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SARJA – SER. D OSA – TOM. 1823 | MEDICA – ODONTOLOGICA | TURKU 2024

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To my family

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ABSTRACT

Sleep difficulties are common in the adult population, but very few studies have evaluated their persistence and have focused mainly on insomnia. Sleep disorders are health conditions diagnosed by the physician, whereas sleep difficulties are more a case of symptoms experienced by the patient. Especially the research data on the sleep difficulties of the working-age population are incomplete. Although it is known that lifestyle can affect sleep, some of the related information is contradictory. Limited information exists on how lifestyle impacts the persistence or course of sleep difficulties. However, a healthy lifestyle and positive changes are key to preventing sleep difficulties and related diseases. Sleep difficulties can be evaluated in several different ways but the most often used tools are easy, free of charge questionnaires.

The first goal of this study was to assess the persistence of sleep difficulties in working-age adults and the impact of lifestyle on them. The second goal was to identify how lifestyle changes affect the development of sleep difficulties. The third goal was to evaluate the reliability and validity of the Jenkins Sleep Scale in the studied sample. The research data consisted of the material of a prospective ongoing Finnish Public Sector survey based study. The number of participants in the study varied from 38,400 to 81,136. The percentage of women were between 80% to 83% and the average age of the participants were 44.7 to 52.1 years.

The follow-up study in question is still ongoing and the material for this dissertation consisted of 16 years of follow-up data. The Jenkins Sleep Scale served as a screening questionnaire for sleep difficulties, and its psychometric properties were investigated as part of the study in order to ensure the reliability of the scale.

The study shows that 60%-90% of sleep difficulties in working-age adults are persistent, with severe cases being particularly long-lasting. Lifestyle factors can affect the onset and alleviation of sleep difficulties, but established issues are hard to reverse. In addition, the Jenkins Sleep Scale is a questionnaire with robust psychometric properties, showcasing reliability in studies conducted with the working-age population. In the future focus should be on preventing the development of sleep difficulties, because recovery from them varies, and may even be unlikely.

KEYWORDS: Sleep difficulties, persistence of sleep difficulties, working-age population, lifestyle changes

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TIIVISTELMÄ

Univaikeudet ovat yleisiä aikuisväestössä, mutta vain harvoissa tutkimuksissa on arvioitu univaikeuksien pysyvyyttä ja tutkimukset ovat käsitelleet pääasiassa unettomuutta. Määritelmänä unihäiriöt ovat lääkärin diagnosoimia terveystiloja, kun taas univaikeudet ovat enemmänkin potilaan kokemia oireita. Etenkin työikäisen väestön osalta univaikeuksia koskettava tutkimustieto on puutteellista. Tiedetään, että elämäntavoilla on jonkin verran vaikutusta unihäiriöihin ja univaikeuksiin, mutta osa tiedoista on ristiriitaista. Etenkin elämäntapojen vaikutuksista univaikeuksien pysyvyyteen ja kulkuun on vain vähän aiempaa tietoa. Aiemmasta tiedetään, että terveelliset elämäntavat ja positiiviset elämäntapamuutokset ovat tärkeitä keinoja ehkäistä univaikeuksia ja niihin liittyviä sairauksia. Univaikeuksia voidaan arvioida monella eri tavalla, mutta useimmin käytettyjä ovat erilaiset kyselylomakkeet, jotka ovat helppokäyttöisiä, nopeita täyttää ja edullisia.

Tämän tutkimuksen tavoitteena oli selvittää työikäisen väestön univaikeuksien pysyvyyttä sekä elintapojen vaikutuksia univaikeuksien jatkumiseen. Toisena tavoitteena oli selvittää elämäntapamuutoksien vaikutuksia univaikeuksien kehittymiseen. Kolmantena tavoitteena oli arvioida Jenkinsin unikyselyn luotettavuutta ja validiteettia tutkitussa aineistossa. Tutkimusaineisto koostui prospektiivisen käynnissä olevan suomalaisen julkisen sektorin kyselytutkimuksen aineistosta.

Kyseinen seurantatutkimus on vielä kesken ja tämän väitöskirjan materiaali koostui yhteensä 16 vuoden seurantatiedoista. Jenkinsin unikysely toimi univaikeuksien seulontakyselynä, jonka psykometrisiä ominaisuuksia tutkittiin osana tutkimusta kyselyn luotettavuuden varmistamiseksi.

Tämän tutkimuksen tulokset osoittavat, että 60–90 % työikäisen väestön univaikeuksista on pysyviä ja niillä on pitkäaikaisvaikutuksia. Elintavat voivat vaikuttaa univaikeuksien ilmaantumiseen ja myös lievittymiseen, mikäli univaikeus on jo kehittynyt ovat vaikutusmahdollisuudet kuitenkin vähäiset. Lisäksi voidaan todeta, että Jenkinsin unikysely on psykometrisiltä ominaisuuksiltaan luotettava. Tulevaisuudessa tärkeintä olisi estää unettomuuden kehittyminen, koska siitä toipuminen on vaihtelevaa ja voi olla jopa epätodennäköistä.

AVAINSANAT: Univaikeus, työikäinen väestö, univaikeuksien pysyvyys, elintapojen muutos.

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Abbreviations

BMI	Body Mass Index
CFA	Confirmatory Factor Analysis
DIF	Differential Item Functioning
EFA	Exploratory Factor Analysis
FPS	Finnish Public Sector Study
GBTA	Group-Based Trajectory Analysis
ICSD-3	International Classification of Sleep Disorders
IRT	Item Response Theory
JSS	Jenkins Sleep Scale
MET	Metabolic Equivalent of Task
NREM	Non-Rapid Eye Movement
REM	Rapid Eye Movement
RMSEA	Root Mean Square Error of Approximation

List of Original Publications

This dissertation is based on the following original publications, which are referred to in the text by their Roman numerals:

I Juhola J, Arokoski JPA, Ervasti J, Kivimäki M, Vahtera J, Myllyntausta S, Saltychev M. Internal consistency and factor structure of Jenkins Sleep Scale: cross-sectional cohort study among 80 000 adults. *BMJ Open*. 2021 Jan 18;11(1):e043276. doi: 10.1136/bmjopen-2020-043276. PMID: 33462100; PMCID: PMC7813292.

II Saltychev M, Juhola J, Ervasti J, Kivimäki M, Pentti J, Myllyntausta S, Vahtera J. Association of changes in lifestyle with changes in sleep difficulties: an analysis of 38 400 participants over a 16-year follow-up. *BMJ Open*. 2021 Oct 18;11(10):e050046. doi: 10.1136/bmjopen-2021-050046. PMID: 34663659; PMCID: PMC8524278.

III Saltychev M, Juhola J, Arokoski J, Ervasti J, Kivimäki M, Pentti J, Stenholm S, Myllyntausta S, Vahtera J. Persistence of sleep difficulties for over 16 years amongst 66,948 working-aged adults. *PLoS One*. 2021 Nov 18;16(11):e0259500. doi: 10.1371/journal.pone.0259500. PMID: 34793496; PMCID: PMC8601511.

IV Juhola J, Arokoski JPA, Ervasti J, Kivimäki M, Vahtera J, Myllyntausta S, Saltychev M. Sex-related differential item functioning of the Jenkins Sleep Scale: a cross-sectional study among 77 967 employees in the Finnish public sector. *BMJ Open*. 2024 Mar 8;14(3):e074867. doi: 10.1136/bmjopen-2023-074867. PMID: 38458793; PMCID: PMC10928794.

1 Introduction

Mild sleep difficulties are common in the general working-age population.[1 2] However, their prevalence, severity and developmental trajectories are poorly known.[1 3] Although these conditions may be mild, they can have a great impact on the individual, social and societal level.[1] Evidence of the roles of the different factors that may affect changes in sleep behaviour over a long period of time is limited. It has been suggested that sex[1], age[4] and overweight[5] might affect sleep patterns in the working-age general population. Especially at the individual level, the effects may also worsen various diseases and increase mortality.[6] Sleep difficulties include problems in falling or staying asleep, or falling back asleep after waking up.[7] Information is also scarce on the persistence of sleep difficulties in the working-age population and most previous studies have dealt with children and the elderly. What is known is that many sleep disorders are long-term, and insomnia, for example, can continue from childhood to adulthood. Sleep difficulties among the elderly are also often long-lasting.

It is important to distinguish sleep disorders from sleep difficulties. Sleep disorders are more severe health conditions diagnosed by the physician, such as sleep disordered breathing, narcolepsy and parasomnias.[7 8] Whereas sleep difficulties are more a case of symptoms experienced by the patient.[7 8] As the symptoms of most sleep disorders include sleep difficulties, the two terms overlap somewhat.

This thesis aimed to investigate the persistence of sleep difficulties and the effects of some lifestyle habits on these difficulties in the working-age population over a 16-year follow-up. The research data consisted of material collected in the survey based prospective ongoing Finnish Public Sector Study (FPS), which is a national-wide study of employees of the municipal and welfare public sector. The results may improve the recognition, assessment, prevention, and management of sleep difficulties in general working age population.

2 Review of the Literature

2.1 Sleep physiology

2.1.1 Sleep in general

Sleep is a cornerstone of life and health.[9] The need for sleep and the duration of sleep are individual.[10] Since 1985 mean sleep duration in the general population has been decreasing. [6 9] In some countries, such as in Australia, Finland, Sweden, the UK, and the USA, the amount of sleep has on contrary increased.[6] Lack of sleep has both long-term and short-term effects on daily brain functioning, cognitive and neurobehavioral performance, memory, mood, and pain perception.[9] Sleep difficulties may affect the metabolism, appetite regulation, immune functioning, and the functioning of cardiovascular and hormone systems.[9] In addition, shorter sleep duration has been linked to a higher risk of mortality, diabetes, cancer, depression, obesity, cardiovascular diseases, and cerebrovascular diseases.[9]

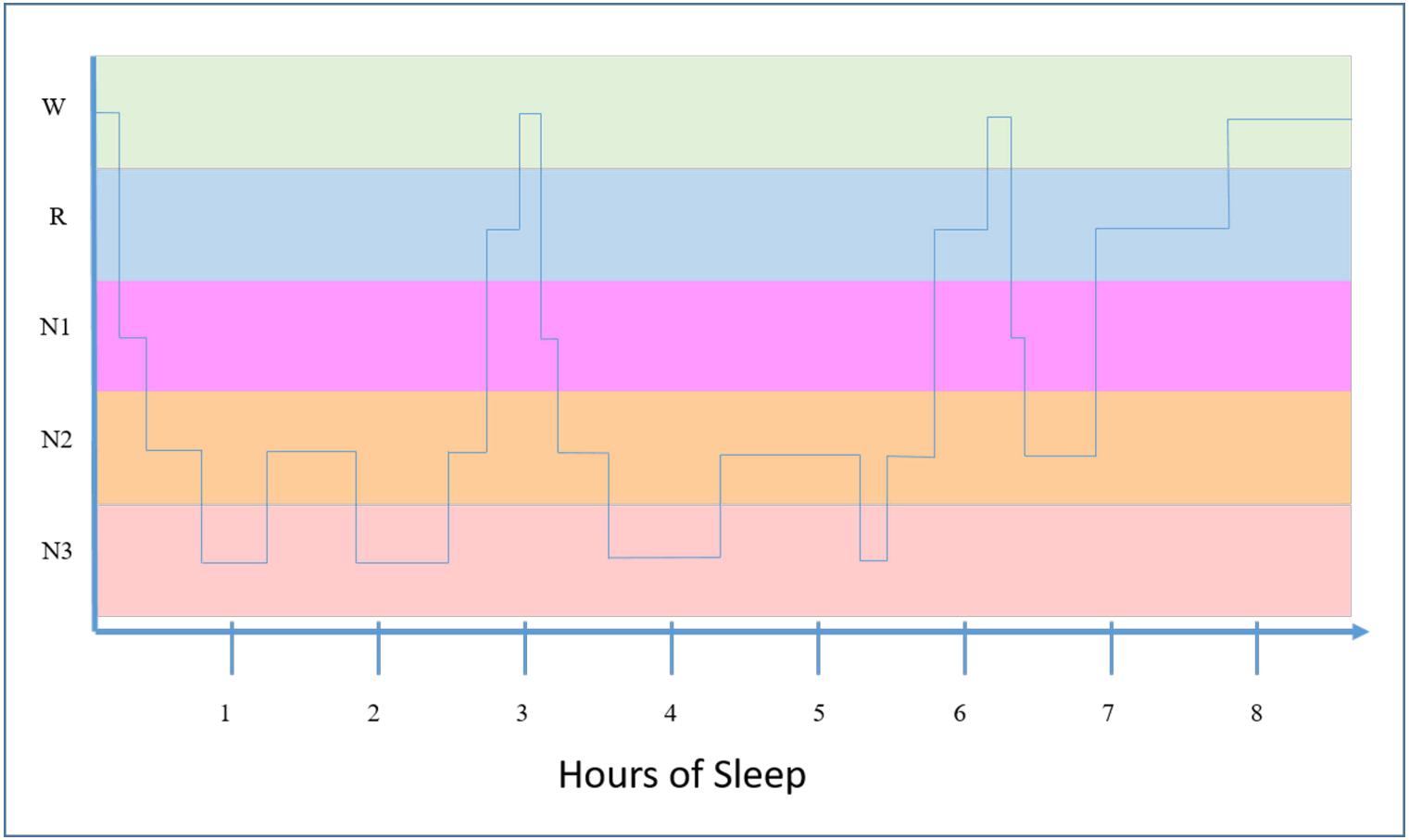
Sleep and wake periods are regulated by the circadian rhythm and neural networks.[11-14] Falling and staying asleep require optimal functioning of the suppressive functions of the ascending arousal system.[11 13 14] The levels of adenosine in particular must increase for the awake phase to progress to the sleep phase and this happens through the activation of the inhibitory neurons of the ventrolateral pre-optic area, which is also known as “the sleep switch”.[11 13]

Intrinsic biological clocks, also called circadian clocks, follow the rhythms regulated by intrinsic physiological oscillations, which have a cycle of about 24 hours.[11-14] The normal circadian rhythm of humans is a little over 24 hours, but environmental factors, for example, can synchronize this to 24 hours.[13-15] The factor with the most influence on the circadian rhythm is the amount of light and darkness.[12-15] Light sends electrical impulses to the brain via the retina to indicate it is daytime, and when darkness is transmitted throughout the retina, the secretion of melatonin from the pineal gland increases, reaching its highest levels in the early morning.[11 13 14] For example blind people suffer sleep difficulties more frequently.[16] The levels of cortisol, which is a stimulatory hormone also rise in the morning.[11 12 17] Behavioural factors, eating, drinking, body temperature, and hormone secretion are influenced by the circadian rhythm, and vice versa.[11 13 14]

2.1.2 Sleep architecture of adults

Normal sleep is a cyclical process, also known as sleep architecture (Figure 1), in which one cycle comprises three stages of non-rapid eye movement (NREM) sleep and one stage of rapid eye movement (REM) sleep.[11-14] The literature claims that good sleep consists of four to five of these sleep cycles, each lasting about 90 minutes.[11 13 14] NREM sleep can be divided into three stages. During NREM and REM sleep, the sleep varies from light to deep.[11-14] All these stages play their own role in repairing the body and maintaining the cognitive functions of the brain.[11 13 14]

NREM sleep stage 1 makes up approximately 5% of a full night sleep and begins when the eyes close.[11 17] Sleep is light and arousal is easy.[11 13 14] NREM sleep stage 2 makes up about 50% of a night sleep and an electroencephalogram (EEG) typically shows sleep spindles and *k* complexes.[11] The k complex is a phenomenon related to awakening, while during the sleep spindle, the flow of sensory information from the periphery to the cortex is blocked in the thalamus.[18 19] The sleep spindle is therefore considered to be a phenomenon that deepens sleep.[18 19] Sleep spindles occur in N2 and N3 sleep stages and the k complex is an N2 specific phenomenon.[18 19] NREM sleep stage 3 normally makes up 20 to 25% of a night sleep and this stage is also known as the deep sleep stage.[11 17] Among the elderly, the amount of deep sleep decreases.[11 20] EEGs have shown that high-amplitude slow waves predominate during deep sleep, especially in the first half of the night.[11] Normally, it is hard to awaken a person from deep sleep, and most repairment work and strengthening of the immune system happens during this stage.[11 13 14] NREM sleep stage 3 is followed by REM sleep, which is characterized by rapid eye movements and skeletal muscle atonia.[11 13 14] REM sleep makes up about 20% of a night sleep and is common during the second half of a night sleep.[11 17] These stages last longer as the night progresses.[11] It is believed that memory consolidation takes place and people have dreams during REM sleep.[11 21] Heart and respiratory rates might be faster and more irregular during this period of sleep.[11 14]



W = wake, R = Rapid Eye Movement (REM) sleep, N1 = Non-Rapid Eye Movement (NREM) sleep stage 1, = Non-Rapid Eye Movement (NREM) sleep stage 2, N3 = Non-Rapid Eye Movement (NREM) sleep stage 3

Figure 1. Own drawing = Schematic hypnogram presenting normal adult sleep.

2.1.3 Sleep quality

Sleep quality is an independent factor that affects physical and mental health, wellness and overall vitality.[22]Although, the term *sleep quality* is widely used, there is no consensus on its definition. One definition was suggested by Ohayon et al.[22] after The National Sleep Foundation of the USA set up an 18-member specialist panel to evaluate the appropriate sleep quality and duration for different ages.[22 23] The panel did not succeed in creating clear guidelines on how to define the quality of sleep and recommended further research, especially on the influence of sleep architecture and naps on sleep quality.[22] Sleep continuity, sleep latency, awakenings for longer than five minutes, waking up, and sleep efficiency have been the common topics of the studies on sleep quality.[22] In addition, sleep architecture, like REM and the NREM stages and the effects of naps were studied, to determine whether these indicated good sleep quality or not.[22] However, studying the quality of sleep requires both objective and subjective assessment.[24] In a large group of healthy volunteers (N=246), an objective EEG study was combined with a subjective survey and it could be shown that the objective assessment and the subjective assessment are connected to each other.[24] Similar results have also been obtained in other studies. [25] [26] On the other hand, The Sleep Heart Health Study, which is based on data from a multicenter study consisting of sleep study data from more than 5,000 adults, has presented opposite conclusions in its cross-sectional study.[27] In that case, polysomnography has not been correlated in all situations with the subjective assessment of sleep quality.[27] For example, obstructive sleep apnoea in COPD patients does not seem to significantly affect the subjective quality of sleep.[28] In conclusion, the term sleep quality can be seen as a collection of different objective and subjective measures that include total sleep time, sleep onset latency, sleep maintenance, total wake time, sleep efficiency, and sleep disruptive events.[29]

2.1.4 Sleep duration

According to recommendations appropriate sleep duration varies from 7 to 9 hours for adults.[6 23] It is suggested that individuals whose sleep durations considerably deviate from the norm might have intentional sleep restrictions, but also serious health problems.[6 23] However, the results of cohort and population studies on the topic might be affected by the fact that they do not normally separate time in bed and actual sleep time, and therefore sleep duration is typically less than that shown in the data.[23] It should be noted that many studies have set the cut-offs for long and short sleep differently.[6] For adults, short sleep duration is usually defined as less than seven hours of sleep [30-32] and long duration sleep as more than nine hours[32 33]. The aforementioned panel of American National Sleep Foundation has suggested that additional research is needed to evaluate sleep duration.[23]

2.2 Definition of term “sleep difficulties”

The literature uses several comparable terms for *sleep difficulties*, such as *poor sleep, complaints about sleep, insomnia symptoms, sleep disturbances, and sleep problems*.[29 34-39] The term *insomnia* is also used differently in the literature. Some studies have used the term *insomnia* synonymously with *sleep difficulties* and *insomnia symptoms*, whereas in other studies the term *insomnia* only refers to symptoms that meet the formal diagnostic criteria of insomnia disorder.[34-39] The term *sleep disturbances* is also used in the literature to describe *sleep disorders*.[40] The diagnosis of insomnia usually requires the presence of also daytime symptoms.[41] This thesis uses the term *sleep difficulties* when dealing with sleep symptoms that are milder than insomnia. The terms *insomnia symptoms* and *poor sleep* have been defined in some studies as initial, middle or late insomnia that occurs on at least three nights a week but does not meet the diagnostic criteria for an insomnia disorder.[35 42-44] People in this group are able to sleep satisfactorily, do not have distress or daytime problems and symptoms do not continue for more than a month.[35 42-44] The following complaints have also been used in surveys to define the term *poor sleep* and *insomnia symptoms*: *difficulty falling asleep, difficulty staying asleep, early morning awakening* or *unrefreshing sleep*.[37 39 44] In some studies, the term *sleep difficulties* has covered the same complaints expressed by the participants as *poor sleep* and *insomnia symptoms*.[7 45] Sleep difficulties are thus rather symptoms or difficulties related to sleep perceived by the patient: for example, shortened sleep duration, difficulties in falling asleep or maintaining sleep.[7 46-51]

Sleep difficulties often start with a life change.[10] In short-term or transient insomnia, symptoms typically manifest, but if the condition persists, it can also lead to alterations in the brain's regulation of the sleep-wake rhythm.[10] However, if they persist, they can become more difficult and can develop into an *insomnia disorder*. If they continue as mild, they are called *sleep difficulties* or *insomnia symptoms*.[52]

The state of alertness is a significant regulator of the balance between sleep and wakefulness.[52] When it increases too much, it can form an obstacle to sleep.[52] The state of alertness can be increased by excessive mental or physical activity late in the evening, problems coming to mind at night, anxiety, or worry about sleep or disruption of the sleep–wake rhythm.[52] Coffee and caffeine have also been found to delay the onset of sleep and make it more superficial, especially in people who are sensitive to distractions affecting sleep, the findings were presented in an extensive systematic review article covering a total of 58 different articles.[53]

Sleep difficulties are sometimes described using a three-step scale: mild, moderate and severe, divided into different categories.[39] Other studies have used the number of nights with sleep difficulties per week. The Jenkins Sleep Scale (JSS) describes the number of nights with sleep difficulties over the last month.[7] The respondent evaluates the extent of their sleep difficulties in each question on a scale

of 0 to 5 points, in which composite score less than 12 points means few sleep difficulties and more than 11 represents the great amount of sleep difficulties.[54]

2.3 International Classification of Sleep Disorders

Sleep disorders are a group of sleep-related diagnoses categorized into seven different groups by the American Academy of Sleep Medicine's Board of Directors[8], which were published in the 2014 International Classification of Sleep Disorders.[8] This classification is shown table 1.

Insomnia

The term *insomnia syndrome* is comparable to the term *insomnia disorder*.[35 42 55] The diagnosis of insomnia syndrome requires that all the diagnostic criteria for insomnia are met, i.e. dissatisfaction with sleep patterns and symptoms of *initial insomnia*, sleep onset latency of more than 30 minutes; *middle insomnia*, with time awake of more than 30 minutes after sleep onset; or *late insomnia*, with waking up in the morning more than 30 minutes before the planned wake-up time.[35 42 55] The symptoms must occur on at least three nights a week for at least a month, cause significant psychological distress or a decrease in daytime functioning, and be combined with sleep difficulties.[35 42 55] Based on the diagnostic criteria, insomnia disorder is also associated with daytime symptoms, such as impaired functioning.[10]

Sleep-related breathing disorders

The four types of sleep-related breathing disorders are: obstructive sleep apnoea, central sleep apnoea syndromes, sleep-related hypoventilation disorders, and sleep-related hypoxemia disorder. These also have several subtypes.[8]

Central disorders of hypersomnolence

Central disorders of hypersomnolence are sleep disorders of which the common factor is a daily need or irresistible need for daytime sleep.[8] Narcolepsy[56], idiopathic hypersomnia[8], hypersomnolence disorder[56], Kleine–Levin syndrome, and hypersomnia associated with other diseases and psychiatric diseases[57 58] belong to this group.

Circadian rhythm sleep–wake disorders

Circadian rhythm sleep disorders can be divided into intrinsic and extrinsic disorders.[59] Extrinsic disorders include jet lag disorder and shift work disorder.[15]

Parasomnias

Parasomnias are unusual behaviour caused by or related to sleep.[60] They are divided into three groups: NREM-related parasomnias, REM-related parasomnias and other parasomnias.[8]

Sleep-related movement disorders

Common to the sleep disorders of this group are movement disorders during sleep, for example, restless leg syndrome, periodic limb movement disorder, sleep-related leg cramps, sleep-related bruxism, sleep-related rhythmic movement disorder, benign sleep myoclonus of infancy, propriospinal myoclonus of sleep onset, sleep-related movement disorder due to a medical disorder, sleep-related movement disorder due to a medication or substance, and unspecified sleep-related movement disorder.[8]

Other sleep disorders

Other sleep problems that do not belong to the above mentioned groups.[8]

Table 1. Classification of sleep disorders and subtypes of sleep disorders.

Sleep disorder	Subtype
Insomnia	
	Initial insomnia
	Middle insomnia
	Late insomnia
Sleep related breathing disorder	
	Obstructive sleep apnoea
	Central sleep apnoea syndromes
	Sleep related hypoventilation disorders
	Sleep related hypoxemia disorders
Central disorders of hypersomnolence	
	Narcolepsy
	Idiopathic hypersomnia
	Hypersomnolence disorder
	Leine-Levin syndrome
	Hypersomnia associated with other diseases and psychiatric disease
Circadian rhythm sleep-wake disorders	
	Intrinsic disorders
	Extrinsic disorders: Jet lag and shift work disorder
Parasomnias	
	NREM- related parasomnias
	REM-related parasomnias
	Other parasomnias
Sleep related movement disorders	
	Restless leg syndrome
	Periodic limb movement disorder
	Sleep-related leg cramps
	Sleep-related bruxism
	Sleep-related rhythmic movement disorder
	Benign sleep myoclonus of infancy
	propriospinal myoclonus of sleep onset
	Sleep-related movement disorder due to a medical disorder
	Sleep-related movement disorder due to a medication or substance
	Unspecified sleep-related movement disorder
Other sleep disorders	
	Sleep problems that not belong any other groups

2.4 Sleep and general health

Interest in the effects of sleep disorders on general health has increased in recent years.[61] Li et al., in their extensive review of 69 meta-analyses combined cohort size over 25 million participants, and da Silva et al., in their systematic review and meta-analysis of over 77,000 participants, have demonstrated that both short and long self-reported sleep durations in surveys are associated with various diseases and increased mortality.[6 61] A cross-sectional survey based study of 823 person aged 55-75 living in Finland found that sleep problems are also linked to a reduced quality of life.[62]

2.4.1 Cardiovascular diseases, metabolic syndrome and sleep

The prevalence of obesity has increased worldwide to become a global epidemic.[63]

In cross-sectional studies, the risk of obesity has been associated with short sleep duration.[63] However, Capuccio et al. underlined in their review article, that weight itself appears to be just one factor influencing sleep, which is also influenced by other factors related to being overweight.[63] Sleep deprivation causes changes in the levels of the hormones leptin and ghrelin, which are associated with hunger and satiety[63]. Shorter sleep also gives people more time to eat.[5 63]

Type II diabetes and a disturbed glucose metabolism are often related to obesity and therefore short sleep can be seen as a secondary risk factor to these health conditions.[63] However, short sleep is also an independent risk factor for unhealthy changes in glucose metabolism.[63 64] Tuomilehto et al. found in their cross-sectional population based survey among 2770 persons that, especially among women, short sleep duration of ≤6 hours or long sleep duration of ≥8 hours has been linked to a higher risk of type II diabetes.[65]

Poor-quality sleep may also be associated with cardiovascular diseases.[66] Short sleep duration is a risk factor for hypertension, especially when sleep is less than five hours. This also poses a risk for coronary calcifications and hypercholesterolemia.[63] There is evidence that the rise in blood pressure is reversible and that blood pressure decreases when sleep duration increases.[63]

Large population-based studies have shown that the risk of coronary heart disease and stroke is higher among people who sleep for less than five or six hours per night.[63] The mortality rate may grow due to the higher prevalence of cardiovascular diseases.[63]

The relationship between sleep duration and health seems to be U-shaped and, in some studies, health problems have increased when sleep duration has been longer than eight hours.[63] However, more research is needed to form firm conclusions on this subject.[63]

2.4.2 Mental health and sleep

Mental health disorders, most common anxiety and depression, are linked to cardiovascular diseases, diabetes and even mortality, causing major global economic costs assessed by disability-adjusted life years.[38 67 68] The connection between sleep difficulties and mental illnesses is well known.[38] Zhang et al. showed in their systematic review and meta-analysis including 52 studies and over 1,400,000 persons that, insufficient sleep duration is an individual risk factor for mental health problems, especially among women.[38] In addition to the direct effect on mental health, insufficient sleep duration may cause depression disrupting circadian rhythms through the hypothalamic-pituitary-adrenal axis and resulting in hormonal changes towards high stress levels.[38]

Mental health and older age are interconnected and mental disorders and dementia are common problems among the elderly.[49] While different dementia syndromes may have different sleep profiles,[69] the overall risk of dementia is higher among individuals with sleep disorders.[49] Even though dementia is rare in the working-age population, its incidence doubles every 10 years after the age of 60 years, and it has been suggested that sleep problems should be identified and treated early and effectively to minimize later dementia-related sleep problems and sleep-related dementia difficulties.[70]

2.4.3 Alcohol and sleep

While alcohol is commonly used to help falling and staying asleep, it has been proven that alcohol worsens the quality of sleep even in small but especially in moderate and high doses.[71 72] Helaakoski et al., in their survey based cross-sectional study of the Finnish Twin cohort involving 13,851 participants, demonstrated that excessive alcohol consumption predicts long-term sleep problems in a 36-year follow-up.[72] The sleep-disrupting mechanisms of alcohol are quite well known. Alcohol affects electrophysiological sleep architecture and causes insomnia, changes in circadian rhythm, short sleep duration, and breathing-related sleep problems.[71]

2.4.4 Pain and sleep

The association between sleep problems and pain have been widely studied, because both symptoms have a major influence on daily life.[73-79] Two systematic reviews and meta-analysis studies including 6,175 and 240,820 participants have shown that poor sleep quality is common in the population with chronic pain.[78 79] It is estimated that 40–80% of patients with chronic pain have sleep problems.[10] For example, rheumatoid arthritis, chronic back pain, osteoarthritis and especially fibromyalgia increase the risk of sleep problems.[79] There is also limited evidence that sleep

deprivation increases pain perception in both healthy individuals and the population with chronic pain.[79] Evidence that sleep disorders might independently predict chronic pain is scarce.[46] Respectively, the influence of chronic pain on sleep disorders is not fully understood, but some evidence shows that non-drug treatments of chronic pain also improve the quality of sleep.[78]

2.5 Outcome measures of sleep

2.5.1 Objective measures used to evaluate sleep

The gold standard of sleep assessment is polysomnography (PSG), which is based on measuring multiple body functions.[80] PSG broadly encompasses any physiological measurement, and by definition includes sleep measurements such as electroencephalography (EEG), eye movements (EOG), and muscle tone (chin-EMG).[80] The term 'polygraphy' is less commonly used but refers to studies that may also be part of a polysomnography study.[80] Analysis of PSG results involves the assessment of sleep stages (Wake, NREM stages N1, N2, N3, and REM), which are recorded every 30 seconds, with definitions based on specific changes in EEG, eye movements, and muscle tone.[80] The PSG study can also include measures such as total sleep time, sleep efficiency, wake after sleep onset, sleep onset latency, REM latency, arousal index, percentage of total sleep time in each stage, apnoea-hypopnea index, average and minimum SaO2, periodic limb movements per hour of sleep, and heart rate. Based on these results, the diagnosis and severity of sleep disorders are determined.[80] Based on these results the diagnosis of the sleep disorder is determined and the degree of severity is assessed.[10] The basic differences between polysomnography and polygraphy are revealed in table 2.

Table 2. Physiological measurements of sleep.

Typical polygraphy	Typical PSG	Additional signals
Airflow	EEG	Oronasal flow
Respiratory movements	EOG	EtCO2
ECG	Chin-EMG	Tibialis-EMG
SpO2	Nasal pressure	Diaphragm-EMG
Activity	Respiratory movements	Abdominal Muscle-EMG
	SpO2	Actigraphy
	TcCO2	Esophageal pressure
	Snoring sound	Movement sensitive mattresses (SCSB or piezo bed)
	ECG	Research specific signals eg. blood pressure
	Video	

Night polygraphy is mainly designed to evaluate sleep apnoea including respiratory measurements and differs from sleep polygraphy or polysomnography.[10] Night polygraphy can also be done at home.[10] Actigraphy is a useful method for measuring daily activity and activity at bedtime and during sleep.[10] Measuring the blood level of melatonin, heart rate variability, blood pressure, and concentrations of medicinal substances that affect sleep can be helpful when evaluating sleep problems to find the correct diagnosis and treatment option.[10]

2.5.2 Patient-related outcome measures

Anamnesis is the basic method for investigating sleep problems.[10] In addition to sleep surveys, a sleep diary is an easy-to-use assessment tool for screening sleeping habits and sleep problems.[10] Objective measures of sleep quality, for example polysomnography, are expensive, difficult to use in daily practice and time consuming.[29] Numerous sleep questionnaires are available.[29] As the diagnosis is mostly based on the results of sleep questionnaires, it is important to establish their psychometric properties.[29] The psychometric properties of many of sleep questionnaires have extensively been studied. Among them are the Pittsburgh Sleep Quality Index (PSQI), the Athens Insomnia Scale (AIS), the Insomnia Severity Index (ISI), the Mini-Sleep Questionnaire (MSQ), the Jenkins Sleep Scale (JSS), the Leeds Sleep Evaluation Questionnaire (LSEQ), the SLEEP-50 Questionnaire and the Epworth Sleepiness Scale (ESS).[29] The JSS and the PSQI are probably the most commonly used questionnaires for evaluating sleep difficulties.[81] The main properties of some commonly used sleep scales are shown in table 3.

The PSQI is a 24-item questionnaire for measuring sleep quality in both non-clinical and clinical populations.[29] Despite the popularity of the PSQI, its factor structure is uncertain, varying between unidimensional and three-factor models. Its internal consistency is sufficient (Cronbach's alpha 0.76), and its test–retest reliability is good.[29]

The AIS is a questionnaire specifically for measuring the severity of insomnia and it has two versions: the eight-item version (AIS-8) and the five-item version (AIS-5).[29] The factor structure of AIS-8 varied from one to two factors, while AIS-5 appeared to be unidimensional. The internal consistency of AIS was good (Cronbach's alpha 0.84 – 0.86) as well as its test–retest reliability.[29]

The seven-item ISI also focuses on insomnia severity.[29] It factor structure varied from one to two and its internal consistency (Cronbach's alpha 0.82) and test–retest reliability were good in both clinical and non-clinical populations.[29]

The 10-item MSQ questionnaire is developed to screen for sleep disorders in the general population and it includes items for measuring both sleep and staying

awake.[29] Unfortunately, it is multidimensional, but its internal consistency is good (Cronbach's alpha 0.69) and it performs better among poor sleepers.[29]

The 10-item LSEQ contains questions on sleep and morning behaviour.[29] There is no consistent evidence in its factor structure or reliability.[29]

The 50-item SLEEP-50 is designed to screen a wide range of sleep complaints and disorders.[29] While internally consistent, it shows a nine-factor structure.[29]

The eight-item ESS is used to measure sleepiness, which is a common symptom in many sleep disorders.[29] Its factor structure varies from one to three factors, and it is internally consistent (Cronbach's alpha of 0.8).[29]

Table 3. The main properties of some commonly used sleep scales.

Scale	Psychometric properties	Notes
Pittsburgh Sleep Quality Index (PSQI)[82-87]	Probably weak construct validity (unidimensional scale in young people but three-dimensional in older); alpha 0.70 to 0.80; well correlates with sleep diary, depression scale and other scales measuring sleep quality and sleep problems; good test-retest reliability	Relatively complex with 10 domains and 24 individual items
Athens Insomnia Scale (AIS)[88 89]	Alpha 0.9, good test-retest reliability; well corelates with Sleep Problems Scale	Explicitly for assessing the severity of insomnia; easy to use – eight items on a four-level scale.
Insomnia Severity Index (ISI)[90-98]	Alfa 0.70 to 0.9; unclear factor structure (one to two factors); good responsiveness, adequate discrimination parameter for five out of the seven items; well corelates with scales of fatigue, quality of life, anxiety, pain and depression; no sex-related DIF; 80% sensitivity and specificity	Explicitly for assessing the severity of insomnia; easy to use – seven items on a five-level scale; modified five-item version recommended by the Finnish Current Care Guidelines; available in three versions – self-reported, reported by a clinician and reported by a significant other; translated in several languages
Mini-Sleep Questionnaire (MSQ)[99 100]	Alpha 0.8, uncertain factor structure (two factors), sensitivity and specificity 0.7 to 0.8.	Developed for screening excessive daytime somnolence; ten items on a seven-level scale; not widely studied.
Leeds Sleep Evaluation Questionnaire (LSEQ)[101 102]	Four-factor structure.	10 binary items; challenging scoring system due to four factors; not widely studied.
SLEEP-50 Questionnaire[103]	Alpha 0.9; good test-retest reliability; good sensitivity and specificity	Not easy to use – 50 items on a four-level scale; not widely studied.
Epworth Sleepiness Scale (ESS)[104-108]	Alpha 0.8 to 0.9; good test-retest reliability; marginal floor and no ceiling effects; unidimensional; good responsiveness; good correlation with other sleep scales	Easy to use – eight items on a four-level scale; probably the most widely used measure of sleepiness.

2.5.3 Jenkins Sleep Scale

The four-item JSS (Figure 2) was developed in 1988 and it is one of the most commonly used sleep questionnaires in epidemiological studies as a short standardized scale for investigating sleep disturbances.[50 81 109 110] It aims to roughly identify sleep difficulties and has been translated into several different languages.[111-116] It has proven to be a valid and reliable scale in several patient groups, such as those with rheumatoid arthritis[113], psoriatic arthritis[112], ankylosing spondylitis[111], fibromyalgia[116 117], chest pain[118], post-cardiac surgery[109], cognitive disorder[119], and epilepsy[120], as well as in a healthy general population.[109 110 114 115 121 122] Its factor structure has been found to be unidimensional [110 114 115], even though confirmatory factor analysis (CFA) has been used in only one previous study.[110] To study the psychometrics of the JSS, the item response theory (IRT) and potential differential item functioning (DIF), e.g., by sex, had not been used before. The psychometric properties of the Finnish translation of the JSS have not previously been studied.

How often in the past month did you:	(0) Not at all	(1) 1-3 days	(2) 4-7 days	(3) 8-14 days	(4) 15-21 days	(5) 22-31 days
1. Have trouble falling asleep?	0	1	2	3	4	5
2. Wake up several times per night?	0	1	2	3	4	5
3. Have trouble staying asleep (including waking far too early)?	0	1	2	3	4	5
4. Wake up after your usual amount of sleep feeling tired and worn out?	0	1	2	3	4	5

Figure 2. Jenkins sleep scale questionnaire.

2.6 Recommendations for improving quality and duration of sleep

The recommendations for the length and quality of sleep have been made by a panel of 18 experts, set up by the National Sleep Foundation of the USA.[22 23] First, a systematic literature review was conducted and then each specialist analysed the accepted studies according to pre-planned protocol.[22 23] The analysis was made by age groups.[23]

Sleep latency of ≤30 minutes was considered good sleep quality in young adults (18-25 years) and adults (26-64 years), and 45–60 minutes in older adults (≥65 years). In other age groups, the sleep latency of 45–60 minutes was considered poor sleep quality, as was the latency of over 60 minutes in all age groups.[22] In all age groups, one or less awakening per night, and among older adults, two awakenings

per night indicated good sleep quality.[22] For all age groups, waking up 20 minutes or less after sleep onset indicated good sleep quality. In the age groups other than older adults, sleep onset of >40 minutes indicated poor sleep quality, and in the older adults group sleep onset of >50 minutes indicated poor sleep quality.[22] Sleep efficiency of ≥85%, seemed to be a good indicator of good sleep quality, and sleep efficiency of ≤74% indicated poor sleep quality, but in the young adults group sleep efficiency of ≤64% indicated poor sleep quality.[22] The significance of the other groups in terms of sleep latency, awakening, sleep onset and sleep efficiency remained uncertain.[22]

The architecture of sleep were examined.[22] A high amount of REM sleep was an indicator of good sleep quality, but the required amount varied between age groups and good quality of adult sleep required 21%–30% to be REM.[22] Among young adults and older adults, for whom ≥41% REM indicated poor sleep quality and also in adults, an increase in REM sleep by more than 41% predicted poor sleep quality.[22]

When sleep quality was good, NREM stage 1 made up ≤5% of the sleep of young adults and adults, 20% NREM stage 1 indicating poor sleep quality among young adults and adults.[22] The respective cut-off for older adults was > 25%.[22] Sleep quality was considered poor when NREM stage 2 rises >80%.[22] Good quality sleep consist of 16%–20% NREM stage 3 among adults.[22] The amount of NREM stage 3 sleep that indicates poor sleep quality was ≤5% among young adults and adults.[22]

Naps were also rated, "no naps" among young adults indicated good sleep quality.[22] More than four naps per day indicated poor sleep quality in the older adults, whereas for young adults, even three naps or more.[22] Nap duration and frequency were also assessed, and a nap of over 100 minutes among young adults, adults and older adults indicating poor sleep quality.[22] Weekly frequency was not indicative for most of the age groups, except for young adults with no naps indicating good sleep quality.[22]

As a result, better sleep efficiency, shorter sleep latencies, fewer awakenings, and less waking up after sleep onset seemed to be connected to good sleep quality, lower sleep efficiency indicating poor sleep.[22] The appropriate sleep duration was considered 7–9 hours for young adults and adults, and 7–8 hours for older adults.[23] There was some disagreement within the panel on the several indicators.[22] Nevertheless, they agreed that increased REM sleep indicated poor sleep quality among young adults, adults and older adults and that decreased NREM stage 3 sleep indicated poor sleep quality, except among older adults. Respectively, less and short naps indicated good sleep quality.[22] More research on the topic was suggested to distinguish good and poor sleep quality and to define optimal sleep.

Table 4. Descriptive characteristics of sleep quality and sleep duration.

Age group	18-25 years		26-64 years		>65 years	
	Sleep quality		Sleep quality		Sleep quality	
	Good	Poor	Good	Poor	Good	Poor
Variable						
Sleep latency (time)						
≤30 minutes	X		X			
45-60 minutes		X		X	X	
>60 minutes		X		X		X
Awakenings						
≤1	X		X		X	
2					X	
Waking up after sleep onset						
≤20 minutes	X		X		X	
>40 minutes		X		X		
>50 minutes						X
Sleep efficiency						
≤64%		X				
≤74%		X		X		X
≥85%	X		X		X	
Amount of REM sleep						
21%-30%	X		X		X	
≥41%		X		X		X
Amount of NREM sleep: N1						
≤5%	X		X			
20%		X		X		
>25%						X
N2						
>80%		X		X		X
N3						
≤5%		X		X		
16%-20%			X			
Number of naps						
0	X					
≥3		X				
>4						X
Nap duration						
100 minutes		X		X		X
Appropriate sleep duration						
7 to 8 hours					X	
7 to 9 hours	X		X			

2.7 Sleep difficulties in the general adult population

2.7.1 Prevalence among

The prevalence of sleep problems varies from a few up to 60%, depending on the criteria used in previous studies.[3 123-128] Morin et al. conducted a study of 3,073 people of whom 29% had sleep difficulties and 17% had insomnia.[42] Other studies in turn have found the prevalence to be slightly lower with 9%–15% having sleep difficulties, 7%–10% having insomnia, and 8%–18% being unsatisfied with their sleep.[34] Myllyntausta et al.[7] studied the sleep difficulties of the population around the transition to retirement reporting the prevalence of sleep difficulties of 30%.[7] Suh et al. observed the 44% prevalence of insomnia in the general population.[37] In a larger population study from the UK, the prevalence of sleep difficulties was 28%.[129] In another study of the working-age population, the frequency of insomnia symptoms was as high as 45%.[130] Larger population surveys have showed that as many as one in three suffer from temporary insomnia, 10%–15% have performance problems related to insomnia, and 12% of adults have long-term insomnia.[10]

The prevalence of restless leg syndrome among adults is 4%–10%, but up to 25%–40% report having symptoms even before adulthood.[56] Among the elderly, the prevalence of sleep difficulties of all degrees varies between 22%–50% depending on the study, and these difficulties cause a significant daily functioning problem for many elderly people.[4 131 132] Working-age people have many sleep disorders, but the prevalence of sleep problems varies considerably, ranging from 5% to 45%, depending on the group under study.[3 66 130 133-137] In shift work, the number of sleep problems is clearly higher,[66 137] but they also differ at the population level, depending on social status[135 138] and gender,[125 139-142] Differences can also be found among countries.[3 123 125 133 138 143]

Advanced sleep–wake phase disorder mainly prevails among middle-aged adults at 1%. Over 50% of blind individuals suffer from non-24-hour circadian rhythm disorder and 10%–38% of shift workers have shift-work circadian rhythm disorder.[2] On the other hand, in the general middle-age population, 30%–50% of men and 11%–23% of women have been estimated to suffer from moderate or severe sleep apnoea.[2] Restless leg syndrome occurs in approximately 15% of adults, being the most common movement disorder during sleep and occurring more often among women and the elderly.[2]

2.7.2 Incidence of sleep difficulties

LeBlanc et al. found the incidence of insomnia symptoms to be 29% and that of insomnia syndrome to be 3.9%.[35] The incidence of sleep difficulties in a study by

Morin et al. was 14% and insomnia 4%, and both sleep difficulties and insomnia were more common among women, but age was not so important.[42] Depending on the source, the incidence rates of sleep difficulties vary from 3% to 20%, the main reasons for this being the differences between populations and what definition of insomnia is used, because in some studies, insomnia is defined as a disorder and in others as a set of symptoms.[35] However, it has been estimated that in a one-year period, 20% of the general population can suffer from sleep difficulties and 6% develop insomnia syndrome.[35] Insomnia symptoms can be understood in the same way as sleep difficulties.[35] For instance, predisposing factors such as an increased level of arousal, life events, stress, and coping skills were also more common in the insomnia disorder group.[35] However, psychological and health-related factors might not play such a major role in insomnia symptoms, and thus may be more likely risk factors for severe insomnia symptoms and insomnia disorder.[35]

Among the elderly, the incidence of sleep problems varies from 2% to 12%, depending on the source.[4 132]

2.7.3 Severity of sleep difficulties in the general population

The severity of sleep difficulties in the general population varies greatly. In a large population study of adults, which admittedly represented a population aged from 50 to 62 years, 41% were good sleepers, 27% were poor sleepers, and 32% belonged to a group that fell between these groups.[129] In a Korean study of the general population, in which the age of the participants varied from 45 to 74 years, 44% had insomnia symptoms, but the degree of severity of the symptoms was not defined.[37] However, the risk of insomnia disorder seemed to be clearly higher among young women, and the incidence of a disorder, with day-to-day symptoms, was up to 9%.[44] The number of milder or temporary insomnia symptoms, is likely to be slightly higher in the general population.[10]

The number of sleep difficulties was greater among the elderly than among the younger people, and the degree of difficulty varied from sleep-related complaints to insomnia that met the diagnostic criteria.[132] The incidence of milder difficulties related to sleep was as high as 50% and they were mostly related to falling asleep or staying asleep, and the prevalence of more severe sleep difficulties, such as insomnia disorder, was 12%–20%.[132]

It is important to ascertain the degree of severity of insomnia, because severe insomnia is more persistent[42] affecting the choice of treatment of sleep difficulties.[10] Some studies have suggested that an objective short sleep duration of ≤6 hours in particular might be a marker of severe insomnia.[39]

2.7.4 Persistence of sleep difficulties in the general population over time

The persistence of sleep difficulties has mainly been studied among children and the elderly.[4 144-146] Only a few studies have examined the persistence of sleep problems among people of working age.[123]

The persistence of sleep disorders in the working-age population has been studied very little, and any studies that have been conducted have mainly dealt with sleep problems, insomnia-related symptoms and poor sleep.[42 123 134] Suh et al. studied a population of 1,274 participants aged 45–74 years for four years,[37] and they found that 44% consistently experienced sleep difficulties at some point during the follow-up period, and that 56% of those who did not have sleep difficulties at the beginning also had none during the follow-up period either.[37] Overall, 35% of those who had sleep problems at the beginning had them at all follow-up points.[37] Some sleep difficulties had subsided at some previous point in time, but the remission rate was as high as 29%.[37] Morin et al. found in their study that the persistence of sleep difficulties in the one-, three-, and five-year follow-up windows was 63%, 37%, and 27%, respectively.[42] For those diagnosed with insomnia, the percentages were even higher, at 86%, 72% and 59%, respectively.[42] Persistence rates in other studies have been similar to these.[123 134] Insomnia seem to be a long-term disorder, and if it starts in youth, it can continue into adulthood.[147] Fok et al. found that about 45% of the elderly ≥65-year population have sleep-related complaints, and in their one-year follow-up, they persisted for about 66%.[4]

Based on the literature, it seems that sleep difficulties and sleep disorders occur widely, in almost all age groups. Sleep difficulties and insomnia disorder are also mostly long-lasting, and the problem can continue from childhood to the older age.

2.7.5 Factors associated with changes in sleep in the general population

Sleep duration changes between adolescence and adulthood, and the background to this is influenced by individual factors and family relationships during adolescence.[148] However, it is possible that poor sleep in adulthood is a continuation of childhood sleep problems.[148] This means that more attention should be paid to sleep problems in youth, if they are to be prevented later and their persistence reduced.[148] Being overweight has shown to shorten the duration of sleep among adults and children, and overweight is also known to have negative effects on other health conditions, and to be a risk factor for some sleep disorders.[5]

Regarding sleep difficulties, the greater severity of depression has been linked to the persistence of sleep difficulties, as have a generally worse mood and suboptimal general health.[37] However, no significant differences were found with regard to

alcohol and smoking in comparison to the control group.[37] In addition, PSQI values of 9 points or higher significantly raised the risk to 38% compared to 5% in the PSQI group with values below 9 points.[37] Poor sleep, as part of sleep difficulties, is a significant risk factor for developing chronic insomnia, and as such, is more serious than many other risk factors for insomnia.[44] The risk of being a poor sleeper has also shown to be higher among the elderly, women, and some ethnic minorities.[129] In addition, socioeconomic disadvantage and deprivation increase the risk of poor sleep.[129] Health factors, such as unhealthy lifestyles and being overweight, increase the risk of poor sleep, whereas good general health reduces it.[129] Sex, age, body weight, physical disorders, depression, and alcohol consumption, in turn, are inconsistent risk factors for prolonged insomnia disorder.[37 39]

Architectural sleep changes during the lifespan are quite well studied and therefore it is known that sleep time, sleep efficiency, slow-wave sleep, REM sleep, and REM latency decline with age and that sleep latency, waking after sleep onset, NREM stage 1 sleep and NREM stage 2 sleep increase with age.[1] As people get older, melatonin secretion declines, which influences sleep and increases the risk of sleep disorders such as insomnia, restless leg syndrome, sleep apnoea and REM behaviour disorder.[1] The elderly in particular report difficulties falling asleep and maintaining sleep, although do not report increased levels of dissatisfaction of sleep, which younger adults are more likely to report.[1] There is evidence that general sleep difficulties are more common among younger adults and that their incidence decreases with age, despite sleep becoming objectively worse.[1] Sleep without disturbances and sleep duration of 7–8.5 hours between the ages of 50 and 75 also predict a longer, healthier life.[149]

Sex-related differences in sleep have been widely reported.[1 141 150-152] Women in particular report shorter sleep duration, more sleep symptoms, greater rates of insomnia, lower rates of sleep apnoea, more night time sleep disturbances, and more daytime tiredness than men, and the rate of reported sleep disturbances is higher among women in all age groups.[1] Some of these sex-related differences can be explained by hormonal issues,[140] and sleep disturbances are more common during pregnancy and the menopause. Young parents also suffer more from sleep problems.[1] In contrast, sleep apnoea is more common among men and men are more likely to die as a result of sleep apnoea complications.[1] In addition, REM behaviour disorder and a steeper decline of slow-wave sleep are more common among men.[1]

On the social level, home, neighbourhood, work, ethnicity, socioeconomics, religion, and culture; and on the societal level, technology, globalization, the environment, public policy, and geography are believed to affect sleep.[1]

When examining the factors that predispose people to sleep problems, it is also important to consider the factors that predispose and aggravate insomnia to become a disorder, as mild sleep difficulties sometimes directly develop into more severe

disorders.[10] Short-term insomnia may become chronic, and its predisposing, precipitating and perpetuating factors have been studied.[153] Genetics, personality traits leading to physiological and cognitive hyperarousal and other non-modifiable factors are considered predisposing factors.[153] Precipitating factors mainly consist of stressful life events or illnesses: displacement due to traumatic events, traffic noise, debt, unemployment, racial discrimination, homelessness, traumatic childhood, divorce, military deployment, anxiety, depression, post-traumatic stress disorder, substance abuse, pain, nocturia, dyspnoea, irritable bowel syndrome, and traumatic brain injury.[153] Perpetuating factors are maladaptive behaviours, thoughts and coping strategies that maintain the disorder after the trigger factors are resolved.[153] Several other risk factors have also been found to predispose to insomnia: genes, morningness–eveningness, sensitivity to sleep, female sex, drugs, stimulants, and alcohol.[10]

The risk of prolonged insomnia has increased among women and the elderly in particular.[36 42] Treatment for insomnia should be effective, because insomnia can complicate many other diseases and increases mortality.[42] If insomnia is only a mild symptom, the situation may improve, but for those with a diagnosed insomnia disorder, it is more likely to remain permanent.[42]

3 Aims of the Present Study

The main aim of this thesis was to investigate the persistence of sleep difficulties and their associations with some demographic and lifestyle factors in a working-age population. Among these factors were the excessive use of alcohol, smoking, physical activity, overweight, age and gender. The secondary goal was to assess the validity and reliability of the Jenkin's Sleep Scale in the studied sample. The research data consisted of the material of a prospective ongoing Finnish Public Sector (FPS) survey based study

4 Materials and Methods

4.1 Material and methods

The data for this thesis were collected from the FPS study, which is an survey based ongoing prospective study. The suitable population (n=151,618) consisted of employees who had worked for a minimum of six months at the studied organizations between 1991 and 2005. The FPS has been running since 1997, and still continues through the "Kunta-10" surveys and the well-being surveys of the Well-being Service Counties that are carried out every other year. Employees of municipal services in 10 Finnish cities and 21 public hospitals were asked to participate in the survey. There were some differences between the content of surveys offered to the participating organizations. The city of Helsinki joined the survey in 2014. The collected data covers almost 30% of the Finnish public sector employees (Figure 3). The data are owned by the Finnish Institute of Occupational Health. The ethics committee of the Hospital District of Helsinki and Uusimaa approved the study plan and the informed consent form. Respondents participated in the survey voluntarily and did not receive any compensation for their participation.

The data for Studies I and IV were collected from 2016–2017 surveys, which had an average response rate of 70%. The data for Studies II and III were collected between 2000 and 2017, and the average response rate was the same 70%. The total number of selected respondents for Study I was 81,136. The data for Study II were collected from the 2000, 2004, 2008, 2012 and 2016 questionnaires, with a total of 122,969 respondents, of whom 86,467 responded to at least two surveys, which was the first criterion for inclusion in the study. Another inclusion criterion in Study II was respondent-specific perceived sleep difficulty in at least one survey and no sleep difficulties in at least one survey, which led to 38,400 respondents being accepted for Study II. The data for Study III consisted of respondents who answered five surveys every four years between 2000 and 2017. The total number of respondents was 66,948. The starting point was the responses from 2000 or 2004. In the Study IV, a total of 77,967 people had responded to at least one JSS question. The JSS questionnaire was chosen for the survey because it was established in the original 1988 study as a valid, practical, and quick-to-complete tool.[109]

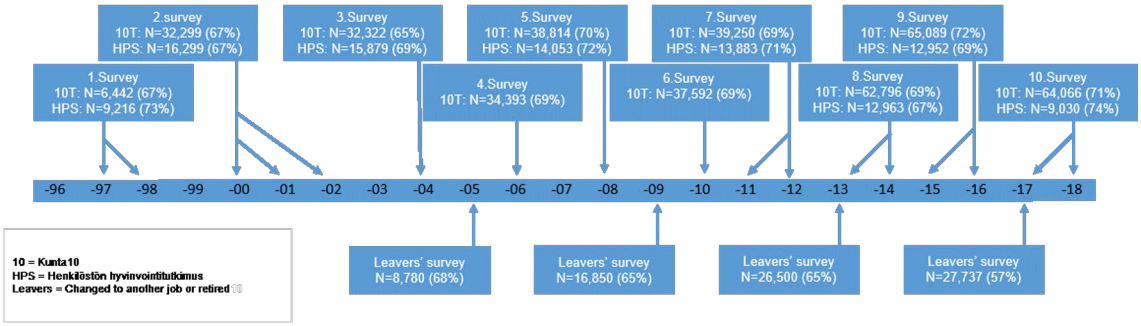


Figure 3. Finnish Public Sector study: number of participants between 1997 and 2018 (number of respondents and response rate).

Age was given in full years at the time of the response to survey. Weight was reported in Studies I and IV as a Body Mass Index (BMI) value (weight in kg/ height in m^2) and in Studies II and III, the BMI was dichotomized *>30 kg/m²* vs. *≤30 kg/m²*. Physical activity level was measured from the questionnaire responses and transformed into metabolic equivalents of task (MET).[154] In Studies I and IV, physical activity was expressed as MET/hour-week. In Studies II and III, the low physical activity limit was defined as 14 MET/hour-week, representing a lower quartile of the physical activity rate. These were compared to other groups. Alcohol consumption from the survey responses was converted into g/week, and >210 g consumption of pure alcohol was considered the limit for the excessive use. For the analysis, alcohol consumption was dichotomized as *excessive consumption* vs. *no excessive consumption*. Smoking status was defined as current smoking *yes* vs *no*. Sleep was defined as continuous scores or as dichotomized estimate sleep *≤7 hours/night* vs. *>7 hours/night*.

To measure the association between lifestyle changes and sleep difficulties, age, BMI, level of physical activity, smoking and alcohol consumption were measured and compared to the repeated responses. Regarding the amount of sleep, respondents had to choose the most suitable option from nine alternatives of sleep per 24 hours: *<6 hours, 6.5 hours, 7 hours, 7.5 hours, 8 hours, 8.5 hours, 9 hours, 9.5 hours* and *≥10 hours.*

The amount of sleep problems in the last month were assessed by the JSS, which consists of four items: *difficulty falling asleep*, *waking up at night*, *difficulty staying asleep,* and *non-restorative sleep*.[109] All four the JSS items are rated on a Likert-type scale from 0 *never* to 5–6 *nights/week (15–21 days/month)*. The total score is the sum of the scores of all four items with minimum of zero points (*no sleep problems*) and maximum of 20 points (*the most sleep problems*). A score <12 indicates no or a mild sleep disturbances, whereas a score of >11 meant substantial sleep disturbances. [54] Another way of the interpretation of the JSS results (used in Study II), is

dichotomizing the score as *none* vs. *at least one yes response* to any item (>15 nights in the previous 4 weeks).[118 155-157] In Study III, the JSS total score was substituted by the average score of the answered items, using the person-mean imputation method to ensure that the incomplete JSS responses were also included in the analysis.

4.2 Statistical analyses

The descriptive statistics were defined as means and standard deviations or as absolute numbers and percentages. If appropriate, 95% confidence intervals (95% CI) or two-tailed *p*-values were reported. The associations of the risk factors were presented as odds ratios (ORs) with their 95% confidence intervals (95% CIs). The level of significance was $p<0.005$.

To ensure that the results regarding the persistence and risk factors of sleep difficulties were reliable, the psychometric properties of the JSS were evaluated. Cronbach's alpha was used to define internal consistency and it was reported together with a one-sided (lower) 95% confidence limit (95% CL). The alpha was considered excellent when it was ≥0.9, good at ≥0.8, acceptable at ≥0.7, questionable at ≥0.6, poor at ≥0.5, and unacceptable at <0.5.[158 159] Exploratory factor analysis (EFA) was used to evaluate the construct structure of the JSS. The aim was to determine whether the JSS only measures sleep disturbances or whether there are other latent factors involved. The data were analysed both numerically and graphically.

The root mean square error (RMSEA) was used as the primary index to assess whether the confirmatory factor analysis (CFA) model well fit the observed data. Model fit was tested assuming no covariances between the unique factors. After thus, the modification indices suggested by the software were added to the covariance between the factors (double-headed arrows in Figure 5) one at a time. Each time the closeness of the RMSEA to <0.05 or at least the <0.08 threshold was tested for acceptance of model fit. The maximum likelihood method of CFA was used. The CFA estimates were reported in a standardized form as correlation coefficients. A correlation of <0.2 was considered poor, 0.21–0.4 fair, 0.41–0.6 moderate, 0.61–0.8 significant, and >0.8 perfect.[160] Coefficients of determination were calculated to assess whether the common structure of sleep disorders could be explained by the items.

The fixed-effects method (also known as the quasi-experimental case-control method), with conditional logistic regression models, was used to measure individual lifestyle changes and their associations with sleep difficulties. These models used data from those who had sleep problems at least one of the five study waves (case) and those who had no sleep problems at least one study wave (control) and had undergone modifiable lifestyle changes. The fixed-effects model combined changes

in sleep difficulties with changes in obesity, alcohol consumption, smoking, and physical activity (in both directions), and thus controlled for all the measured and unmeasured stable individual characteristics and other potential confounders that did not vary over time.[161 162] The fixed-effects model also excluded all the employees with no change in sleep difficulties between the survey interval responses, as they could not serve as their own control.

The group-based trajectory analysis (GBTA) method is a form of limited mixture modelling for analysing longitudinal repeated measures data,[163-165] and was used in this thesis to evaluate the developmental trajectory of the severity of sleep disorders measured by the JSS. While conventional statistics only show the trajectory of an average change of outcome over time, GBTA is able to separate and describe any subgroups that exist within the studied population, which can differ markedly from other subgroups and from the average trajectory of the studied cohort as a whole.

The average level of reported sleep problems was measured using the item response theory (IRT), which is based on the principle of maximum likelihood. The rate of sleep problems per respondent was then compared to the average level observed in the studied cohort as a whole. Difficulty describes the needed level of sleep problems to choose a certain response. Discrimination is the steepness of the regression curve, in which the severity of sleep problems is on the X axis and the assumed score of the JSS is on the Y axis. In an ideal situation, the steepest interval corresponds to the patients with an average score of two or three points, when using the JSS. In that scenario, the test or the item is especially sensitive and separates those with a level of sleep problems below average from those with levels above average.

An item information curve helps illustrate the IRT estimates graphically and shows the steepest interval of the curve, at which point the level of severity is associated with the most information that can be obtained from the item.

Differential item functioning (DIF) is the statistical characteristic of a scale item and in this thesis described whether the item measured the severity of sleep problems differently for the two sexes within the studied cohort. To evaluate the DIF, the probit logistic regression was used to test whether an item showed a uniform or nonuniform DIF between the sexes, that is, whether an item favoured one sex over the other in all values of the severity of the sleep problems or in only some of its parts.[166 167]

The analyses were performed using Stata/IC Statistical Software: Release 16 and 17, College Station (StataCorp LP, TX, USA). The additional Stata module ‘traj’ was required to conduct the GBTA. The module is available free of charge.

5 Results

5.1 Descriptive characteristics

The number of those selected for the studies varied from 38,400 to 81,136 and 80–82% were women. The average age of the participants varied from 44.7 to 52.1 years.

In Studies I and IV, physical activity varied from 29.4 (25.3) MET-hour/week to 29.6 (25.3) MET-hour/week. The low activity group consisted of 24%–35% of the respondents in Studies II and III. In Studies I and IV, mean alcohol consumption varied from 49.7 (90.9) g/week to 50.1 (91.3) g/week. Of the Study II respondents, 17% had excessive consumption of alcohol and in Study III, 36%. In Study I, 52% slept 7 hours or less and their JSS score was 6.4 (4.8) points whereas in Study II, 72% slept 7 hours or less and their JSS score was 6.4 (4.8) points. In Study II, 36% experienced sleep difficulties. In Study II, 17% were smokers and in Study III, 12%. In Study I and IV, mean BMI was 26.2 (4.7) kg/m^2. The proportion of overweight people was 20% in Study II and 42% in Study III. Table 5 presents the descriptive characteristics of the studied cohort.

Table 5. Descriptive characteristics of participants of Studies I–IV.

Characteristic	Study			
	I	II	III	IV
N (% women)	N=81,136	N=38,400	N=66,948	N=77,967
Women, %	82%	83%	80%	82%
Age, years	52.1 (13.2)	45.5 (9.2)	44.7 (9.4)	51.9 (13.1)
Physical activity, MET-hour/week	29.4 (25.3)	–	–	29.6 (25.3)
Low physical activity, %	–	35%	24%	–
Alcohol, g/week	49.7 (90.9)	–	–	50.1 (91.3)
Excessive alcohol consumption, %	–	17%	36%	–
Sleep duration ≤7hours	52%	–	–	72%
JSS score, points	6.4 (4.8)	–	–	6.4 (4.8)
Sleep difficulties, %	–	36%	–	–
Smoking, %	–	17%	12%	
BMI, kg/m^2	26.2 (4.7)	–	–	26.2 (4.7)
BMI ≥30 kg/m^2, %	–	20%	42%	–

5.2 Persistence of sleep difficulties in the studied population

Six clusters with different trajectories of changes in the JSS score were identified. Conventional statistics typically show the average change in outcomes over time, but distinct subpopulations within a studied group can be identified and described using group-based trajectory modeling. The trajectories of these subpopulations often differ significantly from one another and from the overall population average. These trajectories were created with proceeding steps: 1) Censored normal modeling was applied, with minimum and maximum values set at the lowest and highest possible JSS scores (0 to 5). 2) The population was divided into six gender-age groups: men and women under 40, 40–49, and 50+. 3) The number of trajectory groups was determined based on the size of the dataset, with the smallest group comprising around 3% of the sample or approximately 300 cases.[165] The number of trajectory groups was standardized across all gender-age groups for consistency. Six clusters were identified for each group. 4) Model fit was assessed using a cubic regression, with the procedure repeated for up to six subpopulations. The goodness of fit was confirmed using the Bayesian Information Criterion (BIC), Akaike Information Criterion (AIC), and average posterior probability (APP).

All the trajectories followed similar patterns for all gender–age groups (Figure 4). Sleep difficulties were more common among women than men. In the group suffering from sleep difficulties the most, the proportion of women was 84%.

Only mild changes were observed in the number of sleep difficulties during the 16-year follow-up in the trajectories by age and sex. An increase was observed in trajectory group #3 (9%): number of sleep difficulties grew from one night per week to 2–4 nights per week and group #6 (9%): number of sleep difficulties grew from 2–4 nights per week to 5–6 nights per week. A decrease was observed in group #5 (5%): number of sleep difficulties decreased from 2–4 nights per week to less than one night per week.

Amongst **women <40 years**, no significant changes were observed in groups #1 (17%), #2 (52%) and #6 (2%). Instead, an increase was observed in group #4 (14%): number of sleep difficulties grew from less than one night per week to one night per week, and group #3 (7%): number of sleep difficulties grew from one night per week to 2–4 nights per week. In turn, a decrease was observed in group #5 (8%): number of sleep difficulties decreased from one night per week to less than one night per week.

Amongst **men aged 40 to 49 years**, no significant change was observed in groups #1 (12%), #2 (47%), or #6 (3%). An increase was observed in group #3 (20%): number of sleep difficulties grew from less than one night per week to one night per week, and group #4 (12%): number of sleep difficulties grew from one night per week to 2–4 nights per week. A decrease was observed in group #5 (5%):

number of sleep difficulties decreased from one night per week to less than one night per week.

Amongst **women aged 40 to 49 years**, no significant change was observed in the groups #1 (10%), #3 (47%), and #6 (3%). An increase was observed in group #2 (22%): number of sleep difficulties grew form less than one night per week to one night per week, and group #4 (11%): number of sleep difficulties grew from one night per week to 2–4 nights per week. A decrease was observed in group #5 (7%): number of sleep difficulties decreased from one night per week to less than one night per week.

Amongst **men aged 50+ years**, no significant change was observed in groups #1 (7%), #2 (41%), #3 (31%), and #4 (13%). A slight decrease was observed in group #6 (4%): number of sleep difficulties diminished from 5–6 nights per week to 2–4 nights per week. Even more significant decrease was observed in group #5 (3%): number of sleep difficulties decreased from 2–4 nights per week to <1 night per week.

Amongst **women aged 50+**, no significant change was observed in groups #1 (11%), #2 (44%), #4 (13%), and #6 (3%). A slight increase was observed in group #3 (21%): number of sleep difficulties grew from less than one night per week to one night per week. A decrease was observed in group #5 (8%): number of sleep difficulties decreased from 2–4 nights per week to less than one night per week.

The two trajectories with the mildest sleep problems at baseline showed no substantial change during the follow-up and accounted for 50–70% of the respondents. In the next analyses, these two trajectories were combined into one cluster, which served as the reference cluster (Table 6 and 7). In groups with initially severe sleep difficulties, the patterns of the trajectories were alike and the persistence of sleep difficulties seemed stronger than in the other groups. For each gender–age group there was a cluster with a high frequency of sleep difficulties (every night), representing 2–4% of the cohort.

The possible risk factors for sleep difficulties were inconsistently associated with either sleep difficulties or good sleep. Despite this, some statistically significant associations were observed (Table 6 and 7). Except for young men and women, excessive alcohol consumption predicted worse sleep difficulties – its OR varied from 1.15 (95% CI 1.01 to 1.31) to 2.30 (95% CI 1.62 to 3.27). Smoking was related to worsening sleep difficulties among young women (OR 1.23, 95% CI 1.04 to 1.46). Low physical activity predicted sleep difficulties among older men (OR 1.29, 95% CI 1.07 to 1.56). Obesity was related to sleep difficulties among all men (OR 1.92, 95% CI 1.36 to 2.70) and older women (OR 1.19, 95% CI 1.08 to 1.30 for middle-aged and OR 1.47, 95% CI 1.22 to 1.77 for older).

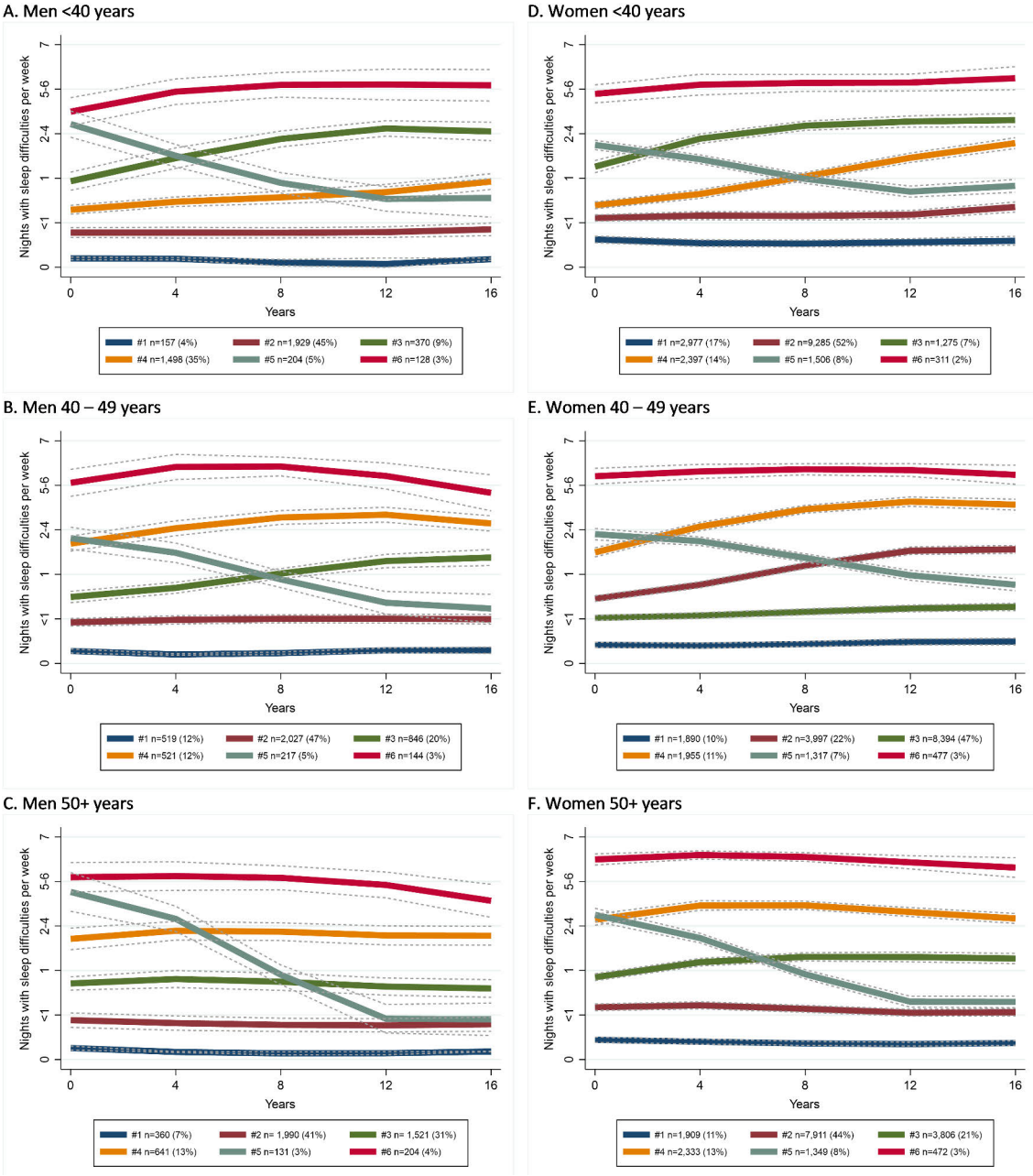


Figure 4. Trajectories of JSS by gender–age group (95% confidence limits are shown as dotted lines). From Saltychev et al. Persistence of sleep difficulties for over 16 years amongst 66,948 working-aged adults. PLoS One. 2021 Nov 18;16(11):e0259500. With permission from a copyright holder (2023).

Table 6. Strength of prediction of modifiable risks and probability of being placed in a specific cluster among men.

Trajectories	Risk factors											
	Excessive alcohol consumption			Smoking			Low physical activity			Obesity		
	OR	95% CI		OR	95% CI		OR	95% CI		OR	95% CI	
Men aged <40 (Fig 1A)												
Steadily average sleepers	1.27	1.11	1.45	1.02	0.85	1.23	1.16	0.97	1.40	1.19	1.04	1.35
Steadily worsening sleepers	1.98	1.37	2.85	1.51	0.96	2.36	1.82	1.19	2.79	1.43	1.00	2.05
Worsening sleepers	1.06	0.85	1.32	1.24	0.92	1.66	1.54	1.16	2.04	0.78	0.62	0.98
Improving sleepers	1.49	1.11	1.98	1.10	0.74	1.63	1.93	1.37	2.72	1.07	0.80	1.42
Men aged 40–49 (Fig 1B)												
Steadily average sleepers	1.62	1.34	1.96	0.93	0.72	1.19	1.21	0.97	1.50	1.19	0.99	1.44
Steadily worsening sleepers	2.30	1.62	3.27	1.06	0.69	1.64	1.15	0.78	1.70	1.92	1.36	2.70
Worsening sleepers	1.03	0.89	1.21	1.03	0.84	1.26	1.14	0.95	1.37	1.02	0.87	1.19
Improving sleepers	0.93	0.71	1.23	0.83	0.56	1.23	1.32	0.97	1.80	0.90	0.68	1.19
Men aged 50+ (Fig 1C)												
Steadily average sleepers	1.15	1.01	1.31	0.83	0.68	1.00	1.15	1.00	1.33	0.94	0.83	1.07
Steadily poor sleepers	1.12	0.94	1.33	1.04	0.81	1.33	1.29	1.07	1.56	0.93	0.78	1.11
Steadily worsening sleepers	1.04	0.78	1.39	1.11	0.75	1.65	1.17	0.86	1.60	0.99	0.74	1.32
Improving sleepers	1.01	0.71	1.44	0.95	0.57	1.59	1.45	1.00	2.10	1.20	0.84	1.71

Table 7. Strength of prediction of modifiable risks and probability of being placed in a specific cluster among women.

Trajectories	Risk factors											
	Excessive alcohol consumption			Smoking			Low physical activity			Obesity		
	OR	95% CI		OR	95% CI		OR	95% CI		OR	95% CI	
Women aged <40 (Fig 1D)												
Steadily worst sleepers	1.10	0.88	1.39	1.05	0.74	1.49	1.51	1.17	1.96	1.31	1.05	1.64
Worsening sleepers	0.94	0.86	1.02	1.10	0.96	1.26	1.16	1.04	1.30	0.90	0.83	0.99
Worsening sleepers	1.05	0.94	1.19	1.23	1.04	1.46	1.08	0.93	1.25	1.01	0.90	1.14
Improving sleepers	1.25	1.12	1.39	1.03	0.87	1.22	1.17	1.02	1.33	1.19	1.07	1.32
Women aged 40–49 (Fig 1E)												
Steadily worst sleepers	1.23	1.01	1.49	2.00	1.59	2.50	1.47	1.21	1.79	1.30	1.08	1.57
Worsening sleepers	0.97	0.89	1.05	1.08	0.97	1.20	1.07	0.98	1.16	0.95	0.88	1.03
Worsening sleepers	1.15	1.03	1.27	1.31	1.15	1.50	1.16	1.04	1.29	1.02	0.92	1.13
Improving sleepers	1.02	0.90	1.16	1.29	1.10	1.52	1.21	1.07	1.38	1.03	0.92	1.16
Women aged 50+ (Fig 1F)												
Steadily average sleepers	0.97	0.90	1.06	0.87	0.76	0.99	1.12	1.03	1.21	0.97	0.90	1.05
Steadily poor sleepers	1.11	1.01	1.23	0.99	0.85	1.16	1.24	1.12	1.36	1.19	1.08	1.30
Steadily worsening sleepers	1.29	1.06	1.57	1.28	0.96	1.71	1.27	1.04	1.54	1.47	1.22	1.77
Improving sleepers	0.93	0.82	1.05	1.10	0.91	1.32	1.34	1.18	1.51	1.10	0.98	1.24

5.3 Factors associated with changes in sleep in the studied population

In regard to the risk factors for sleep difficulties and possibly also the factors affecting their persistence, all factors except smoking were positively associated with sleep difficulties (Table 8). The number of person-observations varied between 139,178 and 142,969. The obese participants were at a 1.41 (95% CI 1.35 to 1.48) times greater risk of sleep difficulties than when they had been non-obese. The corresponding ORs for physical activity and alcohol consumption were 1.10 (95% CI 1.06 to 1.13) and 1.43 (95% CI 1.35 to 1.51), respectively. A negative association was only observed for smoking, with an OR of 0.81 (95% CI 0.76 to 0.86). When all four modifiable risks were included in the same model, the estimates changed slightly. Ageing had a significant but small association with sleep difficulties (OR 1.03, 95% CI 1.03 to 1.03).

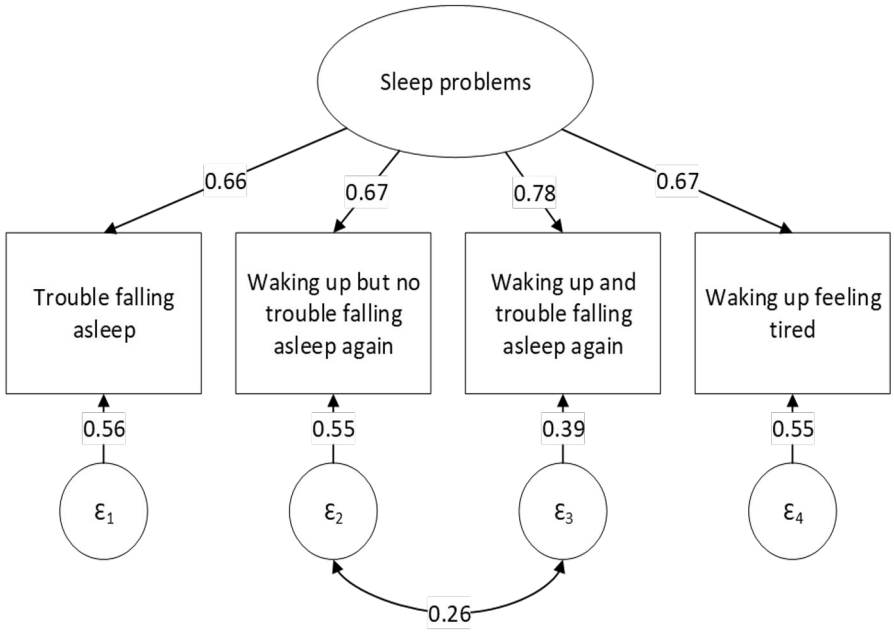
Table 8. Associations between changes in occurrence of sleep difficulties and changes in obesity, physical activity, smoking and alcohol consumption.

RISK	OR AND 95% CI	OR	95% CI	
Separately age adjusted				
Obesity		1.41	1.35	1.48
Low physical activity		1.10	1.06	1.13
Excessive alcohol consumption		1.43	1.35	1.51
Smoking		0.81	0.76	0.86
All risks together	1.0			
Age		1.03	1.03	1.03
Obesity		1.30	1.24	1.36
Low physical activity		1.13	1.09	1.16
Excessive alcohol consumption		1.17	1.11	1.24
Smoking		0.81	0.76	0.87

Psychometric properties of JSS in the studied population

The model reached a good fit when one covariance was added between the second and third items. The RMSEA was 0.03. The JSS demonstrated good internal consistency with an alpha of 0.80 (lower 95% CL 0.80). The **EFA** showed one retaining factor with an eigenvalue of 1.94. The **CFA** showed that all four items correlated positively with a common factor, explaining from 44% to 61% of the variance of the common factor (Figure 5.). The third item, *Waking up and trouble*

falling asleep again, showed the highest correlation, at 0.78 (r^2=0.61). The other items had similar but smaller correlations that were between 0.66 and 0.67 (r^2=0.44 to 0.45).



The 'ε' circles represent a measurement error associated with an observed variable (variance that is predicted by the latent factor). The estimates placed between the ε errors and observed variables represent the amount of variance in the higher-level data that can be explained by a particular variable.

Figure 5. Confirmatory factor analysis of JSS. From Juhola et al. Internal consistency and factor structure of Jenkins Sleep Scale: cross-sectional cohort study among 80 000 adults. BMJ Open. 2021 Jan 18;11(1):e043276. With permission from a copyright holder (2023).

In the **IRT analysis**, all four JSS items showed a mild shift in the direction of more severe sleep difficulties. This means that the respondents might tend to underestimate their sleep difficulties. This shift was seen among both sexes. The discrimination estimates for the item *Waking up and trouble falling asleep again* were high among both sexes: 1.92 for men and 2.04 for women. The other three items had moderate discrimination estimates ranging from 0.71 to 1.16 for men and women, respectively. The discrimination and difficulty parameters were significantly different between the sexes, p<0.001. Among the men, the discrimination parameter was steeper for the item *Trouble falling asleep* and the item *Waking up feeling tired* (Figure 6). Among the women, the discrimination was higher

for the item *Waking up but no trouble falling sleep again* and the item *Waking up and trouble falling asleep again* items.

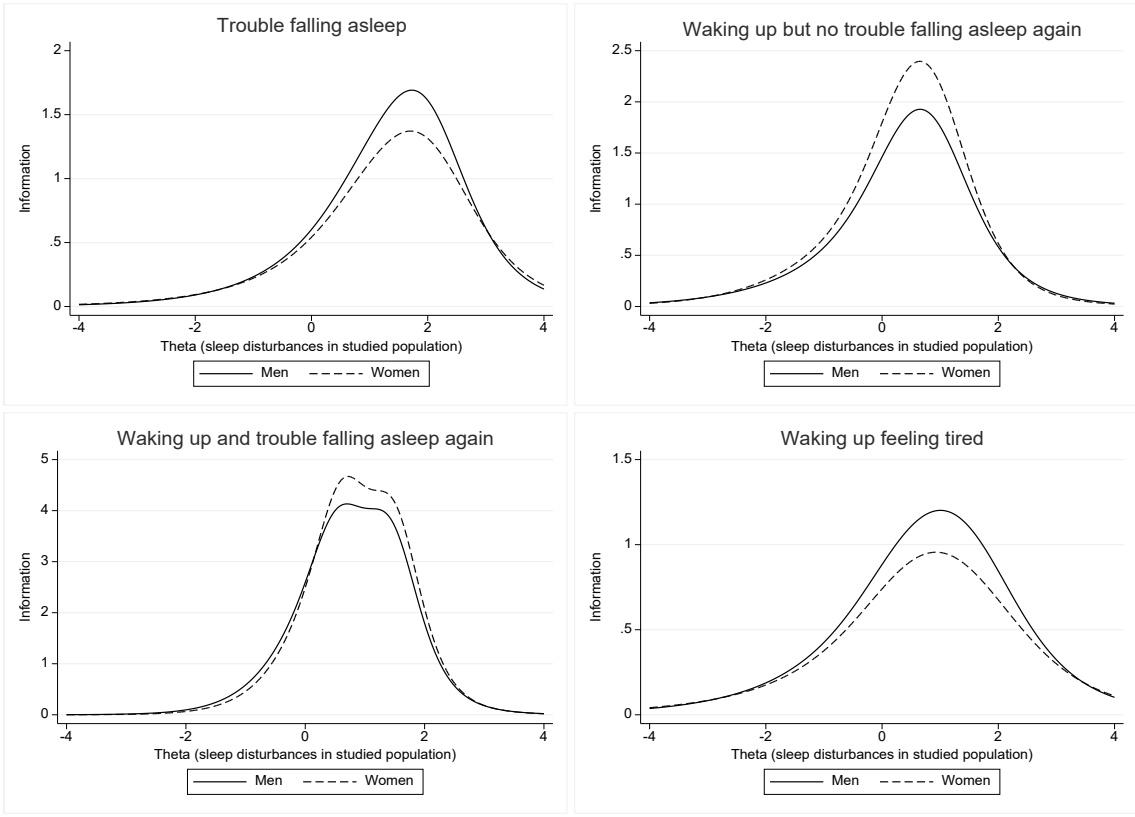


Figure 6. Item information functions of JSS items grouped by sex. From Juhola et al. Does the Jenkins Sleep Scale show sex-related differential item functioning? Prospective cohort study among employees in public sector. Submitted to BMJ Open. With permission from a copyright holder.

6 Discussion

6.1 Main results

This was a prospective survey-based study of 66,948 employees in the Finnish public sector. Its aim was to investigate the persistence of sleep difficulties (mild sleep disturbances) in the working-age population.

In the studied population, the sleep difficulties demonstrated great persistence over time. The severity and prevalence of the sleep difficulties during the 16-year follow-up nearly exclusively relied on the initial severity of sleep difficulty. Depending on age and gender, sleep difficulties did not change in 60%-90% of respondents and worsened in 14%-22% of respondents. Only 3%-8% of sleep difficulties eased during the follow up period. Varying slightly between the sexes and age groups, deteriorating sleep correlated with excessive alcohol consumption, smoking, obesity and low physical activity. The strongest positive correlations between deteriorating sleep and other factors were observed for excessive alcohol consumption and obesity. To ensure the accuracy of the results, the validity and reliability of the JSS (the main outcome measure in this study) were evaluated. The JSS was established as both a valid and reliable measure. It had a unidimensional factor structure and good internal consistency, showed overall good psychometric properties, and was able to differentiate people with different sleep disturbance severities. However, the JSS may produce mildly diverse results among men and women.

6.2 Persistence of sleep difficulties in relation to previous knowledge

The prevalence of sleep difficulties experienced on at least one night a week varied from 12% to 46% at different time points of the study. Among people with severe sleep difficulties, this variation was even smaller from 2% to 4%. Overall, among most of the respondents, the severity of sleep difficulties remained unchanged during the entire 16-year follow-up. In other words, people with severe sleep difficulties will probably experience the same level of sleep problems even after 16 years. Only a few previous studies have observed substantial variations in the developmental

trajectories of sleep difficulties over time emphasizing, however, relatively high remission rates.[34 39 168] Otherwise, the results of this study are in line with most of previous studies reporting substantial persistence of sleep difficulties over time.[37 42 130 134 169] The direct comparison between the present findings and previous reports is difficult due a different terminology and criteria for insomnia and sleep difficulties.

Like this study, previous research has also found that sleep difficulties tend rather to worsen than to improve over time.[43] There have been some exceptions. For example, Myllyntausta et al. reported decrease in sleep difficulties with retirement, which may also explain the downward shift of one trajectory, identified in the current study, among over 50-year-old group.[7] Previous studies have shown that even mild sleep difficulties are a significant risk factor for more severe sleep difficulties, and for this reason, their early consideration when planning treatment is recommended.[44]

6.3 Association between changes in lifestyle and changes in sleep difficulties in relation to previous knowledge

It seems, that the change in sleep difficulties during the follow-up nearly solely relied on initial severity. Varying slightly between the sexes and age groups, deteriorating sleep correlated with excessive alcohol consumption, obesity and low physical activity. The strongest positive correlations were observed between deteriorating sleep and changes in alcohol consumption and obesity. This is in line with results of previous studies on the interconnection between sleep problems and alcohol[72 170] and obesity[39 129 171-173]. This connection has been unclear and probably dose-related as it has been suggested that moderate alcohol consumption and smoking are not significant risk factors for persistent insomnia.[39]

In addition to other effects of **smoking**, a need to smoke may interrupt night sleep. This study found that, at least, among younger women, smoking was associated with worsening sleep difficulties. Smoking has been linked to sleep problems in previous studies.[174 175] The results were uncertain as there were only a small number of smokers among the participants and, during the follow-up, the participants were rather quitting smoking than started it again.

Excessive **alcohol consumption** had similar effect in most of the studied cohort, except among young men and women. On contrary, some previous research have not found the association between smoking or alcohol consumption and the persistence of sleep problems.[37] This may be due to the differences in the severity of studied sleep problems – insomnia instead of milder sleep difficulties. Otherwise, similarly to the current findings, earlier studies have connected excessive alcohol consumption with sleep problems.[44 72 174 175] Establishing the connections between

alcohol consumption and sleep is complicated, because some people drink alcohol to alleviate their sleep difficulties, although it often has the opposite effect.[72 176]

Low **physical activity** predicted sleep problems among older men, which is in line with the findings of previous studies.[135 177] The relations with low physical activity has also been studied before.[177] It should also be noted that there could be a two-way connection and low physical activity can also be the result of poor sleep and fatigue. Also, the potential concurrent effects of overweight and low physical activity should be considered – overweight can affect physical activity and further cause poor sleep.

Overweight among men and middle-aged and older women predicted sleep difficulties, also in line with the results of earlier studies.[178 179] Emotional stress has previously been suggested as the reason for a connection between overweight and sleeping difficulties.[172] However, some previous studies have not observed such associations with obesity, especially when examining the connection with sleep duration.[180 181] It is known that sleep difficulties themselves also cause overweight. Overall, the role of overweight in poor sleep is unclear and it is possible that secondary factors, such as emotional stress, can lay behind the sleep difficulties associated with overweight.[172]

Some differences between the current results and previous reports may be explained by the differences between the studied populations (sex- and age distribution, socioeconomic and educational status, health issues etc.), variations in diagnostic criteria, outcome measures used to assess sleep difficulties and statistical methods used. In the case of a longitudinal study, it is also possible that the events between measurement times are different in different populations, both in terms of the content of the events and their magnitude.

6.4 Validity of JSS in relation to previous knowledge

The JSS was found to be reliable (internally consistent) and a one-dimensional scale with sufficient difficulty and discrimination properties. This is in line with the findings of previous studies.[109-117 121 122] There was only a slight sex-related DIF, which is not directly comparable with previous knowledge as IRT and Rasch analyses have not been previously employed to evaluate the potential DIF in JSS statistics. However, this sex-related variance might be related to differences between the amount and severity of sleep difficulties among men and women.[139 182] It has also been stated that men and women may also answer sleep questionnaires differently.[139 152] On contrary to the current results, the JSS has been reported to be invariant regarding sex in a single study employing the CFA.[110] The same study highlighted the invariance of the JSS also regarding income socioeconomic and marital status.

6.5 Strength and limitations

The main strength of the study was a nation-wide cohort with a long follow-up. In addition, the relatively large number of respondents can also be considered a strength of the study.

Some factors may weaken the generalizability of the results, such as the predominance of women in the studied cohort. Some short-term fluctuations in sleep difficulties between repeated measures might have remained. The data on nonrespondents were not available for an analysis. While the Finnish version of the JSS has been used for more than 20 years, it has not undergone full language validation, which means it might not sufficiently match the original English version. As for any study if similar design, the surveys provide sampled (incomplete) data, which could result in a selection bias. All the available data were self-reported and thus, respondent motivation, attitudes, unintentional biases could impact accuracy. As in any survey, the respondents might not feel comfortable providing answers that present themselves in an unfavourable manner, or the responses might be affected even by boredom.

6.6 Recommendations for further research

Little is currently known about the persistence and prevention of sleep difficulties. Research focusing on these issues should be significantly increased, especially as it is known that sleep-related problems cause a large number of difficulties in daily functioning and work ability and can lead to other diseases. The effects of sleep difficulties on work efficiency and sickness absences should be investigated. The persistence of sleep difficulties should be studied in different countries, to enable comparisons across diverse cultures. Life-style, health-related social and other factors, potentially responsible for fluctuations in the development of sleep problems should be revealed. The effects of other diseases and the preventive measures for these conditions on the development of sleep difficulties should also be investigated. Special attention should be paid to simultaneous changes in sleep problems and other factors – this can be done employing a multigroup trajectory analysis.

6.7 Clinical implications

This study is one of the few that have examined the persistence of sleep difficulties in the working-age population together with possible risk factors. It offers important information on the developmental course of sleep difficulties over time are a problematic set of symptoms and diseases and that influencing them is difficult. While there are some fluctuations in the development of sleep difficulties over time, most of people probably demonstrate the substantial stability of sleep disturbances.

Clinicians should take this stability into account and pay an especially great attention to the prevention of such conditions, primarily through modifying lifestyle risks. This is true, even though the effects of lifestyle changes on sleep difficulties seem to be limited, and the prognosis for recovery from disturbed sleep is poor. Everything, which can prevent the development of sleep difficulties or their transition to chronicity and more severe sleep disorders should be considered for inclusion into a prevention and treatment plan.

7 Conclusions

In a 16-year follow-up, the prevalence and severity of sleep difficulties among working-aged people usually remained unchanged. It seems that developmental trajectory of severity of sleep difficulties depends solely on the initial severity level in most of the respondents. Rarely observed changes were mostly associated with excessive alcohol consumption, overweight, and low physical activity. These connections varied slightly between the age groups and the sexes. No clear connection between sleep difficulties and smoking was observed, this finding contrasts somewhat with previous studies. The results also confirm the previously held notion of gender differences in survey responses. The JSS, which was used as the main outcome measure of this study, was found to be a reliable and valid measure, which can be recommended as an easy scale of screening for sleep difficulties in clinical practice.

Acknowledgements

When I studied medicine, I was certain that I wouldn't pursue a dissertation or research. Little did I know. I was also convinced I wouldn't become a physiatrist. That belief turned out to be wrong, too. Now, however, I can say that I'm very happy and grateful I was mistaken.

The material for this study is part of the Finnish Public Sector Study (FPSS), an ongoing project by the Finnish Institute of Occupational Health. I am especially grateful for the opportunity to use this material in my research.

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