Sleep Medicine 85 (2021) 15–20

Contents lists available at ScienceDirect

Sleep Medicine

journal homepage: www.elsevier.com/locate/sleep

Original Article

Subtypes of insomnia and the risk of chronic spinal pain: the HUNT study

Eivind Schjelderup Skarpsno [a, b, *], Paul Jarle Mork [a], Anna Marcuzzi [a], Tom Ivar Lund Nilsen [a, c], Ingebrigt Meisingset [a, d]

[a] Department of Public Health and Nursing, Norwegian University of Science and Technology (NTNU), Trondheim, Norway
[b] Department of Neurology and Clinical Neurophysiology, St. Olavs Hospital, Trondheim, Norway
[c] Clinic of Anaesthesia and Intensive Care, St. Olavs Hospital, Trondheim University Hospital, Trondheim, Norway
[d] Unit for Physiotherapy Services, Trondheim Municipality, Trondheim, Norway

ARTICLE INFO

Article history:
Received 8 March 2021
Received in revised form
19 May 2021
Accepted 21 June 2021
Available online 28 June 2021

Keywords:
Sleep
Chronic pain
Prospective
Risk
Epidemiol
The HUNT Study

ABSTRACT

Objective: To examine the association between subtypes of insomnia and the risk of chronic spinal pain.
Methods: The study comprised 16,401 participants without chronic spinal pain at baseline who were followed for ~11 years. People were categorized into 'no insomnia symptoms', 'subthreshold insomnia', and 'insomnia'. Insomnia was defined according to the diagnostic classification system requiring both daytime and nighttime symptoms, and further categorized into subtypes based on nighttime symptoms (ie, sleep onset latency [SOL-insomnia], wake after sleep onset [WASO-insomnia], early morning awakening [EMA-insomnia], or combinations of these). Subthreshold insomnia comprised those with only daytime impairment or one or more nighttime symptoms. Chronic spinal pain was defined as pain in either 'neck', 'low back', or 'upper back', or a combination of these.
Results: In multivariable regression analysis using people without insomnia as reference, people with subthreshold insomnia or insomnia had relative risks (RRs) of chronic spinal pain of 1.29 (95% confidence interval [CI] 1.21–1.38) and 1.50 (95% CI 1.34–1.68), respectively. The RRs for people with one nighttime symptom were 1.30 (95% CI 0.83–2.05) for WASO-insomnia, 1.32 (95% CI 1.06–1.65) for EMA-insomnia, and 1.70 (95% CI 1.32–2.18) for SOL-insomnia, respectively. Combinations of nighttime insomnia symptoms gave RRs from 1.45 (95% CI 1.08–1.94) for WASO + EMA-insomnia to 1.72 (95% CI 1.36–2.19) for all nighttime symptoms (SOL + WASO + EMA-insomnia).
Conclusions: These findings suggest that the risk of chronic spinal pain is highest among persons with insomnia subtypes characterized by sleep onset latency or among those having insomnia symptoms in all parts of the sleep period.

1. Introduction

Spinal pain is a highly prevalent and complex condition that has been the world's leading cause of disability the last decades [1]. Globally, years lived with disability caused by low back pain increased by more than fifty percent between 1990 and 2015, mainly because of population increase and ageing, and the greatest increase was observed in low-to-middle income countries [2]. To reduce the burden of chronic spinal pain it is important to identify modifiable risk factors that can inform the development of interventions and preventive measures.

Previous studies have shown that insomnia is associated with increased risk of spinal pain [3–5]. Chronic insomnia is defined by the presence of at least one nighttime symptom (ie, difficulty initiating sleep, trouble maintaining sleep or early morning awakenings) accompanied by daytime sleepiness that influence important aspects of life [6]. Thus, the possible combinations of the daytime and three nighttime symptoms provide a basis for several different subtypes of chronic insomnia. A recent study indicates

* Corresponding author. Department of Public Health and Nursing, Norwegian University of Science and Technology (NTNU), 7491 Trondheim, Norway.
E-mail address: eivind.s.skarpsno@ntnu.no (E.S. Skarpsno).

https://doi.org/10.1016/j.sleep.2021.06.029

that these different subtypes may have different impact on disease [7]. This latter view is partly supported by a recent prospective study showing a dose-dependent association between number of nighttime insomnia symptoms among people with chronic insomnia and risk of chronic musculoskeletal pain and pain-related disability [8]. However, there is a lack of studies examining the influence of insomnia subtypes on the risk of chronic spinal pain.

The aim of the current study was to examine the association between subtypes of chronic insomnia and risk of chronic spinal pain. The different insomnia subtypes were defined according to the possible combinations of nighttime symptoms along with daytime impairment. We also examined the association between subthreshold insomnia (ie, only daytime impairment or one or more nighttime symptoms) and risk of chronic spinal pain.

2. Methods

2.1. Study population

This prospective study utilized data from the third (2006–08) and fourth (2017–19) survey of the Norwegian HUNT Study. All inhabitants aged 20 years or older residing in Trøndelag County in Norway have been invited to participate in the Trøndelag Health Study (the HUNT Study). In the third survey, 50,807 (54%) people accepted the invitation. In the fourth survey, 56,042 (54%) people accepted the invitation. Information on lifestyle and health-related factors were collected by questionnaires and clinical examination at both surveys. More detailed information about the HUNT Study can be found at https://www.ntnu.edu/hunt [9].

We included 33,900 participants who participated in both the third (2006–08) and fourth (2017–19) survey. At baseline in 2006–08, the participants had to answer a questionnaire at home before they attended a basic health examination. After the clinical examination, all participants were given a second questionnaire including questions on sleep quality, chronic spinal pain, demographical and subject characteristics. About 19% of those who attended the clinical examination did not respond to the second part of the survey. To improve efficiency and reduce potential bias due to the missing data, a simulation-based multiple imputation procedure was used to replace missing observations on relevant factors at baseline (more information about the multiple imputation procedure is given in "Statistical analyses"). Our final analytical sample comprised 16,401 people without chronic spinal pain at baseline and with complete follow-up data on chronic spinal pain (See Fig. 1).

The study was approved by the Regional Committee for Ethics in Medical Research (project no. 2014/612 REK midt). The study was carried out according to the Declaration of Helsinki.

2.2. Subthreshold insomnia, chronic insomnia, and insomnia subtypes

Insomnia symptoms at baseline were assessed by the following four questions: 1) "How often during the last three months have you had difficulty falling asleep at night?", 2) "How often during the last three months have you woken up repeatedly during the night?", 3) "How often during the last three months have you woken too early and couldn't get back to sleep?", and 4) "How often during the last three months have you felt sleepy during the day?", with three response options on each question: 'Never/seldom', 'Sometimes' and 'Several times a week'. Participants were classified with chronic insomnia if they answered, 'Several times a week' on at least one of the questions 1–3, and 'Several times a week' on question 4. The information retrieved from these four questions approximates the information necessary to diagnose chronic insomnia [6], ie, persistent sleep difficulty ['difficulty falling asleep', 'difficulty maintaining sleep', and/or 'waking up too early'] accompanied by daytime sleepiness. People who reported daytime sleepiness or at least one insomnia symptom 'several times a week' were defined as having subthreshold insomnia (ie, not fulfill the insomnia diagnosis.

In line with a previous study [7], people classified to have chronic insomnia were further divided into the following seven subtypes: 1) sleep onset latency (SOL) insomnia if they had trouble falling asleep at night, 2) wake after sleep onset (WASO) insomnia if they had trouble maintaining sleep, and 3) early morning awakening (EMA) insomnia if they reported to wake up too early in the morning. For these subtypes, people could not report other nighttime symptoms. People reporting more than one nighttime insomnia symptom were divided into 4) SOL + WASO-insomnia, 5) SOL + EMA-insomnia, 6) WASO + EMA-insomnia, and 7) SOL + WASO + EMA-insomnia.

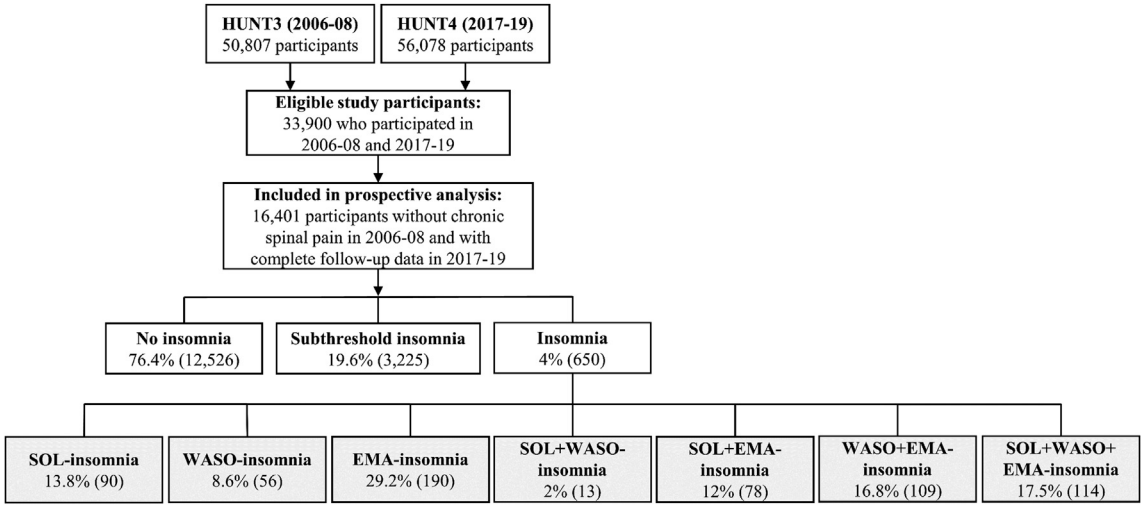

Fig. 1. Selection of the study participants.

2.3. Chronic spinal pain at baseline and follow-up

At baseline, all participants were asked "During the last year, have you had *pain and/or stiffness* in your muscles and joints that lasted for at least three consecutive months?" Those who answered 'yes' were asked to indicate the affected body area(s). Participants were defined to have chronic spinal pain if they answered 'yes' to the first question and reported either 'neck', 'low back', or 'upper back, or a combination of these three,' as affected body areas. Participants who reported to have pain the neck, upper back, or low back pain at baseline were excluded from the study.

At follow-up, an almost identical question was given: "During the last year, have you had *pain* in your muscles and joints that lasted for at least three consecutive months?" Those who answered 'yes' were asked to indicate the affected body area(s). Participants were defined to have chronic spinal pain at follow-up if they reported either 'neck', 'low back', or 'upper back', or a combination of these three, as affected body areas.

2.4. Possible confounding factors

All possible confounders were assessed at baseline. Body mass index (BMI) was calculated as weight divided by the square of height (kg/m^2) by using the standardized measurements of height (to the nearest centimeter) and weight (to the nearest half kilogram) from the clinical examination. Smoking status was assessed by questions about past or present use of cigarettes and were divided in three categories: 'never smoked', 'former smoker' and 'current smoker'. Leisure time physical activity was assessed by three questions on frequency, intensity, and duration. According to the recommendations for physical activity in adults at the time of baseline in 2006–08 [10], we categorized the participants into three levels of physical activity: inactive, below the recommended level or recommended level. The questionnaire on leisure time physical activity has been validated against direct measurements of maximal oxygen uptake and found to perform well [11]. Symptoms of anxiety and depression was assessed by the validated HADS-questionnaire (Hospital Anxiety and Depression Scale) [12]. As recommended, the cut-off score was set to $\geq$8 on both anxiety and depression to indicate presence of anxiety and/or depression [12]. Symptoms of anxiety and depression were then divided into four categories ('no anxiety or depression', 'anxiety', 'depression', and 'anxiety and depression'). Shift work was assessed by the question "Do you work shifts, at night, or on call?", with response options 'no' and 'yes'. Comorbid conditions were assessed by questions on current or previous disease (heart disease, lung diseases, diabetes, cancer, rheumatic diseases, or degenerative joint disease). Alcohol consumption was assessed by the CAGE (Cut down, Annoyed, Guilty, Eye-opener) questionnaire using a cutoff score $\geq$2 to cate possible alcohol abuse [13]. Other sleep conditions such as possible obstructive sleep apnea and restless legs syndrome were assessed by two questions asking about breathing pauses during the night or symptoms or discomfort, tingling or prickling in the legs during the last three months. The response options were 'never/seldom', 'sometimes' and 'several times a week'. People who answered 'several times a week' on one or both questions were considered to have other sleep complaints. Pain medication was assessed by a question on use of pain medication the last month ('never/seldom', 'weekly', 'several times a week/daily').

2.5. Statistical analyses

A modified Poisson regression model was used to estimate risk ratios (RR) for chronic spinal pain at follow-up associated with subthreshold insomnia and the insomnia subtypes at baseline. The precision of the RRs was assessed by 95% CI using robust variance estimation. Participants reporting subthreshold insomnia or one of the seven insomnia subtypes (SOL-insomnia, WASO-insomnia, EMA-insomnia, SOL + WASO-insomnia, SOL + EMA-insomnia, WASO + EMA-insomnia, and SOL + WASO + EMA-insomnia) were compared with the reference group of people without insomnia symptoms. Selection of confounders was done based on a priori knowledge about factors that could be related to the exposure and outcomes under study. In our multi-adjusted analysis, we adjusted for age (continuous), BMI (continuous), leisure time physical activity (inactive, below the recommended level, recommended level), shift work (no, yes), alcohol consumption (no, yes), and smoking (never, former, current).

We conducted a series of sensitivity analyses to test the robustness of the results. First, to assess the possible influence of other sleep disorders on the association between insomnia subtypes and risk of spinal pain, we excluded people who reported frequent breathing pauses during the night and/or symptoms of discomfort, tingling or prickling in the legs. Second, there is an overlap but unclear temporal association between sleep quality and comorbid disorders, such as mental disorders and several medical conditions [14–16]. We therefore repeated the main analysis adjusting for anxiety and/or depression and other comorbid conditions (heart disease, lung diseases, diabetes, cancer). Finally, to reduce the possible influence of reverse causation (ie, that other chronic pain conditions is associated with insomnia at baseline), we repeated the main analysis adjusting for other pain conditions (upper and lower extremity pain, rheumatoid arthritis, arthritis) and use of pain medication.

2.5.1. Multiple imputation procedure

The pattern for the missing observations on sleep, spinal pain, and the covariates was visualized in a matrix structure to detect trends in the dataset and further explored in descriptive tables by comparing complete data with those with incomplete data. To reduce sampling variability from the imputation process [17], hundred imputed datasets were generated by chained equations (ie, ordered logistic for ordinal data, logistic for binary data, and linear for continuous data). All the variables used in the main analysis were included as prognostic variables in our model. To increase the precision, we included comorbid somatic conditions (headache, diabetes, heart disease, lung disease, rheumatic diseases), other sleep disorders (obstructive sleep apnea syndrome and restless leg syndrome), negative life events, use of pain medication, blood pressure, marital status, overall health, and working status as auxiliary variables.

All statistical analyses were performed using Stata for Windows, version 16.0 (StataCorp LP, College Station, Texas).

3. Results

Table 1 presents the baseline characteristics of the participants stratified by the presence of insomnia. The proportion who reported subthreshold insomnia or fulfilled the criteria for chronic insomnia at baseline were ~20% and ~4%, respectively. Among people with chronic insomnia, the largest subtype was EMA-insomnia (~30%), whereas 17% reported all three nighttime symptoms (SOL + WASO + EMA-insomnia). Overall, 4084 incident cases of chronic spinal pain were reported at follow-up (crude absolute risk [AR] = 24.8%). Supplementary table 1 shows that the complete cases and the imputed study population had similar baseline characteristics.

Table 2 shows the associations between subthreshold insomnia, chronic insomnia subtypes and risk of chronic spinal pain. Compared to people without insomnia, people with subthreshold

Table 1
Characteristics of the study population at baseline stratified by insomnia symptoms.

Variables	No insomnia	Subthreshold insomnia[a]	Chronic insomnia[b]
Participants, no.	12,526	3225	650
Age, mean (SD), years	50.7 (13.5)	51.8 (14.2)	47.0 (14.3)
Females, % (no.)	52.0 (6509)	57.3 (1847)	61.5 (400)
Body mass index, mean (SD), kg/m^2	26.7 (4.0)	26.9 (4.23)	27.3 (4.9)
Low physical activity or inactive, % (no.)[c]	78.3 (9813)	75.6 (2438)	73.2 (476)
Anxiety and/or depression, % (no.)[d]	5.8 (723)	17.4 (562)	34.8 (226)
Shift work, % (no.)	26.5 (3324)	29.1 (939)	33.5 (218)
Current smoker, % (no.)	19.6 (2454)	21.0 (676)	25.1 (163)
Possible alcohol abuse, % (no.)[e]	7.7 (965)	10.4 (336)	17.1 (111)
Comorbid condition(s), % (no.)[f]	17.5 (2198)	22.4 (722)	23.4 (152)
Symptoms of obstructive sleep apnea and/or restless legs syndrome, % (no.)	4.0 (495)	10.5 (339)	19.1 (124)

Abbreviations: SD, standard deviation.
[a] At least one insomnia symptom ('difficulty falling asleep', 'difficulty maintaining sleep', 'waking up too early', 'daytime sleepiness') but not the combination of nighttime insomnia symptoms and daytime sleepiness.
[b] Persistent sleep difficulty ('difficulty falling asleep', 'difficulty maintaining sleep', and/or 'waking up too early') accompanied by daytime sleepiness.
[c] Classified according to physical activity recommendations among adults at baseline (2006–08).
[d] Defined by a score ≥8 on the Hospital Anxiety and Depression Scale (HADS).
[e] Defined by a score ≥2 on the CAGE questionnaire.
[f] At least one of the following conditions: Heart disease, lung diseases, diabetes, cancer, fibromyalgia, rheumatic diseases or degenerative joint disease.

Table 2
Risk of chronic spinal pain at follow-up associated with insomnia symptoms and chronic insomnia subtypes at baseline.

	No. of persons	No. of cases	Age-adjusted, RR[a]	Multi-adjusted, RR[b] (95% CI)
Insomnia symptoms				
No insomnia symptoms	12,526	2874	1.00	1.00 (reference)
Subthreshold insomnia[c]	3225	966	1.34	1.29 (1.21–1.38)
Chronic insomnia[d]	650	244	1.61	1.50 (1.34–1.68)
Chronic insomnia subtypes[e]				
SOL	90	39	1.87	1.70 (1.32–2.18)
WASO	56	17	1.32	1.30 (0.83–2.05)
EMA	190	63	1.43	1.32 (1.06–1.65)
SOL + WASO	13	6	1.80	1.62 (0.81–3.25)
SOL + EMA	78	30	1.68	1.51 (1.11–2.04)
WASO + EMA	109	38	1.51	1.45 (1.08–1.94)
SOL + WASO + EMA	114	48	1.85	1.72 (1.36–2.19)

Abbreviations: CI, confidence interval; RR, risk ratio; SOL, sleep onset latency; WASO, wake after sleep onset; EMA, early morning awakening.
[a] Adjusted for age (continuous).
[b] Multi-adjusted for age (continuous), gender (women, men), body mass index (continuous), leisure time physical activity (inactive, below recommended level, recommended level), shift work (no, yes), alcohol consumption (no alcohol abuse, possible alcohol abuse), and smoking (never, former, current).
[c] Daytime sleepiness or at least one insomnia symptom ('difficulty falling asleep', 'difficulty maintaining sleep', 'waking up too early', 'daytime sleepiness').
[d] Persistent sleep difficulty ('difficulty falling asleep', 'difficulty maintaining sleep', and/or 'waking up too early') accompanied by daytime sleepiness.
[e] People with chronic insomnia categorized into insomnia subtypes based on predominant nighttime symptoms (sleep-onset-latency-insomnia [SOL-insomnia], wake after sleep onset-insomnia [WASO-insomnia], early morning awakening-insomnia [EMA-insomnia], and combinations of these).

insomnia had a RR of 1.29 (95% CI 1.21–1.38), whereas people with chronic insomnia had a RR for chronic spinal pain of 1.50 (95% CI 1.34–1.68). The RRs for the subtypes of chronic insomnia were 1.70 (95% CI 1.32–2.18) for SOL, 1.30 (95% CI 0.83–2.05) for WASO-insomnia, and 1.32 (95% CI 1.06–1.65) for EMA-insomnia. Among people categorized with combinations of nighttime insomnia symptoms, the RRs were 1.62 (95% CI 0.81–3.25) for SOL + WASO-insomnia, 1.51 (95% CI 1.11–2.04) for SOL + EMA-insomnia, 1.45 (95% CI 1.08–1.94) for WASO + EMA-insomnia, and 1.72 (95% CI 1.36–2.19) for all nighttime symptoms (SOL + WASO + EMA-insomnia). Supplementary table 2 shows both multiple imputation and complete case results tabulated, showing similar patterns between the insomnia subtypes and risk of chronic spinal pain using complete cases.

3.1. Supplementary analyses

When excluding people with other possible sleep disorders (obstructive sleep apnea syndrome and restless leg syndrome), the results remained largely unchanged, ie, compared to people without insomnia, those with WASO-insomnia and EMA-insomnia had RRs of 1.22 (95% CI 0.71–2.09) and 1.27 (95% CI 0.98–1.65), respectively, increasing to 1.73 (95% CI 1.34–2.24) among those with SOL-insomnia and 1.79 (95% CI 1.39–2.32) among those with SOL + WASO + EMA-insomnia. Similar, when adjusting for anxiety and/or depression, we observed only 10–15% reduction in risk in some of the categories compared to the main analysis. Adjustment for other comorbid conditions (ie, heart disease, lung diseases, diabetes, cancer), other chronic pain conditions or use of pain medication had negligible influence on the results (<10% reduction in risk).

4. Discussion

Among adults without chronic spinal pain at baseline, people with subthreshold insomnia, EMA-insomnia or WASO-insomnia had a ~30% increased risk of chronic spinal pain at ~11 years follow-up, compared to people without insomnia symptoms. This risk increased to ~70% among people with SOL-insomnia or chronic insomnia characterized by symptoms in all parts of the sleep period (SOL + WASO + EMA insomnia).

Previous studies have found an association between insomnia and risk of chronic spinal pain [3], [-5] but none of these studies

have assessed the influence of different insomnia subtypes on this association. One recent study highlights inter-individual differences in chronic insomnia by showing that the number of nighttime symptoms is dose-dependently associated with risk of chronic musculoskeletal pain and pain-related disability [8]. Although our results showed that the commonly used definition of chronic insomnia was associated with 50% greater risk of chronic spinal pain compared to people without insomnia symptoms, the risk estimates ranged from 30 to 72% when people were divided into chronic insomnia subtypes. These findings are important because they suggest that chronic insomnia comprises subtypes that are likely to have different impact on the long-term risk of chronic spinal pain.

People with SOL + WASO + EMA-insomnia had the greatest risk of chronic spinal pain, which is in agreement with data showing that insomnia with symptoms in all phases of the sleep period is the most severe subtype with regard to poor health outcomes [7,18]. However, that people with WASO-insomnia had 30% greater risk is somewhat surprising considering the adverse effect of fragmented sleep on pain outcomes shown in the experimental setting [19]. Our data show that delayed sleep onset latency emerge as an important symptom that is strongly associated with the risk of spinal pain. Although the strong contribution of sleep onset latency could be related to mental distress [20], use of hypnotics [7], or the presence of other sleep disorders [21], similar patterns remained after a series of sensitivity analyses adjusting for these factors. It remains uncertain why those with SOL-insomnia have almost similar risk as those with symptoms in all parts of the sleep period. However, some evidence indicates that SOL-insomnia and SOL + WASO + EMA-insomnia are more prevalent among people with an evening chronotype [7], and that people with an evening preference report shorter sleep, poorer sleep efficiency, and increased pain sensitivity [22–25]. Sleep duration is considered important because it may be an index of the biological severity of the insomnia disorder [26]. Our results showing different pain burden between the subtypes could therefore be related to other sleep related characteristics such as circadian dysfunction and sleep duration. Moreover, hyperarousal, such as overactive neurobiological and psychological systems, is considered a key component in the pathophysiology of insomnia [27]. Insomniacs with high stress-related premorbid sleep reactivity are more likely to have trouble initiating sleep than nonreactive sleepers [28]. It is therefore conceivable that people suffering from SOL-insomnia have a higher level of hyperarousal than people with other subtypes, and that this subtype is a precursor for more severe and phenomenologically diffuse insomnia [29].

4.1. Implications of findings

Findings of a detrimental effect of insomnia subtypes on the risk of chronic spinal pain add to the literature regarding the disease burden of specific insomnia phenotypes [30–32]. Importantly, all the subtypes were associated with an increased risk of chronic spinal pain, but our data show that particular attention should be drawn to those with SOL-insomnia or symptoms in all parts of the sleep period. These findings are valuable because they enable identification of high-risk individuals for preventive interventions based on three simple nighttime symptoms. Although it remains unclear how to optimally deliver subtype-specific interventions to reduce the risk of chronic spinal pain, it may be useful to assess sleep hygiene behavior, sleep habits, and sleep environment when diagnosing insomnia [6]. This may help clinicians to provide more targeted advice to manage specific subtypes of insomnia.

Moreover, subthreshold insomnia was associated with similar risk as those with WASO-insomnia and EMA-insomnia. This latter finding shows the importance of considering subthreshold insomnia as another subgroup encompassing people with variable levels of sleep problems despite not fulfilling the insomnia diagnosis based on the daytime sleepiness criteria. This view is supported by studies showing that frequency of sleeplessness or number of insomnia symptoms are dose-dependently associated with the risk of chronic pain [33,34]. Thus, clinicians and researchers should not only consider insomnia symptoms exclusively based on the vague insomnia definition, but also consider all types of insomnia symptoms irrespective of daytime sleepiness that influence important aspects of life. Acknowledging the unsatisfactory diagnostic accuracy of insomnia is important because it may translate into improved clinical effectiveness. In the long term, combining several sleep dimensions may be an important step towards creating improved treatment strategies and preventive initiatives. To fully understand the relation between subthreshold insomnia and chronic insomnia subtypes on risk of chronic spinal pain, more research investigating the impact of other sleep characteristics in combination with the insomnia symptoms is required (eg, sleep duration, sleep quality, circadian preferences, and comorbid sleep disorders). Additionally, to obtain more reliable answers, future studies attempting to mitigate key sources of bias (eg, triangulation) [35] when exploring the causal effect of different sleep characteristics should be investigated further.

4.2. Strengths and limitations

Key strengths of the current study include the prospective design, the large study population, and the adjustment for several important confounders. Another strength is that our simulation-based imputation procedure may have improved the efficiency of our study [36] because we were able to categorize people into subtypes with greater precision. However, we cannot exclude the possibility that our findings are explained by an imprecise insomnia definition, lumping together severe and milder forms of the disorder, or that chance influenced our findings due to some of the small subtypes. We were unable to distinguish between pain in different regions (neck, upper back, low back) or could not exclude people with lower or upper limb pain at baseline, but similar patterns were observed when we adjusted for other chronic pain conditions and use of pain medication. Our question on spinal pain was based on pain and/or stiffness that had lasted for at least three consecutive months, and it is possible that those with a recent pain episode were more likely to report insomnia symptoms. Moreover, we had no information about pain severity, nor fluctuations in pain severity throughout the follow-up period. It should also be noted that our sample constitutes pain-free participants who took part in two surveys during ~11 years. It is possible that people with more severe insomnia were not able to participate in both surveys, and that this selection may lead to underestimation of the effect of insomnia subtypes on the risk of spinal pain. Although we adjusted for several health-related factors, residual confounding due to unknown or unmeasured factors influencing both insomnia and chronic spinal pain cannot be excluded. Thus, we cannot exclude the possibility that other undetected diseases could have influenced our findings or that clearer subtypes could have emerged if we included biologically based traits such as cognitions, mood, history of life events, or family history [30,37]. Since the participants in this study had to take part in two consecutive surveys over ~11 years, it is conceivable that we have a particularly healthy cohort that underestimated our findings. Finally, although understanding the previously unrecognized heterogeneity of the insomnia disorder could be the key to facilitate elucidation of the mechanisms linking insomnia and spinal pain, our results should be interpreted in view of the long follow-up and the possible

instability of insomnia symptoms [29], although time-consistent insomnia phenotypes over several years also have been reported [30].

5. Conclusions

The current study shows that people with subtypes of insomnia have an increased risk of chronic spinal pain, compared to those without insomnia symptoms. However, the risk was ~30% higher among people with subthreshold insomnia, EMA-insomnia, or WASO-insomnia, increasing to ~70% higher among those with SOL-insomnia or symptoms in all parts of the sleep period. These findings suggest that interventions aiming to reduce risk of chronic spinal pain should target people with all types of sleep problems, and especially people with the subtypes characterized by sleep onset latency as the predominant symptom or among those having insomnia symptoms in all parts of the sleep period.

Funding

This work was supported by a grant to Eivind Schjelderup Skarpsno from the Liaison Committee between the Central Norway Regional Health Authority (RHA) and the Norwegian University of Science and Technology (grant number: 90502200).

Credit author statement

ESS, PJM, AM, TILN and IM designed the study. ESS analyzed the data. ESS, PJM, AM, TILN and IM interpreted the data. ESS and IM drafted the manuscript. ESS, PJM, AM, TILN, and IM revised the manuscript critically for important intellectual content. All authors approved the final version of the manuscript. All authors declare that they accept full responsibility for the conduct of the study, had access to the data and controlled the decision to publish.

Acknowledgement

The Trondelag Health Study (HUNT) is a collaboration between the HUNT Research Centre (Faculty of Medicine and Health Sciences, Norwegian University of Science and Technology), the Trondelag County Council and the Norwegian Institute of Public Health.

Conflict of interest

The authors have no conflicts of interest to declare.

The ICMJE Uniform Disclosure Form for Potential Conflicts of Interest associated with this article can be viewed by clicking on the following link: https://doi.org/10.1016/j.sleep.2021.06.029.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.sleep.2021.06.029.

References

[1] Hurwitz EL, Randhawa K, Yu H, et al. The Global Spine Care Initiative: a summary of the global burden of low back and neck pain studies. Eur Spine J 2018;27:796–801.
[2] Hartvigsen J, Hancock MJ, Kongsted A, et al. What low back pain is and why we need to pay attention. Lancet 2018;391(10137):2356–67.
[3] Agmon M, Armon G. Increased insomnia symptoms predict the onset of back pain among employed adults. PloS One 2014;9(8):e103591.
[4] Uhlig BL, Sand T, Nilsen TI, et al. Insomnia and risk of chronic musculoskeletal complaints: longitudinal data from the HUNT study, Norway. BMC Muscoskel Disord 2018;19(1):128.
[5] Yabe Y, Hagiwara Y, Sekiguchi T, et al. Sleep disturbance is associated with new onset and continuation of lower back pain: a longitudinal study among survivors of the great east Japan earthquake. Tohoku J Exp Med 2018;246(1):9–14.
[6] Riemann D, Baglioni C, Bassetti C, et al. European guideline for the diagnosis and treatment of insomnia. J Sleep Res 2017;26(6):675–700.
[7] Bjorøy I, Jørgensen VA, Pallesen S, et al. The prevalence of insomnia subtypes in relation to demographic characteristics, anxiety, depression, alcohol consumption and use of hypnotics. Front Psychol 2020;11. 527-527.
[8] Skarpsno ES, Mork PJ, Hagen K, et al. Number of chronic nighttime insomnia symptoms and risk of chronic widespread pain and pain-related disability: the HUNT study. Nat Sci Sleep 2020;12:1227–36.
[9] Krokstad S, Langhammer A, Hveem K, et al. Cohort profile: the HUNT study, Norway. Int J Epidemiol 2012;42(4):968–77.
[10] Haskell WL, Lee IM, Pate RR, et al. Physical activity and public health: updated recommendation for adults from the American College of Sports Medicine and the American Heart Association. Circulation 2007;116(9):1081–93.
[11] Kurtze N, Rangul V, Hustvedt BE, et al. Reliability and validity of self-reported physical activity in the Nord-Trøndelag Health Study: HUNT 1. Scand J Publ Health 2008;36(1):52–61.
[12] Bjelland I, Dahl AA, Haug TT, et al. The validity of the Hospital Anxiety and Depression Scale. An updated literature review. J Psychosom Res 2002;52(2):69–77.
[13] Ewing JA. Detecting alcoholism. The CAGE questionnaire. J Am Med Assoc 1984;252(14):1905–7.
[14] Taylor DJ, Mallory LJ, Lichstein KL, et al. Comorbidity of chronic insomnia with medical problems. Sleep 2007;30(2):213–8.
[15] Katz DA, McHorney CA. Clinical correlates of insomnia in patients with chronic illness. Arch Intern Med 1998;158(10):1099–107.
[16] Alvaro PK, Roberts RM, Harris JK. A systematic review assessing bidirectionality between sleep disturbances, anxiety, and depression. Sleep 2013;36(7):1059–68.
[17] Sterne JA, White IR, Carlin JB, et al. Multiple imputation for missing data in epidemiological and clinical research: potential and pitfalls. BMJ 2009;338:b2393.
[18] Espie CA, Kyle SD, Hames P, et al. The daytime impact of DSM-5 insomnia disorder: comparative analysis of insomnia subtypes from the Great British Sleep Survey. J Clin Psychiatr 2012;73(12):e1478–84.
[19] Smith MT, Edwards RR, McCann UD, et al. The effects of sleep deprivation on pain inhibition and spontaneous pain in women. Sleep 2007;30(4):494–505.
[20] Glozier N, O'Dea B, McGorry PD, et al. Delayed sleep onset in depressed young people. BMC Psychiatr 2014;14:33.
[21] Hornyak M, Feige B, Voderholzer U, et al. Polysomnography findings in patients with restless legs syndrome and in healthy controls: a comparative observational study. Sleep 2007;30(7):861–5.
[22] Jankowski KS. Morning types are less sensitive to pain than evening types all day long. Eur J Pain 2013;17(7):1068–73.
[23] Juda M, Vetter C, Roenneberg T. Chronotype modulates sleep duration, sleep quality, and social jet lag in shift-workers. J Biol Rhythm 2013;28(2):141–51.
[24] Vitale JA, Roveda E, Montaruli A, et al. Chronotype influences activity circadian rhythm and sleep: differences in sleep quality between weekdays and weekend. Chronobiol Int 2015;32(3):405–15.
[25] Lehnkering H, Siegmund R. Influence of chronotype, season, and sex of subject on sleep behavior of young adults. Chronobiol Int 2007;24(5):875–88.
[26] Vgontzas AN, Fernandez-Mendoza J, Liao D, et al. Insomnia with objective short sleep duration: the most biologically severe phenotype of the disorder. Sleep Med Rev 2013;17(4):241–54.
[27] Kalmbach DA, Cuamatzi-Castelan AS, Tonnu CV, et al. Hyperarousal and sleep reactivity in insomnia: current insights. Nat Sci Sleep 2018;10:193–201.
[28] Kalmbach DA, Pillai V, Arnedt JT, et al. Identifying at-risk individuals for insomnia using the ford insomnia response to stress test. Sleep 2016;39(2):449–56.
[29] Pillai V, Roth T, Drake CL. The nature of stable insomnia phenotypes. Sleep 2015;38(1):127–38.
[30] Blanken TF, Benjamins JS, Borsboom D, et al. Insomnia disorder subtypes derived from life history and traits of affect and personality. Lancet Psychiatry 2019;6(2):151–63.
[31] Jarrin DC, Ivers H, Lamy M, et al. Cardiovascular autonomic dysfunction in insomnia patients with objective short sleep duration. J Sleep Res 2018;27(3):e12663.
[32] Bertisch SM, Pollock BD, Mittleman MA, et al. Insomnia with objective short sleep duration and risk of incident cardiovascular disease and all-cause mortality: sleep Heart Health Study. Sleep 2018;41(6).
[33] Skarpsno ES, Mork PJ, Nilsen TIL, et al. The interplay between sleeplessness and high-sensitivity C-reactive protein on risk of chronic musculoskeletal pain. Longitudinal data from the Tromso Study. Sleep 2019;42(9):zsz127.
[34] Skarpsno ES, Nilsen TIL, Sand T, et al. The joint effect of insomnia symptoms and lifestyle factors on risk of self-reported fibromyalgia in women: longitudinal data from the HUNT Study. BMJ Open 2019;9(8):e028684.
[35] Lawlor DA, Tilling K, Davey Smith G. Triangulation in aetiological epidemiology. Int J Epidemiol 2016;45(6):1866–86.
[36] Harel O, Mitchell EM, Perkins NJ, et al. Multiple imputation for incomplete data in epidemiologic studies. Am J Epidemiol 2018;187(3):576–84.
[37] Benjamins JS, Migliorati F, Dekker K, et al. Insomnia heterogeneity: characteristics to consider for data-driven multivariate subtyping. Sleep Med Rev 2017;36:71–81.