers and the other of more highly educated in-flight shift workers. These two shift-work groups diverged as regards the shift work system, shift rotation being more regular among ground crew shift workers, and the number of night shifts being greater in the in-flight workers' work schedules. In addition, according to several metabolic parameters, the female in-flight workers of the company were healthier than the female ground crew shift workers (Viitasalo et al. 2012).

In the present study, adverse food choices were more often observed among the ground crew shift or in-flight shift workers. Lower consumption of fruit and vegetables, as well as higher consumption of high-fat milk products were observed among male ground crew shift workers than among male day workers. Similarly, earlier studies have shown that rotating shift workers' food intake differs from day workers' dietary habits. Vegetable intake was lower among shift workers than among day or fixed shift workers (Morikawa et al. 2008; Li et al. 2011; Winkler et al. 2017) and fruit consumption was lower among nurses working on rotating shift schedules with night shifts than in fixed work or rotating shift work without night shifts (Han et al. 2016). One large prospective study reported that workers' longer exposure to night shift work lowered the intake of vegetables and fruit (Vimalananda et al. 2015).

The reasons for the dietary habit differences between the work schedules may be various. Shift work may increase sleep problems and short sleep duration has shown to decrease individuals' fruit and vegetable consumption (Noorwali et al. 2018). In the present study, male ground crew shift workers had more sleep problems than workers on other schedules and this might have caused the lower consumption of fruit and vegetables. On the other hand, catering services may be different at worksites, depending on the workplace or time of day. Day workers are more likely to have meals at canteens, but in the evenings and at night-time, proper meals are not always provided. In Finland, regularly having lunch at a staff cafeteria, which consists of main meal, salad bar and bread, has shown to promote healthier dietary habits (Raulio et al. 2010). In the present study, most of the day-shift workers were able to have lunch at a staff canteen, but in the evenings and nights, the options were scarce. The flight crew had meals on the plane, with bread and fruit served as snacks. Thus, the smaller supply of proper meals for ground crew shift workers may have influenced the food choices of the workers. In the present study, male ground crew shift workers' rye and crispbread consumption was higher than that of the other workers. This might indicate that packed sandwiches are substitutes for some meals because of a shortage of canteens. In a study of motor freights, meals brought to work from home predicted higher fruit and vegetable consumption (Buxton et al. 2009), showing that, depending on the workplace, eating a meal in a cafeteria is not always the healthiest option. Besides offering their workers healthy meals, employers can promote healthier dietary habits by restraining unhealthy food options. In a workplace intervention including lifestyle counselling, sugar-sweetened beverages were banned and this was associated with a reduction in workers' beverage intake as well as decreased waist circumference (Epel et al. 2019). The same study showed that rather simple changes in the work environment can lead to favourable effects on dietary habits.

Despite the in-flight workers' better metabolic health and lifestyle, some adverse food habits that can affect the quality of fat intake were also observed. Although shift workers' higher saturated fat intake has been reported earlier, (Morikawa et al. 2008; Esquirol et al. 2009), one large study found no such association (Hulsegge et al. 2016). Even though female in-flight workers had a higher saturated fat intake, which is a risk factor for CHDs, their high-density lipoprotein (HDL) cholesterol levels were higher than those of other workers. This may indicate that despite exposure to shift work, which is a risk factor for CHDs (Vyas et al. 2012), a healthy lifestyle may prevent the adverse effects of shift work on health.

In the present study, sucrose intake was higher among female in-flight workers than day workers, and saturated fat intake was higher among male ground crew shift workers than in-flight workers. These associations attenuated after controlling for confounding of age and education and even further when sleep problems and stress were controlled for. This shows that when associations between shift work and diet are investigated, factors that influence dietary intake other than shift work should be taken into account. In the present study, older age predicted a higher intake of fruit and vegetables. Differences between age groups were also seen in the national Finnish survey, showing more recommended food intakes in older age groups (Valsta et al. 2018). In the present study, the impact of education on diet quality was modest and it seems that shift work itself is a rather strong modifier of diet. Contrary to our findings, higher education level predicted better diet quality in a study of Finnish adults (Prättälä et al. 2007).

6.3 RECOVERY FROM WORK, SLEEP PROBLEMS, STRESS AND DIETARY HABITS

No earlier studies investigating the relationship between recovery from work and diet were found. Thus, as far as I am aware, this is the first time that the relationship between higher NFR scale and unhealthy dietary habits is reported. In the present study, poor recovery from work, sleep problems, and stress associated with unhealthy dietary habits, and the associations were mostly seen among men. These three indicators of stress correlated highly, suggesting that the conditions are somewhat interrelated. In a study of nurses, a high NFR scale and four different sleep-related complaints associated highly (Silva-Costa et al. 2012), showing that restorative sleep plays an important part in the process of recovery from stress after a working day.

In the present study, a close relation between NFR scale and sleep score was evident, as the associations were similar between the NFR and sleep and dietary habits such as eating occasions, fruit, fast food and sweet consumption among men and fast food consumption among women. Due to the lack of earlier studies on recovery from work and diet, and because the NFR scale correlated highly with fatigue, the results of the present study are here compared with the results of studies on the association between sleep quality and dietary habits. Katagiri et al. reported higher confectionary and sugary drink consumption among those with lower sleep quality (Katagiri et al. 2014), and in another study, restorative sleep had the opposite impact, showing a decrease in sugar-sweetened drink and sugary snack intake (Buxton et al. 2009). Consistent with previous studies, the present study showed poor recovery from work and sleep problems to be associated with an increase in sugar consumption. In a population-based study of Finnish adults, higher added sugar intake was associated with lower fibre, fruit, and vegetable consumption as well as an increase in butter consumption (Kaartinen et al. 2017), indicating that higher sugar intake may otherwise associate with poorer overall dietary habits. In our study, poor recovery from work and sleep problems were also associated with fast food consumption. Fast food has been associated with higher energy intake, higher BMI and lower diet quality (Schröder et al. 2007). In summary, the associations between sleep problems and poorer dietary habits are consistent with those in previous studies. Similarly, poor recovery from work was associated with poorer dietary habits.

According to current evidence, sleep quality and duration seem to affect the quality of dietary habits. Some biological and behavioural explanations have been explored (Frank et al. 2017). A study of nurses' eating behaviours concluded that poor sleep quality was associated with uncontrolled and emotional eating (Jesus Gazquez Linares et al. 2019). The study showed that management of stress mediated the association and better sleep predicted better ability to manage stress. In a community-based study of day workers, disinhibited eating seemed to mediate the association between poor sleep quality and higher weight (Blumfield et al. 2018). A small experimental study showed that only one night of fragmented sleep resulted in a greater desire to eat in the afternoon (Gonnissen et al. 2013). Similarly, an experimental study showed that stress influenced food intake, but only among overweight participants and those who were emotional eaters (Oliver et al. 2000; Sinha et al. 2019). These studies show that sleep quality plays a significant role in individuals' dietary behaviours and habits. However, the results suggest that the association might be stronger among those who are vulnerable to uncontrolled eating. The present study did not evaluate workers' eating behaviours and thus, no conclusions can be drawn on their effect on the results.

Behavioural mechanisms between stress and eating habits can be related to changes in hormonal secretion. In an experimental study, sleep restriction altered hormonal secretion, increasing the appetite stimulating hormone ghrelin which is associated with an increase in calorie intake through an increase in snacks (Broussard et al. 2016). When investigated in a natural setting, poor sleep quality was also reported to associate with greater ghrelin concentration (Mota et al. 2014). In addition, excessive daytime sleepiness associated with lower levels of leptin, a hormone inhibiting appetite, among shift-working women. The results regarding the association between hormones and dietary habits were not presented, but despite hormonal differences, only a few correlations between lower sleep quality and food intake were found (Mota et al. 2014). The stress hormone cortisol is another rather often investigated hormone that shows an impact on dietary habits (Adam and Epel 2007). Small-scale experimental studies have shown that cortisol increases food intake (Epel et al. 2001; George et al. 2010). Thus, cortisol may be a link between dietary habits and stress symptoms. Overall, poor recovery from work, sleep problems, and stress can have a negative impact on workers' dietary habits.

Although short sleep duration and sleep problems can predispose to unhealthy food choices, the relationship between sleep and diet can be bidirectional. A review of sleep and diet concluded that a well-balanced, healthy diet that is rich in fresh fruit, vegetables, whole grains, and low-fat protein sources may improve sleep (Peuhkuri et al. 2012). In an experimental study, diets of adults of normal weight that were low in fibre and high in saturated fat and sugar led to lighter, less restorative sleep with more arousals during sleep (St-Onge et al. 2016a). Moreover, a randomized controlled study showed that an increase in sleep duration decreased the intake of sugars (Al Khatib et al. 2018). These two studies point to a bidirectional association between sleep and sugars in diet. In our study, those who reported more sleep problems also tended to report consuming more sweets and fast food, food choices that indicate high sugar and high fat intake. These unhealthy food choices may, together with sleep problems, lead workers into a vicious circle in which sleep problems increase unhealthy food choices and unhealthy food choices worsen sleep quality.

As regards workers' long-term work ability, poor recovery from work has predicted sleep problems as well as the duration of future sickness absence (Sluiter et al. 2003). Similarly, a nationally presentative survey (Lallukka et al. 2014) found sleep disturbances to predict future sickness absence. According to the results, preventing sleep disturbances may lower the direct costs of sickness absence by up to 28%.

To conclude, insufficient recovery from work and sleep patterns should be a topic of discussion in occupational health service counselling meetings. Because sleep problems and poor recovery from work, as indicators of work-related stress, also have a negative impact on workers' dietary habits, occupational health services should incorporate dietary counselling into workplace interventions. In addition, recovery from work has shown to be successful if work demands are low, control at work is high, supervisor support and justice are high, and workers spend free time on physical and social activities (Siltaloppi et al. 2012). Diminishing the causes of work stress may also improve workers' dietary habits.

6.4 ASSOCIATION OF CHANGES IN STRESS SYMPTOMS AND NIGHT SHIFTS WITH NUTRIENT INTAKE

The present two-year follow-up study found changes in work-related stress symptoms and in number of night shifts to be associated with workers' dietary habits, shown particularly in the quality and quantity of fat intake. An increase in perceived stress and a decline in work ability was associated with an increase in fat and saturated fat intake, and during follow-up an increase in sleepiness was associated with an increase in saturated fat intake among male workers. Among women, an increase in night shifts was associated with an increase in total fat and saturated fat intake. As far as I know, prospective studies of changes in stress or stress symptoms and accompanying changes in nutrient intakes have not been previously reported. Three cross-sectional studies have shown that the higher the stress level (work stress, stress at work and at home or stress due to studies) the higher the fat intake (Hellerstedt and Jeffery 1997; Ng and Jeffery 2003; Barrington et al. 2014; Vidal et al. 2018). These studies also suggested a gender difference, showing that men were more likely to increase their fat intake if stressed (Hellerstedt and Jeffery 1997; Vidal et al. 2018). These results are consistent with present study results showing that an increase in perceived stress associates with a higher fat intake. These studies did not investigate the influence of stress on the quality of fat, but Isasi et al. found that higher perceived stress was associated with lower diet quality, higher energy and a modestly higher saturated fat intake (Isasi et al. 2015). Moreover, when work stress was included in the stress score, Isasi et al. found an association only between higher chronic stress and higher energy intake. Laitinen et al. revealed that stress-driven eaters were more likely to consume fast food and chocolate, indicating a higher fat and saturated fat intake. However, they did not assess nutrient intakes (Laitinen et al. 2002). One study showed urinary cortisol to modestly predict a higher intake of fat and saturated fat, but perceived that stress was not associated with fat intake (Laugero et al. 2011). Based on the above studies we can summarized that higher stress as well as work stress seems to be associated with higher fat intake, but association with fat quality is not established.

An increase in fat intake can be a risk factor for weight gain due to increased energy intake. Several studies have shown a link between stress and weight gain (Block et al. 2009; Mouchacca et al. 2013; Harding et al. 2014; Geiker et al. 2018; Klingberg et al. 2019). An increase in saturated fat intake, as shown in the present study, can be detrimental to health. The risk of coronary heart diseases increases when saturated fat intake increases (Mozaffarian et al. 2010) and high fat and saturated fat and low fibre diet has been reported to predispose to T2D (Lindström et al. 2006). The present study only assessed saturated fat and therefore the effect of different fatty acid categories could not be evaluated.

Chronic stress has a long-term impact on health. One study found that stress-related eating predicted poor work ability fifteen years later, showing that long-lasting and stress-related unhealthy behaviours increase the risk of poor work ability (Nevanperä et al. 2016). After young novice nurses started working three-shift work schedules, dramatic negative changes in uncontrolled and emotional eating, sleep duration, sleep onset latency, sleep quality, and stress levels were observed during the first six months (Han et al. 2019). Among these nurses, a small adaptation to strenuous work was seen after six months, but their conditions did not return to baseline level even two years after starting rotating three-shift work. This study shows that when work stress gets too high a worker can no longer recover from work before the next shift. One study showed that lowering nurses' strain by no longer doing night work or rotating shift work decreased sleepiness and insomnia symptoms, but that sleepiness or insomnia symptoms did not increase among nurses who started working nights (Thun et al. 2016). One study showed that poor sleep quality predicts uncontrolled and emotional eating and that it is partly mediated by stress (Jesus Gazquez Linares et al. 2019). The study also showed that those who slept well could manage stress better than those with poor sleep. In the present study, an increase in night shifts increased stress, which in turn seemed to affect dietary habits.

The present study participants were followed for over two years and some positive nutrient intake changes were seen among those who took part in the face-to-face lifestyle intervention one to two times. Negative changes in nutrient intake were seen in turn when workers' stress increased during follow-up. Some dietary interventions targeting shift workers have been conducted in workplaces, but results have been modest (Lassen et al. 2018). A study of firefighters observed an increase in fruit and vegetable consumption and a decrease in fat intake (Elliot et al. 2004; Elliot et al. 2007). The participants had at least 4 individual or 11 team meetings. Another study among men in the metal industry showed reduced sweetened beverage consumption following an intervention that consisted of a personal meeting and other supportive material (Morgan et al. 2011). In comparison to Morgan et al.'s study, our study had quite a low-intensity intervention, but nevertheless rather successful results. Therefore, low-intensity interventions in the workplace might also have an impact on workers' lifestyle habits. In order to support worker's healthy lifestyles, occupational health services should evaluate and follow up workers' stress levels, the causes of stress in the work environment, and lifestyle habits, and offer interventions for those workers in need.

Some successful interventions aiming to lower stress symptoms have been implemented in workplaces. Reduced working time with full-time salary reduced sleep complaints and stress in a prospective 18-month study (Schiller et al. 2017). The study also showed that increased time spent on recovery activities during free time might have lowered workers' perceived work stress and promoted their health (Schiller et al. 2018). A workplace intervention on stress management that concentrated on lowering stress reactivity prevented mental health and sleep problems in a seven-year follow-up of men (Herr et al. 2018). Another study showed that modest weight reduction and a healthy diet shortened sleep onset latency during a six-month intervention among men with insomnia symptoms (Tan et al. 2016). The above studies are good examples of employers' possible means to support workers' ability to cope with work, which may have a long-lasting effect on workers' health and work ability and hence extend working careers.

6.5 MAIN STRENGTHS AND LIMITATIONS

This thesis is based on one large cohort of airline workers. The study population differs from population-based cohorts because atypical working time applies to over half of the study participants, compared with one fifth in the general working population. It has previously been shown that psychosocial strain at work affects health. This thesis explored the associations between strain at work and lifestyle, focusing on nutrition. Studies of shift work have mainly focused on men and regular shift work schedules. Therefore, the strength of this thesis is its inclusion of both men and women, as well as diverse information on workers' stress symptoms and work-related strains.

One important aspect of interpreting the results of large cohorts is that the participation rate may introduce bias to the results if the participants are not representative of the entire target population. In this thesis, 55% of the invited workers participated in the study at baseline and of the eligible baseline participants, 61% participated in the follow-up. The participation rates are similar to those of Finnish population surveys, which have shown to decline over the past 25 years, being 51% among men and 60% among women in 2012 (Reinikainen et al. 2018). In the present study, at baseline, the characteristics of the participants and non-participants could not be compared, except for their work schedules. Only a slightly lower participation rate among in-flight workers and a higher rate among day workers in comparison to invited workers were found (Viitasalo et al. 2012). In the follow-up study, the participants were more often men, older and were day or shift workers. Female participants had a higher FINDRISK score (Viitasalo et al. 2015). The in-flight workers, particularly women, were healthier than the day or shift workers in terms of lifestyle, anthropometric measurements and metabolic parameters (Viitasalo et al. 2012). Therefore, in the present study, the healthy participant selection effect did not seem to be present at follow-up. In addition, it has been previously reported that lower socioeconomic groups participate in population health surveys less actively than higher socioeconomic groups (Reinikainen et al. 2018), contrary to the present study participants, who took part in the follow-up study regardless of education level (Viitasalo et al. 2015).

The results of this thesis are, for the most part, based on follow-up data. Therefore, it would be valuable to evaluate the impact of the discussions that the participants had with the occupational physician or a nurse as well as their participation in the lifestyle interventions, and see the changes in the workers' lifestyle habits at follow-up. The programme resulted in modest positive changes in weight only among men with an elevated risk of T2D. Therefore, the risk factors of the participants in Studies II and III did not seem to be much different to what they had been at baseline. Contrary to Studies II and III, Study IV mostly included workers with an elevated risk of T2D. In most cases, risk of T2D is caused by poor lifestyle habits (Bellou et al. 2018). Considering this, it is possible that participants in Study IV at an increased risk of T2D had poorer dietary habits and control of food intake when stressed than participants with no risk factors for T2D. Maybe because of this, we found that work stress negatively affected nutrient intake in Study IV. However, if the study population had consisted of participants without risk factors of T2D, the study results might have been attenuated.

The results presented in this thesis are based on workers in a shift work-intensive workplace and therefore should be generalized with caution, due to the differences between the proportion of shift workers in the study and in the Finnish working population. Furthermore, due to a potential healthy worker effect, only shift workers who have managed to adapt to the stressors of shift work may remain on the shift-work schedule; the others may have changed to day work (Knutsson 2004). In the present study, some of the day workers reported being shift workers in the past and this might attenuate the results between day and shift workers. For example, in this same study population, the prevalence of metabolic syndrome was higher among former male shift workers than day workers who had never worked in shifts (Puttonen et al. 2012).

Study II found differences between the age and education levels of the studied work schedule groups. As these characteristics are known to impact food intake, we adjusted the results for these variables. As shift work associates with sleep problems, the results were further adjusted for sleep problems in Study II.

In this thesis, food and nutrient intake results were based on the FIQ used and validated in the study. Individuals' food and nutrient intake assessment is prone to measurement errors. Therefore, validation was carried out in the recommended manner based on the experiences of the earlier studies and literature. Participants kept food records (reference method) for seven days, which is considered sufficient to cover intra-individual variation between days. Food recording does not rely on memory and differs from the questionnaire, which is based on the respondents' memory. This also ensures that sources of errors are independent. If food recording could be kept for two to four separate periods, it would increase reliability even more (Willett et al. 1985), but in this study this was not feasible, neither was testing the reproducibility of the FIQ. Intra-individual food intake measurement errors were prevented using dietary assessment tools, scales and a picture booklet of portion sizes, to help participants estimate portion sizes and improve the dietary assessment in terms of precision. As a result, the FIQ seems to estimate the most important food and nutrient intakes for preventing chronic disease reasonably well. The validation of the FIQ in the same study population as the actual study makes the results more generalizable to the target population. One limitation of the validation study is the exclusion of the in-flight workers from the FIQ validation study. This decision was made because during working days, in-flight workers' food options on a plane are limited and may differ from food choices made during free time. Therefore, in-flight workers' nutrient intakes in Study II should be interpreted with caution.

The occupational health services of the airline, together with the experts of the Finnish Institution of Occupational health and the Finnish Institute for Health and Welfare (former National Institute for Health and Welfare) compiled the study questionnaire and added several validated questionnaires to it. The study questionnaire aimed to evaluate many work-related stress factors. As a limitation, some of the questions were only added to the follow-up questionnaire such as the NFR and FIQ (at baseline filled in by elevated T2D risk and validation study participants) and this hindered the evaluation of the longitudinal associations of work-related factors and dietary habits in this thesis.

The results of this thesis are based on the self-administered exposure data. This might over- or under-estimate the results, depending on the respondents' ability to remember reliable answers to the questions. The participants' stress level was assessed using one question regarding the participants' feeling of general stress. The one stress question has been validated in four different study samples against several work-related psychosocial measurements (Elo et al. 2003). The stress question seemed to reflect workers' psychological symptoms and sleep disturbances and proved to be valid for stress level estimation on the group level. Therefore, conclusions regarding the associations between food intake and work stress can be drawn, even though the work stress expression was not included in the stress question (Study IV). It is possible that all relevant work-related items were not included in the questionnaire: for example, questions on work environment or long weekly working hours might also explain the associations found with dietary habits. Working long hours has shown to associate with a risk of sleep disturbances (Salo et al. 2014).

7 CONCLUSIONS AND FUTURE PERSPECTIVES

This thesis explored the associations of work-related factors such as work schedule, sleep problems, recovery from work, stress, and stress symptoms, with workers' dietary habits by sex in a shift work intensive workplace. Changes in work-related stress symptoms that predicted changes in nutrient intakes were also studied. The main findings of this thesis can be summarized as follows:

I. The relative validity of the FIQ was acceptable. Based on the FIQ answers, nutrient intake prediction models were created for men and women using food diaries as the standard. The assessed nutrients included the proportion of energy from fat, saturated fat and sucrose as well as the amount of fibre, vitamin C, iron, and vitamin D. The validity of the method was good for fibre, fat, and saturated fat, and acceptable for sucrose, vitamin C, vitamin D, and iron. The FIQ can be used as a valid tool in individual dietary counselling and for monitoring food and nutrient intake changes on the group level, but the reliability of the models should be confirmed in a representative national population.

II. Dietary habits differed between work schedule groups being better among day workers than ground grew shift or in-flight workers. The male shift workers' fruit and vegetable consumption was lower than that of the male day and in-flight workers. Older age predicted higher vegetable and fruit consumption among both men and women. Higher fat intake was found among shift-working men than among day or in-flight workers. Older shift and in-flight female workers' fat and saturated fat intakes were higher than those among day workers. These analyses controlled for potential confounders such as education, sleep and perceived stress, showing that shift work had an independent effect on nutrient intake.

III. Among men, poor recovery from work and sleep problems were associated with an increase in eating occasions, fast food, sweets, grain products, and alcohol consumption, as well as a decrease in fruit and vegetable consumption. Among women, poor recovery from work and sleep problems were associated with an increase in eating occasions, fast food, desserts, and sweet consumption. Negative effects of poor recovery from work on dietary habits have not been previously reported. In occupational health services, poor recovery from work should be considered an early sign of work stress and a subject for conversation.

IV. During an over two-year follow-up, an increase in stress and a decrease in work ability was associated with an increase in fat and saturated fat intake among men, and an increase in night shifts was associated with increased fat and saturated fat intakes among women. An increase in saturated fat due to work stress can be considered detrimental to health and may increase the risk of chronic diseases. Shift workers' risk of coronary heart diseases has been already proven, and the observed increase in saturated fat in parallel with increasing work stress may accelerate the risks of chronic disease among shift workers.

The combination of work stress, shift work, and unhealthy diet exposes workers to risks of many chronic diseases. Dietary evaluation and counselling to reduce diet-related risks should therefore be included in workers' health assessment meetings.

Work and work environments are complex entities that can affect workers' health in a variety of ways. Working life research should acknowledge these different aspects of work. Studies on work-related factors in relation to dietary habits have mostly been cross-sectional, meaning that the effects of the changes in work-related factors on dietary habits cannot be investigated.

Longitudinal studies are needed to explore the principals of working life changes that promote healthy dietary habits. If a link between work-related factors and dietary habits is discovered, the next question is, what are the prospects for changing these factors.

Concrete changes in work environments can have an effect on employees' dietary habits. It is known that eating in a good staff canteen improves workers' diet, but usually this option is only offered to day workers. By providing a healthy eating opportunity for workers with differing working schedules, the effect of an eating place on workers dietary habits could be evaluated.

This thesis shows that work stress is associated with lower quality diet. Longitudinal studies with interventions aiming to reduce work stress and improve dietary habits are needed to understand which work-related factors have the most impact on workers' wellbeing and work ability. Further research on the potential reciprocity of work stress and diet is warranted.

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APPENDICES

Appendix 1. Scoring of the food intake questionnaire items based on the linear regression models for predicting nutrient intakes, instructions [a] and an example [b] of how to calculate fat intake (E%) on the basis of questionnaire responses.

Questionnaire Items	Scoring of Different Questionnaire Items by Nutrients						
	Fat, E%	**Saturated fat, E%**	**Sucrose, E%**	**Fibre, g**	**Vitamin D, µg**	**Vitamin C, mg**	**Iron, mg**
Number of fish dishes per week					☐ × 4 = ☐		☐
Number of sausage dishes per week	☐	☐					
Butter or hard cooking margarine as main cooking fat **(a)** Yes **(b)** No	6 0 } ☐	5 0 } ☐					
Vegetable-based margarine on bread **(a)** Yes **(b)** No		−1 0 } ☐			9 0 } ☐		
Cream, low fat cream, yoghurt, *etc*. used in cooking **(a)** Yes **(b)** No		1 0 } ☐					
Consumption of fruit and berries: choose one **(a)** ≥2 portions per day **(b)** 1 portion per day **(c)** 4–6 portions a week **(d)** 1–3 portions a week **(f)** <1 portion a week or none	−16 −12 −8 −4 0 } ☐	−8 −6 −4 −2 0 } ☐	4 3 2 1 0 } ☐	4 3 2 1 0 } ☐		4 3 2 1 0 } ☐	

Questionnaire Items	Scoring of Different Questionnaire Items by Nutrients						
	Fat, E%	**Saturated fat, E%**	**Sucrose, E%**	**Fibre, g**	**Vitamin D, µg**	**Vitamin C, mg**	**Iron, mg**
Consumption of vegetables: choose one (a) 2 portions or more per day (b) 1 portion per day (c) 4–6 portions per week (d) 1–3 portions per week (f) <1 portion per week or none		−4 −3 −2 −1 0 } □		8 6 4 2 0 } □		8 6 4 2 0 } □	
Number of slices of cheese with >20% fat per day	□	□					
Number of high-fat sausages per day e.g. frankfurters (35g)	□ × 3 = □	□					
Slices of rye or crispbread per day				□ × 2 = □			□
Slices of graham- or mixed grain bread or roll per day				□			□
Decilitres of porridge per day				□			□
Decilitres of muesli or high-fibre breakfast cereals per day				□ × 2 = □			□ × 2 = □
Decilitres of milk products per day					□		
Consumption of sweet patisseries, ice-cream, chocolate: choose one **(a)** 2 portions or more per day **(b)**1 portions or more per day **(c)** 4–6 portions per week **(d)** 1–3 portions per week **(e)** <1 portion per week or none			12 9 6 3 0 } □				

Consumption of sugar, honey or sweets: choose one **(a)** 2 portions or more per day **(b)** 1 portion per day **(c)** 4–6 portions per week **(d)** 1–3 portions per week **(e)** <1 portion per week or none			16 12 8 4 0 } ☐				
Bottles (1/3 L) of soft drink with sugar per week			☐				
Glasses of sugar-sweetened juice per week			☐ × 2 = ☐				
Glasses of fruit juice per week			☐			☐	
Man Woman	−5 0 } ☐	−4 0 } ☐	−4 0 } ☐	6 0 } ☐	6 0 } ☐	−1 0 } ☐	5 0 } ☐
SUM SCORE (SC)	☐	☐	☐	☐	☐	☐	☐
MODEL	Fat E% =3 6.66 + (SC × 0.45)	Saturated fat E% = 14.35 + (SC × 0.33)	Sucrose E% = 5.58 + (SC × 0.19)	Fibre g = exp(2.22 + 0.036 × (SC) + MSE/2)	Vitamin D, μg = exp(0.88 + 0.043 × (SC) + MSE/2)	Vitamin C, mg = exp(3.62 + 0.065 × (SC) + MSE/2)	Iron, mg = exp(2.14 + 0.035 × (SC) + MSE/2)
Mean squared error, MSE				0.053	0.208	0.297	0.047
Coefficient of determination, R^2	0.33	0.34	0.28	0.49	0.34	0.24	0.31

Notes: [a] Place your answer to each question in the white box on the right side of the columns. Fill in all the boxes. If two white boxes are in the same row and column, then place the answer to the question in the first box and multiply it with the corresponding multiplier and write the points in the second box. Parenthesis means that you need to choose one of the questionnaire responses and write the corresponding points in the box on the right side of the column. Sum the points by columns and write the result in the last white box of the columns ('sum score'). [b] An example of how to estimate fat intake. Male participant's questionnaire responses are: 2 sausage dishes/ week scores 2 points; no use of butter for cooking scores 0 points; 1 portion of fruit and berries/ day scores −12 points; 6 slices of cheese/day score 6 points; no frankfurters scores 0 × 3 = 0 points; male sex −5 points. Fat sum score (SC) is 2 + 0+ (−12) + 6 + (0 × 3) + (−5) = −9, Model to estimate fat intake: 36.66 + (SC × 0.45) = 36.66 + (−9 × 0.45) = 32.6 E%. Estimated fat intake is 32.6 E%.

Appendix 2. Nutrient intake at baseline and nutrient intake change during follow-up, by sex and participation in interventions.

		All			All						All						
		(N=366)			Men (N=209)			Women (N=155)			Participants (N=262)			Non-participants (N=104)			
		Mean	SD	p-value	Mean	SD	p-value[1]	Mean	SD	p-value[1]	Mean	SD	p-value[1]	Mean	SD	p-value[1]	p-value[2]
Sucrose, E%	BL	8.7	2.2		8.4	2.0		9.1	2.4		8.7	2.2		8.7	2.2		
	change	-0.3	2.0	**0.002**	-0.3	2.0	**0.03**	-0.4	2.1	**0.02**	-0.4	2.0	**<0.001**	-0.1	2.1	0.52	0.18
Fat, E%	BL	33.0	3.3		32.7	3.4		33.3	3.2		33.0	3.3		33.0	3.4		
	change	-0.3	3.1	0.13	-0.3	3.1	0.14	-0.2	3.2	0.55	-0.3	3.0	0.07	0.0	3.3	0.98	0.25
Saturated fat, E%	BL	12.3	1.9		12.1	2.0		12.5	1.9		12.3	2.0		12.3	1.8		
	change	-2.5	1.7	**0.005**	-0.4	1.6	**0.002**	-0.1	1.7	0.41	-0.3	1.7	**0.004**	-0.1	1.6	0.47	0.28
Alcohol, g per week	BL	71.4	80.8		91.4	93.3		44.1	47.8		75.1	86.4		62.0	63.5		
	change	+9.6	63.6	**0.004**	+11.9	78.2	**0.03**	+6.4	35.0	**0.02**	+11.1	70.1	**0.01**	+5.7	42.9	0.18	0.24
Fibre, g	BL	20.0	4.9		21.6	5.3		17.8	3.3		19.8	4.8		20.4	5.2		
	change	-0.3	4.2	0.25	-0.1	4.8	0.78	-0.5	3.2	0.07	+0.04	4.4	0.90	-1.0	3.4	**0.005**	0.12
Vitamin D, µg	BL	6.3	2.1		7.1	2.1		5.3	1.5		6.4	2.2		6.1	1.6		
	change	+0.3	1.8	**0.003**	+0.2	1.9	0.07	+0.3	1.6	**0.01**	+0.3	1.9	**0.005**	+0.2	1.5	0.30	0.16
Vitamin C, mg	BL	90.0	32.6		84.9	31.7		96.8	32.7		91.1	34.5		87.1	27.3		
	change	-4.7	28.1	**0.002**	-4.0	31.0	0.06	-5.6	24.4	**0.005**	-6.2	30.0	**<0.001**	-0.8	24.7	0.74	0.24
Iron, mg	BL	12.4	1.9		13.5	1.6		11.0	1.0		12.4	1.9		12.5	1.7		
	change	+0.1	1.5	0.12	+0.1	1.7	0.24	+0.1	1.3	0.28	+0.2	1.6	**0.02**	-0.1	1.1	0.19	0.07

[1] Statistical significance for change in nutrients intake within the group

[2] Statistical significance for change in nutrient intake among lifestyle intervention participants and non-participants, analyses adjusted for baseline nutrient intake and sex