UiT The Arctic University of Norway

Faculty of Health Sciences, Department of Psychology

Studies of sleep and seasonal variations in patients with chronic musculoskeletal pain

Karin Abeler

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List of abbreviations

AASM	American Academy of Sleep Medicine
AHI	Apnea-Hypopnea Index
BPI	Brief Pain Inventory
CFS	Chalder Fatigue Scale
CWP	Chronic widespread pain
EEG	Electroencephalography
HSCL	Hopkins Symptom Checklist
IASP	International Association for the Study of Pain
ICD-11	International Classification of Disease, 11th edition
ICSD-3	International Classification of Sleep Disorders, 3rd edition
ISI	Insomnia Severity Index
N1	Non-REM sleep stage 1
N2	Non-REM sleep stage 2
N3	Non-REM sleep stage 3
PCS	Pain Catastrophizing Scale
PSG	Polysomnography
PSQI	Pittsburgh Sleep Quality Index
REM	Rapid eye movement
SBSM	Society of Behavioral Sleep Medicine
SE	Sleep efficiency
SOL	Sleep onset latency
SWS	Slow wave sleep
TIB	Time in bed
TST	Total sleep time
WASO	Wake after sleep onset

List of papers

Paper I

Abeler K., Friborg O., Engstrom M., Sand T., & Bergvik S. (2020). Sleep characteristics in adults with and without chronic musculoskeletal pain: The role of mental distress and pain catastrophizing. *Clin J Pain 36*(9), 707-715.

Paper II

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Paper III

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1 Abstract

Background/aims: Chronic pain is a major health problem, and contributing factors include poor sleep and mental distress. In the subarctic city of Tromsø, clinical impression also suggests worse pain in winter. We aimed to examine whether sleep in patients with chronic musculoskeletal pain differs from pain-free controls, and how psychological processes are related to sleep in these groups. We also examined day-to-day associations between sleep and pain as well as seasonal variations in symptoms.

Methods: We assessed self-reports of pain, sleep quality, insomnia, mental distress, and pain catastrophizing, and recorded 1 week of actigraphy and 1 night of home polysomnography (PSG) in patients and controls. Patients were examined both during summer and winter.

Results: Group differences indicating worse sleep in patients than in controls were large in sleep quality and insomnia, and small to medium in actigraphy and PSG measures. Mental distress was strongly related to more severe insomnia symptoms and reduced sleep quality in both groups and explained group differences in these measures. Pain catastrophizing was associated with less slow-wave sleep (SWS), and thus potentially less restorative sleep, in patients only. A weak reciprocal association between daytime pain and sleep quality was observed. Finally, patients reported slightly more pain and experienced delayed sleep timing in summer compared to winter.

Conclusion: Mental distress was related to worse self-reported sleep quality and insomnia, whereas pain catastrophizing was related to less SWS. In a clinical setting, sleep complaints may therefore be best addressed in a broader context including affective and cognitive functions. The daily reciprocal associations between sleep and pain, and seasonal variations in pain, sleep, and mental distress were minor. However, sleep timing was significantly delayed in summer and may be a target for circadian adjustment in some patients.

2 Introduction

Chronic pain is a common health problem that severely affects daily activities and quality of life for affected individuals, and it also generates substantial societal costs due to increased health care utilization and work disability (Breivik, Eisenberg, & O'Brien, 2013; Gaskin & Richard, 2012). Chronic pain conditions without an established cause may additionally be a source of frustration for both patients and healthcare workers, as it may be a challenge to find common grounds for understanding and treating the condition. Which factors are at play in such pain? And how are they related? Recognizing chronic pain as multifactorial, the prevailing treatment recommendations are interdisciplinary with a biopsychosocial perspective (Kamper et al., 2015). In particular, there is evidence for associations of chronic pain with sleep, mental distress, and cognitive processes, as will be discussed in the following. To further expand the understanding of how pain, sleep, and mental distress are related, this study applied a comprehensive set of sleep assessments, including self-reported measures of symptoms of insomnia and sleep quality, actigraphy, and polysomnography (PSG). The impact of season on pain has barely been studied previously and could potentially call for seasonal adjustments of treatment. Considering the subarctic location of this study, we aimed to enlighten this question by including measurements from both summer and winter.

2.1 Pain

2.1.1 Definition and classification

According to the International Association for the Study of Pain (IASP), pain is defined as *"An unpleasant sensory and emotional experience associated with, or resembling that associated with, actual or potential tissue damage"* (IASP, 2017). Pain is thus a warning sign of potential harm to the body and is thereby functional and necessary to maintain good health. The protective function of pain is illustrated by the detrimental effect of its absence, as in the genetic disorder familial insensitivity to pain, where afflicted patients are more commonly

inflicted with injuries, such as burns, wounds, and fractures with bone deformities (Schon, Parker, & Woods, 1993). However, pain may also occur spontaneously or persist beyond tissue repair, in which case it may be considered dysfunctional. Pain is specified as an emotional experience due to its unpleasant character, and should be respected even without obvious tissue damage, considering its subjective character (IASP, 2017).

Traditionally, pain has been described clinically as neuropathic or nociceptive. Neuropathic pain is defined as *"Pain caused by a lesion or disease of the somatosensory nervous system"* (IASP, 2017), and may occur in different types of neuropathies, radiculopathies, and traumatic nerve injuries. Nociceptive pain is defined as *"Pain that arises from actual or threatened damage to non-neural tissue and is due to the activation of nociceptors"* (IASP, 2017), and may occur in inflammatory, joint, and traumatic disorders. However, as pain conditions may arise without apparent damage to tissues or nerves, an additional pain specifier, termed "nociplastic pain" was proposed in 2016 (Kosek et al., 2016; Trouvin & Perrot, 2019). This is now included as a third pain specifier in the IASP terminology of pain, defined as *"Pain that arises from altered nociception despite no clear evidence of actual or threatened tissue damage causing the activation of peripheral nociceptors or evidence for disease or lesion of the somatosensory system causing the pain"* (IASP, 2017).

Experience of pain includes both peripheral and central neural signaling and modulation of pain pathways. The peripheral pain pathways involve slow conducting peripheral neurons to the spinal medulla, where second order neurons convey the signal to the thalamus, which is further connected to the primary and secondary sensory cortical areas. A central network, the "pain matrix" (Melzack, 1999), comprising the thalamus, several cortical areas, and subcortical nuclei (such as the amygdala and nucleus accumbens) add cognitive, attentional, and affective aspects to the painful experience (Bushnell, Ceko, & Low, 2013). Through

feedback, central networks modulate pain pathways, inducing the hypersensitivity characteristic of the altered nociception defining nociplastic pain. Affective and cognitive processes are thus related to pain by central networks and feedback mechanisms.

In the 11th edition of the International Classification of Diseases (ICD-11) (World Health Organization [WHO], 2018), chronic pain is considered as pain for 3 months, and is subdivided into primary and secondary pain conditions, depending on whether or not there is a known underlying condition accountable for pain. *"Chronic primary pain is chronic pain in one or more anatomical regions that is characterized by significant emotional distress (anxiety, anger/frustration, or depressed mood) or functional disability (interference in daily life activities and reduced participation in social roles). Chronic primary pain is multifactorial: biological, psychological, and social factors contribute to the pain syndrome"* (WHO, 2018). By this definition, the pain coding rationale has been adapted to IASP classification tying the condition to nociplastic pain, as it may occur without, or outlast any tissue damage, and anchoring chronic primary pain in the biopsychosocial model of disease (Nicholas et al., 2019). Accordingly, the recommended treatment strategy for chronic pain is interdisciplinary rehabilitation considering the biological, psychological, and social aspects of the condition (Kamper et al., 2015). Fibromyalgia, chronic widespread pain (CWP), and local/regional musculoskeletal pain without identified tissue damage may be considered primary pain conditions (Nicholas et al., 2019).

2.1.2 Prevalence and impact

Prevalence estimations of chronic pain vary between 10-30 % in the general population, possibly depending on the operationalization comprising different combinations of severity, frequency, and distribution of pain (Breivik, Collett, Ventafridda, Cohen, & Gallacher, 2006; Landmark, Romundstad, Dale, Borchgrevink, & Kaasa, 2012; Nahin, 2015). The stability of

repeated pain ratings over time, suggests that recall of chronic pain is reliable in a cross-sectional setting (Landmark et al., 2012). In a study reporting health care utilization for musculoskeletal disorders (most commonly low back pain and neck pain) in Norway in 2012, 37% and 30% of women and men, respectively, sought primary health care services (physicians, physiotherapists, or chiropractors), whereas 7% and 5% of men and women, respectively, sought specialist service (Kinge, Knudsen, Skirbekk, & Vollset, 2015).

In a study of regional or widespread chronic musculoskeletal pain (defined as persisting for more than 3 months during the last year), the prevalence was 35% (Bergman et al., 2001). Musculoskeletal complaints may even be more common, as 65% of participants in a population study from the municipality of Tromsø in northern Norway reported some muscle pain or stiffness for at least 3 of the preceding 12 months (Andorsen, Ahmed, Emaus, & Klouman, 2014). According to a recent meta-analysis, the prevalence of unspecified chronic pain and musculoskeletal pain was 34% and 25%, respectively, in the general adult populations in low- and middle-income countries (Jackson et al., 2016), underlining the impact worldwide.

Chronic pain profoundly affects a person's ability to perform everyday activities, such as maintaining personal and social relationships, driving a car, and working (Breivik et al., 2006). Andorsen et al. (2017) reported that the development of new musculoskeletal complaints was most strongly associated with low educational levels, female sex, low self-perceived health, high body mass index, and smoking. Moreover, increased mortality has been reported in CWP, and may be related to lifestyle factors, such as body mass index, smoking, sleep disturbance, and physical activity, as observed in a Swedish population study (Andersson, 2009).

In addition to the impact on personal life, chronic pain has societal costs (estimated to exceed expenses due to heart disease, cancer, and diabetes) by a combination of increased medical expenses and reduced work productivity (Gaskin & Richard, 2012). The multidisciplinary rehabilitation approach will likely reduce societal expenses, mainly due to reduced expenses for prescription drugs, costly diagnostic examinations, and acute hospital admissions (Maeng, Baylor, Bulger, & Han, 2018).

Chronic pain conditions are thus common and incur substantial personal and societal costs. Thus, new insights into mechanisms contributing to the maintenance of clinical pain may be of relevance for patients with chronic pain in particular and to the society in general.

2.2 Sleep in chronic pain

Sleep is a universal natural function of restitution, with an impact on both physical and mental health and well-being. Sleep quality is a construct with no consensus definition (Krystal & Edinger, 2008; Ohayon et al., 2017), but usually refers to a subjective feeling of having slept well, reflected by a combination of good daytime functioning and uninterrupted nighttime sleep (Ramlee 2018). Quantitative aspects of sleep may be measured by self-report or by sleep recording devices, such as actigraphy and PSG. Sleep continuity pertains to the distribution of sleep and wake during a sleep period, which may be measured by self-report, actigraphy, or PSG. Sleep architecture describes the modulation of sleep stages during sleep and requires measurement of brain activity by electroencephalography (EEG), which is included in PSG. PSG also has the advantage of measuring further aspects of sleep, such as disordered breathing and periodic limb movements. Therefore, it is often referred to as the gold standard of sleep recording. However, actigraphy has the advantage of being less intrusive and suitable for longer recordings in naturalistic environments, thereby capturing

some of the variability in sleep. The sleep variables used in this study are presented in Table 1.

Table 1 Description of sleep variables, as applied in the current study

Measures of sleep continuity	
Time in bed, TIB	Duration of time between first attempt to sleep in the evening and waking up in the morning.
Total sleep time, TST	Total duration of time spent asleep during time in bed
Sleep onset latency, SOL	Time from attempting to sleep until falling asleep
Wake after sleep onset, WASO	Combined duration of wake periods during the night
Sleep efficiency, SE	Proportion of time in bed spent sleeping (TST/TIB)
Measures of sleep architecture, sleep stages	
Rapid Eye Movement sleep, REM	Characterized by active dreaming
Non-REM sleep stage 1, N1	Light sleep
Non-REM sleep stage 2, N2	Intermediate sleep
Non-REM sleep stage 3, N3	Deepest sleep, the term slow wave sleep (SWS) is used in this study.
Sleep stage shift index	Number of changes between sleep stages, per hour
Arousal index	Number of short electroencephalographic (EEG) activations, per hour
Sleep-related physiological measurements	
Apnea-Hypopnea Index, AHI	Number of apneas and hypopneas, per hour
Periodic Limb Movement Index	Number of leg movements within a sequence of periodic leg movements, per hour

Sleep quality is proposed to be related to both sleep timing and objectively measured sleep indices, such as sleep duration and slow wave sleep (SWS) (Akerstedt, Hume, Minors, & Waterhouse, 1997; Krystal & Edinger, 2008; Ohayon et al., 2017). Variations in sleep quality may be considered a natural part of life, but when sleep disturbance substantially impairs daytime functioning and persists over time, it may be classified as a sleep disorder. Sleep

disorders are described in the 3rd edition of the International Classification of Sleep Disorders (ICSD-3) by the American Academy of Sleep Medicine (AASM), and categorized into the following diagnostic sections: 1) insomnia; 2) sleep related breathing disorder; 3) central disorders of hypersomnolence; 4) circadian rhythm sleep-wake disorders; 5) parasomnias; 6) sleep related movement disorders; and 7) other sleep disorders (AASM, 2014). Insomnia is of particular interest in the context of chronic pain as it is commonly comorbid, with a prevalence of 60-80% depending on the pain population and the applied definition of sleep disturbance (Alfoldi, Wiklund, & Gerdle, 2014; Tang, Wright, & Salkovskis, 2007; Taylor et al., 2007). Insomnia related to pain seems to share clinical characteristics with primary insomnia (Tang, Goodchild, Hester, & Salkovskis, 2012). The diagnostic criteria include difficulties initiating or maintaining sleep such that daytime functioning is impaired, occurring at least three times a week for at least 3 months, and it should not be better explained by another sleep disorder or inadequate sleep opportunity (AASM, 2014). Insomnia is a clinical diagnosis based on patient history, but the use of actigraphy or PSG is recommended for exclusion of other sleep disorders, or to demonstrate misperception of sleep (Riemann et al., 2017). In controlled PSG studies of chronic pain, the observed group differences have varied (Bjurstrom & Irwin, 2015). Nevertheless, two recent meta-analyses of PSG findings in fibromyalgia (Wu, Chang, Lee, Fang, & Tsai, 2017) and miscellaneous chronic pain conditions (Mathias, Cant, & Burke, 2018) observed altered sleep continuity, including reduced total sleep time (TST) and sleep efficiency (SE), and increased wake after sleep onset (WASO). However, only the study of mixed pain found increased sleep onset latency (SOL) (Mathias et al., 2018). Concerning sleep architecture, both meta-analyses reported increased light sleep and reduced SWS with larger effect sizes in fibromyalgia than in mixed pain conditions (Mathias et al., 2018; Wu et al., 2017).

There is evidence that insomnia contributes to the development of pain as well as persistence and exacerbation of existing pain conditions, including headache, musculoskeletal pain, and fibromyalgia (Bonvanie, Oldehinkel, Rosmalen, & Janssens, 2016; Canivet et al., 2008; Mork & Nilsen, 2012; Mundal, Grawe, Bjorngaard, Linaker, & Fors, 2014a; Nitter, Pripp, & Forseth, 2012; Odegard et al., 2011; Uhlig, Sand, Nilsen, Mork, & Hagen, 2018), whereas non-disturbed sleep may facilitate the resolution of chronic pain (Aili, Nyman, Svartengren, & Hillert, 2015). In corroboration, a meta-analysis of nonpharmacological sleep interventions in pain patients with comorbid sleep disturbance showed an effect not only on sleep, but also a small improvement in pain (Tang et al., 2015).

There is also evidence for a reverse association as pain is prevalent in populations with sleep disturbance (Taylor et al., 2007), and longitudinal studies have observed an increased risk of developing sleep disturbance in persons with chronic pain (Jansson-Frojmark & Boersma, 2012; Odegard, Sand, Engstrom, Zwart, & Hagen, 2013). Day-to-day studies propose reciprocal associations between sleep and pain such that a night with more disturbed sleep may be followed by increased next-day pain, and a day with increased pain may be followed by poor sleep. These associations are most consistently observed for self-reported sleep measures and in the direction from sleep to pain in musculoskeletal pain conditions (Alsaadi, McAuley, Hush, Lo, et al., 2014; Gerhart et al., 2017; O'Brien et al., 2011; Whibley, Braley, Kratz, & Murphy, 2019). Thus, the sleep-pain relationship appears to be bidirectional.

Early studies on the effect of experimental sleep deprivation were performed by pioneers in sleep medicine, Cooperman, Mullin, and Kleitman in 1933. They recorded the effect of sleep deprivation for up to 60 hours on the ability to stand upright, name colors, reaction time, and pain sensitivity. They described the effect of sleep deprivation resembling alcohol intoxication (another experimental condition in the study) on most outcomes, except pain.

Pain sensitivity increased (rather than decreased, as was the case for alcohol) across the sleep deprivation period (Cooperman, Mullin, & Kleitman, 1934). Since then, the detrimental effect of sleep deprivation on pain modulation has been reported in studies using a range of different sleep deprivation protocols and pain assessments, including pain thresholds, temporal summation, conditioned pain modulation, and laser evoked potentials (Odegard et al., 2015; Schuh-Hofer et al., 2013; Simpson, Scott-Sutherland, Gautam, Sethna, & Haack, 2018). Abnormal pain modulation has also been observed in persons with isolated insomnia and in sleep disruption comorbid with chronic pain (Edwards et al., 2009; Haack et al., 2012; Sivertsen et al., 2015). Additionally, a synergistic effect of insomnia and chronic pain on pain modulation has been suggested, as pain tolerance in participants with comorbidity was lower than the simple additive effects (Sivertsen et al., 2015).

Available data indicates that impaired sleep contributes to pain. Therefore, factors associated with sleep may also be important for the trajectory of a chronic pain condition.

2.3 Psychological processes in chronic pain

Pain, by its IASP definition, encompasses an unpleasant emotional experience. The affective dimensions of pain are evident by the high comorbidity with depression, as every second patient in a pain clinic may suffer from depression (Bair, Robinson, Katon, & Kroenke, 2003). Depression is a clinical diagnosis. Scoring instruments for symptoms of depression, such as the Hopkins Symptom Checklist (HSCL), are commonly applied to operationalize its diagnosis in research settings (Bair et al., 2003). Such instruments gauge levels of mental distress and may have cut-off scores indicating potential clinical depression (Sandanger et al., 1998).

In a Norwegian population study, which included almost 30 000 participants, the prevalence of either depression or anxiety was doubled among participants with CWP compared to the

general population (11% vs. 5%) (Mundal et al., 2014a), and together with smoking, body mass index (low and high) and sleep problems predicted the development of new-onset CWP in an 11-year follow-up (Mundal, Grawe, Bjorngaard, Linaker, & Fors, 2014b). Poor sleep and concurrent diseases (but not depression) were predictors of persistent pain among 53% of participants at the 11-year follow-up (Mundal et al., 2014a). Other epidemiological and clinical studies report similar results for low back pain (Dunn, Jordan, & Croft, 2011; Melloh et al., 2011; Nordstoga, Nilsen, Vasseljen, Unsgaard-Tondel, & Mork, 2017). In patients with comorbidity, chronic pain and depression seem to be reciprocally related (Kroenke et al., 2011), and optimizing treatment of depression may also alleviate pain (Ang et al., 2010).

Depression is also related to sleep in chronic pain conditions. The presence of depression is associated with poorer self-reported sleep quality and insomnia, and new sleep problems seem to be associated with the development of depression, and vice versa in this patient group (Alfoldi et al., 2014; P. Campbell et al., 2013; Nicassio et al., 2012). These complex associations have been explored in mediation studies, reviewed by Whibley (2019), indicating that bidirectional associations between sleep and pain are partly explained by psychological factors. Furthermore, the increased risk of new chronic pain onset in insomniacs may be partly explained by comorbid depression (Generaal, Vogelzangs, Penninx, & Dekker, 2017).

Thus, symptoms of depression are common in patients with chronic musculoskeletal pain and may play a role in the course of chronic pain, possibly due to its association with sleep.

Catastrophizing pertains to a cognitive pattern of continuous negative thinking about present or future, and an inability to divert attention from such thinking. Catastrophizing revolving around the experience of pain is termed pain catastrophizing and may be measured by the Pain Catastrophizing Scale (PCS) (Sullivan, Bishop, & Pivik, 1995). Pain catastrophizing tends to overlap with negative affect and fear of pain (Quartana, Campbell, & Edwards, 2009;

Sullivan et al., 1995). Persons with a tendency to catastrophize are reported to respond with increased emotional distress, negative thoughts, stress (cortisol), and sensitivity to painful stimuli (Quartana et al., 2010; Sullivan et al., 1995). Such response styles indicate both psychological and physiological implications of pain catastrophizing. Pain catastrophizing is related to poorer recovery from clinical pain and may mediate the effect of pain treatment, including targeted cognitive behavioral therapy (Spinhoven et al., 2004).

Pre-sleep cognitive arousal is a cognitive pattern of racing, intrusive thoughts and worry at bedtime. It is associated with insomnia and reduced sleep quality with or without comorbid pain (Byers, Lichstein, & Thorn, 2016; Palermo, Wilson, Lewandowski, Toliver-Sokol, & Murray, 2011; Riemann et al., 2010; Smith, Perlis, Smith, Giles, & Carmody, 2000; Tang, Goodchild, Sanborn, Howard, & Salkovskis, 2012). Rumination and worry may be shared features between pre-sleep cognitive arousal and pain catastrophizing (Byers et al., 2016; Smith et al., 2000; Sullivan et al., 1995). The implications for pain are illustrated by a study of temporomandibular disorder, where the effect of pain catastrophizing on pain severity and interference was partly explained by sleep disturbance in mediation analyses (Buenaver et al., 2012). The level of pain catastrophizing may also potentially modify the effect of sleep disturbance on pain physiology, as a study reported an effect of low SE (based on data from a sleep diary) on central sensitization in osteoarthritis solely in participants with high pain catastrophizing (Campbell et al., 2015). However, the effect may possibly be explained by pre-sleep cognitive arousal, as an effect of pain catastrophizing on insomnia in chronic pain turned non-significant when controlling for pre-sleep cognitive arousal (Byers et al., 2016). Thus, pain catastrophizing may contribute to pain severity directly, by its effect on sleep disturbance and by increasing the effect of sleep disturbance on pain.

Most studies investigating associations between pain, sleep, and psychological processes have assessed sleep using self-report measures. Psychological processes related to mental distress and pain catastrophizing (such as attention and negative appraisal) may also affect self-report measures of sleep, thereby increasing their association. In addition, the associations may be inflated by using common methods (further discussed in section 6.2.3). These potential biases are avoided using actigraphy and PSG, which have the potential to add further perspectives to the associations of these constructs.

2.4 Seasonality

Circannual variations in climate and light conditions increase with higher latitudes. This study was conducted above the polar circle in the city of Tromsø, Norway at 69º North, which is the regional capital with a population of approximately 77 000 inhabitants (Statistics Norway). Here, we experience the polar night (where the sun does not rise above the horizon) between November 27 and January 15, and the midnight sun (where it does not set) between May 21 and July 22. Thus, Tromsø provides an ideal setting for studies of seasonality in the general population as well as in clinical samples. It is a common notion that we are, to some extent, affected by seasonal variations. To this end, 33% of the participants in a population study, conducted further south in Norway, reported moderate to high seasonal variations in sleep, social activities, mood, body weight, appetite, and fatigue (Oyane, Holsten, Ursin, & Bjorvatn, 2005).

According to clinical experience, patients with chronic pain are more troubled by their pain condition in winter compared to summer, an impression also communicated from Canada (Owen, 1995). Furthermore, patients with chronic pain have reported seasonality in pain intensity, with increments in winter, when self-reported retrospectively (Hawley, Wolfe, Lue, & Moldofsky, 2001; Moldofsky, 1994). Chronic pain could potentially be affected by

seasonal light and climate changes, although studies of weather effects have shown conflicting results (Duong, Maher, Steffens, Li, & Hancock, 2016; Fagerlund, Iversen, Ekeland, Moen, & Aslaksen, 2019). Seasonal effects on pain could also be indirect by variations in determinants, such as sleep, fatigue, mood, or physical activity. The few previous studies applying repeated pain assessments in chronic pain patients do not support any exacerbation of pain in winter (Hawley & Wolfe, 1994; Hawley et al., 2001; Iikuni et al., 2007), though they were conducted at lower latitudes than the present study.

Studies of the general population in Tromsø have suggested an increase in insomnia and fatigue, along with a delay in the sleep-wake cycle during winter (Friborg, Rosenvinge, Wynn, & Gradisar, 2014; Hansen, Jacobsen, & Husby, 1991; Husby & Lingjaerde, 1990; Johnsen, Wynn, Allebrandt, & Bratlid, 2013; Johnsen, Wynn, & Bratlid, 2012). Increased insomnia complaints may interact with pain, as described in a previous section. Late chronotype as a stable trait has been associated with general health risks (Knutson & von Schantz, 2018), increased risk of musculoskeletal pain conditions (Merikanto et al., 2014; Zhang, Duffy, de Castillero, & Wang, 2018), and increased pain sensitivity (Jankowski, 2013). In a clinical sample of patients with fibromyalgia, Kantermann et al. (2012) found that late chronotypes have more severe fibromyalgia symptomatology. Whether a seasonal delay of sleep-wake rhythm may similarly be associated with increased pain has not previously been studied.

There is no evidence of an upsurge in mental distress in winter in Tromsø, or other parts of Norway, as demonstrated in population studies (Hansen et al., 1991; Johnsen et al., 2012; Oyane, Bjelland, Pallesen, Holsten, & Bjorvatn, 2008). In bipolar disorder, a systematic review reports increased hospital admission rates for depressive episodes in early winter and to a lesser degree in summer, and for manic episodes in spring and summer (Geoffroy,

Bellivier, Scott, & Etain, 2014). In Norway, a peak of hospital admissions for depressive episodes in the period 1992-1996 was observed in April and November for men and women, respectively, whereas there was a spring peak of admission for mania only in men. Among women, the seasonal effect was attenuated with age, and among men admission for depression correlated with suicides (Morken, Lilleeng, & Linaker, 2002). Thus, there may be a differential effect of season on depression in the general population and in clinical populations with mood disorders, a view supported by a recent systematic review of seasonality in symptoms of depression (Overland et al., 2019). Several studies in miscellaneous clinical pain conditions, indicate winter-exacerbation in fatigue but not mood (Feldthusen, Grimby-Ekman, Forsblad-d'Elia, Jacobsson, & Mannerkorpi, 2016; Hardt & Gerbershagen, 1999; Hawley & Wolfe, 1994), whereas there may be an increase in non-specific psychological distress (Gallagher, Marbach, Raphael, Handte, & Dohrenwend, 1995). Nevertheless, a study among students in Tromsø observed increased symptoms of depression in winter, and a relatively greater delay of sleep-wake rhythm in winter among students with high mental distress (Friborg et al., 2014). It is plausible that patients with high levels of mental distress (such as pain patients) may also experience more phase delay during winter than the general population.

Leading an active lifestyle has been related to more efficient experimental pain inhibition mechanisms and reduced pain reports in the general population (Landmark, Romundstad, Borchgrevink, Kaasa, & Dale, 2013; Naugle, Ohlman, Naugle, Riley, & Keith, 2017). Moreover, physical inactivity may strengthen the effect of insomnia on pain (Mork et al., 2014). A decrease in physical activity is commonly observed during the winter season, due to cold temperatures and lack of sunlight (Cepeda et al., 2018; Schepps, Shiroma, Kamada, Harris, & Lee, 2018). Decreased physical activity, in combination with increased insomnia complaints, may therefore be expected to augment pain severity in winter.

Seasonal variations in chronic musculoskeletal pain have not previously been tested at such northern latitudes as present and could potentially be related to factors that may be targeted in a seasonally adjusted treatment regime, such as insomnia, sleep timing, and physical activity.

3 Aims and objectives of the study

This study aimed to characterize sleep in patients with chronic primary musculoskeletal pain compared to healthy controls, and to investigate any association between psychological processes and sleep. We also sought to examine how sleep and pain are related in a day-to-day time frame in this patient group. As the study was conducted in the subarctic, another aim was to explore seasonal variations in pain. By recruiting participants with primary pain conditions and excluding secondary pain, we aimed to avoid any confounding by underlying diseases.

The objectives of Paper I were to compare sleep characteristics in a sample of patients with chronic musculoskeletal pain with matched pain-free controls, and to estimate the contribution of mental distress and pain catastrophizing to potential sleep disturbances. The hypothesis was that, compared to the controls, patients would have reduced self-reported sleep quality with increased scores on the Insomnia Severity Index (ISI) and Pittsburg Sleep Quality Index (PSQI) as well as increased SOL, WASO, N1, and reduced SE, TST, and SWS retrieved from actigraphy and PSG. We also hypothesized that mental distress and pain catastrophizing would be predictors of subjective and objective sleep parameters, and further explain group differences in selected sleep indices (ISI, PSQI, SE, SWS) in mediation analyses.

The objectives of Paper II were to compare winter and summer measures of pain severity and dissemination among patients with chronic musculoskeletal pain. We also wanted to examine potential seasonal variations in determinants of pain, such as sleep, mental distress, fatigue,

and physical activity, and their influence on pain measures. The hypotheses were that the pain scores, mental distress, sleep disturbance, and fatigue would be increased, whereas physical activity would be decreased in winter. We also hypothesized that seasonal variation in the pain determinants would moderate the effect of season on pain measures.

The objectives of Paper III were to examine the day-to-day associations between sleep and pain, and whether potential associations were modified by mental distress or season. The hypotheses were that reduced sleep quality (self-reported), SE, TST, and delayed sleep timing (three latter measured by actigraphy) would be associated with increased next-day pain, and that increased daytime pain would be associated with reduced sleep quality, SE, TST, and delayed sleep timing the next night. Another hypothesis was that mental distress and season would moderate the daily sleep-pain associations, such that stronger associations would be observed in winter and with high mental distress.

4 Materials and methods

4.1 Recruitment and inclusion

Patients were recruited from outpatient clinics at the Rehabilitation Department and Pain Clinic, both at the University Hospital of North Norway (UNN). The recruitment period was from May to November 2016, and criteria for inclusion were visits at the respective clinics during the last 18 months, age 18-65 years, and having chronic primary musculoskeletal pain defined by selected codes from the International Classification of Diseases 10th Edition (ICD 10) (Table 5).

Potential participants were identified by searching electronic patient records for the main diagnosis at the last visit to the respective clinics, and registered address within the municipality of Tromsø. Patients were invited by mail, and those willing to participate in the study responded by returning written consents. Upon receiving the written consent, the

patient's medical journal was inspected for exclusion criteria. Patients were excluded if they had a major medical condition (cancer, inflammatory, symptomatic heart or lung, metabolic, or endocrine disease), neurologic condition, psychiatric illness (current major depression episode, psychotic disorder), drug abuse, were pregnant or participated in ongoing intervention studies. Patients previously diagnosed with sleep disorders other than insomnia were excluded. Eligible persons were contacted by telephone to make appointments for participation. Participants meeting exclusion criteria were informed by mail. A reminder was sent after approximately 4 weeks.

Pain-free controls were recruited by poster advertisement among hospital and university employees and at a blood donor center. Persons willing to participate as controls were registered as potential participants. A group of controls, matched to the pain patients one to one by age (+/- 5 years), sex, and season of investigation were invited. A list of the exclusion criteria, identical to the pain patients, and written consent was presented at this point. Written consent was signed at show-up for the examinations, allowing further interview and inspection of medical records for exclusion criteria.

4.2 Procedure

The prospective design included two study periods of 7 days per participating pain patient, one during mid-summer and the other during mid-winter, while healthy controls contributed a single study period (Figure 1). The dates, duration of daylight, and median temperature during study periods were: June 6, 2016 to July 28, 2016; 22-24 h, 8°C, November 3, 2016 to February 13, 2017; 0-7 h, -1°C and May 2, 2017 to July 20, 2017; 19-24 h, 10°C. (Lilje et al. 2019, 4-27; MET Norway 2020). Potential sequence effects were controlled for by counterbalancing the enrollment sequence of the participants starting during summer and during winter. Counterbalancing was non-randomized as the participants were enrolled

consecutively for practical reasons.

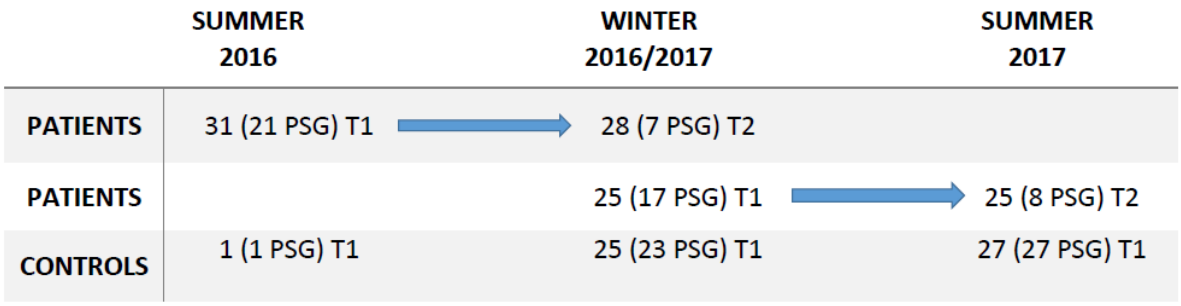

Figure 1 Overview of data collection. Patients with chronic primary musculoskeletal pain (patients) participated at two occasions, summer and winter. The first occasion was termed T1, and the second occasion was termed T2. Pain-free controls (controls) participated once, termed T1. Polysomnography (PSG) was performed at either T1 or T2 for patients and at T1 for controls, as indicated in parentheses.

Each study period, T1 (first study period) and T2 (second study period), comprised 1 week of continuous actigraphy with accompanying sleep diary and daily questionnaires. Depending on convenience for the participant, an unattended home PSG was performed the first night of T1 or T2. The first day of each study period was scheduled at the Department of Clinical Neurophysiology, UNN, where participants received detailed written and oral information, completed questionnaires, and had a short training session with attachment of the actigraphy device. During the study period including PSG, the PSG-device was also attached the first day, and participants returned the next morning to have it disconnected. Participants returned after 7 days with the actigraphy-device and the completed sleep diary. Blood samples were also drawn for later analyses in further projects (Figure 2).

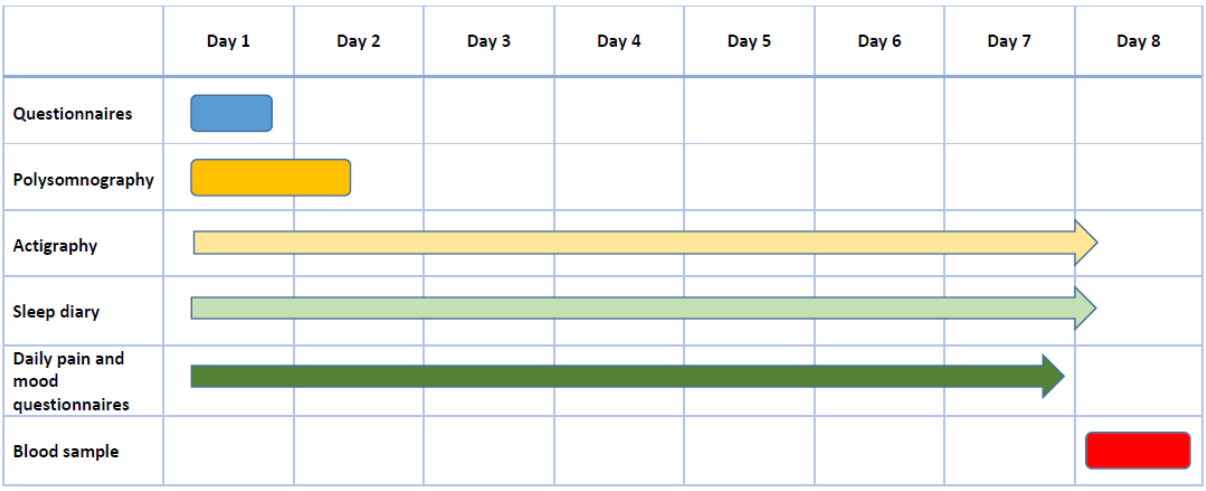

Figure 2 Study period with PSG recording. The study period without PSG was identical, just without PSG. Actigraphy and sleep diary were recorded including 7 nights, therefore yellow and light green arrows extend into the morning of day 8. Daily questionnaires were completed for 7 days, therefore end in the evening of day 7.

Participants were instructed to conduct their daily lives as usual during the study period. There were no restrictions on sleep schedule, habitual medication, or daily activities. A few participants (predominantly nurses) had work including sporadic night shifts, in which case the study periods were planned to avoid night shifts. However, we did not collect data on professions or shiftwork. Pain patients were offered a gift voucher of 250 NOK when attending the second study period.

The healthy controls contributed one study period identical to the pain patients, including PSG, which was timed to concur with the season of the matched pain patient.

Data from the study period entailing the PSG study (either summer or winter) were used for Paper I. For Paper II and III, data from both T1 and T2 (exclusively from pain patients) were used. For Paper II, the sleep variables averaged across the data collection period were analyzed, whereas in Paper III, the daily measures were entered in analyses.

4.3 Self-report measures

The questionnaire used for baseline assessments on the first day of the study period included several instruments; only the ones included in this study are described below.

Demographic information: The demographic variables age, sex, educational level (10-year high school vs. higher education), marital status (single vs. married/partner), employment (non-employed vs. part or full-time employed), and perceived financial situation (good vs. medium/poor) were registered. The type of social benefit was registered when applicable.

Pain: The pain severity subscale of the Brief Pain Inventory (BPI) short form (Cleeland, 1991) and a modified body map were applied. We used a front and back body map containing 25 named body regions. Pain dissemination was measured as the number of marked body regions. The severity of pain was reported on an 11-point numeric rating scale (0-no pain to 10-worst imaginable pain). Participants rated their worst, least, and average pain during the last week as well as their current pain. For the analyses of daily associations in Paper III, pain was scored in the evening, and the time span was adjusted to the current day. The mean severity score of these four ratings was used. The Norwegian version of the BPI, including both pain severity and pain interference items, provides reliable (Cronbach's alpha 0.87) and valid scores (Klepstad et al., 2002). The BPI severity subscale applied separately has been validated in chronic non-malignant pain (Tan, Jensen, Thornby, & Shanti, 2004), and the minimal clinically important difference has been estimated at one point (Dworkin et al., 2008).

Insomnia: The ISI includes seven items regarding sleep onset, maintenance, and early morning awakening as well as questions about daytime function, sleep satisfaction, and worry about sleep (Morin, 1993). Considering the last 2 weeks, items are scored on a five-point Likert scale (0- no problem to 4- very severe problem), with higher scores indicating worse

insomnia (range 0-28). An ISI cut-off value > 14 indicates clinical insomnia (Bastien, Vallieres, & Morin, 2001). Reliability was found to be good (Cronbach's alpha 0.74-0.91) (Bastien et al., 2001; Morin, Belleville, Belanger, & Ivers, 2011), whereas the total score showed weak or no significant correlation with PSG measures (Morin et al., 2011). ISI is a recommended research measure of insomnia (Buysse, Ancoli-Israel, Edinger, Lichstein, & Morin, 2006). ISI is widely used, although it is not validated in the Norwegian language.

Sleep quality: The PSQI comprises 19 items probing sleep quality and disturbance during the previous month across the seven components: 1) subjective sleep quality; 2) sleep latency; 3) sleep duration; 4) habitual SE; 5) sleep disturbance; 6) sleep medication; and 7) daytime dysfunction. Each component receives a score of 0-3 based on a scoring algorithm (Buysse, Reynolds, Monk, Berman, & Kupfer, 1989), yielding a global score (range 0-21), with higher scores indicating more disturbed sleep. A cut-off value > 5 indicates impaired sleep quality. The original publication of the PSQI reported good reliability (Cronbach's alpha, 0.83) and validity, but absent or weak correlations with PSG measures (Buysse et al., 1989). The Norwegian translation has shown acceptable reliability and validity (Pallesen, 2005).

In analyses of daily sleep-pain associations in Paper III, a simple VAS scale was applied in the morning, rating last night as a good (0) – poor (100) night's sleep.

Mental distress: The HSCL-25 is a self-report inventory designed to screen for symptoms of depression and anxiety in the last 2 weeks, indicating mental distress (Derogatis, Lipman, Rickels, Uhlenhuth, & Covi, 1974). The 25 items are scored on a 4-point Likert scale (1 - not at all to 4 - very much), from which a global average score is calculated (range: 1-4). The score reliability in the Norwegian version is good (Strand et al., 2003). A cut-off score > 1.75 has been recommended to indicate a clinical diagnosis of mental disorder in women, whereas a lower cut-off score of > 1.67 has been suggested in men (Sandanger et al., 1998).

A shorter variant, including 10 items (HSCL-10), was used for the daily measures in Paper III. This variant has been validated in Norwegian and has shown good reliability and high correlation with the longer HSCL-25 version. The cut-off score for potential clinical diagnosis of the HSCL-10 version was recommended at > 1.85 (Strand et al., 2003).

Pain catastrophizing: The PCS was developed by Sullivan (1995) to investigate cognitive processes activated when experiencing pain. The PCS consists of 13 items assessing the presence of negative pain-related thoughts graded on a 5-point Likert scale (0 - not at all to 4 - all the time). The sum score (range 0-52) was used for analyses in Paper I. The Norwegian version has been validated in a study of patients with low back pain (Fernandes, Storheim, Lochting, & Grotle, 2012) displaying good reliability and validity (Cronbach's alpha, 0.90).

Fatigue: The Chalder Fatigue Scale (CFS) covers physical (8 items) and mental (3 items) fatigue. The presence of each symptom during the last month is graded on a 4-point Likert scale (1 - less than usual to 4 - much more than usual) (Chalder et al., 1993). The Norwegian version of the scale has shown good psychometric properties (Loge, Ekeberg, & Kaasa, 1998). The present study used the combined score of mental and physical fatigue in Paper II.

4.4 Actigraphy

The Actiwatch Spectrum Plus device was used to register sleep and physical activity, and post-processing of the raw actigraphy data was conducted in the Actiware version 6.0.9 software (both Phillips Respironics, Inc., Murrysville, PA). For the detection of movement, the Actiwatch Spectrum Plus device contains a microelectromechanical system (MEMS) accelerometer with a sampling rate of 32 Hz. Light was detected at wavelengths of 400-700 nm (Philips). The recording and raw-data post-processing were performed in line with the guide by the Society of Behavioral Sleep Medicine (SBSM), which includes patient instructions, technical, scoring, and reporting considerations (Ancoli-Israel, et al., 2015). The

validity of actigraphy seems to depend on the device, scoring algorithm, and target population. The accuracy may be lower in poor sleepers (Sadeh, 2011; Sivertsen et al., 2006). However, the Actiwatch device and Actiware software have shown good validity for sleep variables in insomnia and low back pain (Alsaadi, McAuley, Hush, Bartlett, et al., 2014; Kahawage, Jumabhoy, Hamill, de Zambotti, & Drummond, 2020). Recordings of more than 5 nights provide reliable estimates of SE (Aili, Astrom-Paulsson, Stoetzer, Svartengren, & Hillert, 2017). The Actiwatch Spectrum Plus has not been validated for physical activity monitoring, yet the previous generation Actiwatch Spectrum (piezoelectric accelerometer) and other MEMS-type accelerometers have (Rabinovich et al., 2013).

The Actiwatch was worn on the non-dominant wrist, only to be removed shortly during shower or if required at work (due to hygiene or safety considerations). The participants received one-to-one instruction and training on how to register the time of the first sleep attempt and final morning awakening by pushing an event button on the Actiwatch. Rest periods were scored by a trained research assistant (psychology student) supervised by the PhD candidate. Both were blinded to participant identity and group affiliation. The start and end of a rest period were guided by a significant sustained reduction or increase in activity, and additionally by the event marker, sleep log information, and light intensity. The sleep period was scored by the software algorithm in 30-second epochs within the defined rest period. Medium sensitivity (40 activity counts/epoch) was chosen for activity detection, and an inactivity threshold of 10 minutes was set to define sleep onset and offset. The variables associated with sleep continuity, TST, SOL, WASO, and SE were obtained. We also calculated the midpoint of the sleep period, midsleep $\left(\frac{sleep\ onset - sleep\ offset}{2}\right)$, separately for weekdays and weekends, as a measure of sleep timing. A 7-day actigraphy recording is illustrated in Figure 3.

4.5 PSG

SOMNOscreen equipment and Domino version 2.7.0 software (Somnomedics, Randersacker, Germany) were used for PSG, and the recording and scoring were performed in accordance with the AASM guidelines (AASM, 2017). The scoring was performed by the PhD candidate (certified somnologist by the European Sleep Research Society 2014, with clinical experience in PSG scoring), who was blinded to participant identity and group affiliation. Six EEG leads (F3/F4, C3/C4, O1/O2), right and left EOG, and submental electromyography were used for sleep scoring. Pressure flow nasal cannula, inductive thoracic and abdominal belts (effort), and oximetry were used for respiratory assessment. The AASM hypopnea scoring rule 1A was applied (≥ 10 seconds duration of ≥ 30% of air flow reduction associated with a ≥ 3% decrease in oxygen saturation and/or an EEG-arousal). Bilateral pretibial electromyography recordings were used to assess periodic limb movements. The participants used a marker button to indicate their first attempt to fall asleep. The TST, SOL, WASO, SE, distribution of sleep stages (N1, N2, N3, and REM sleep stages as proportion of TST), indexes of sleep stage shifts, wake bouts, EEG-arousals, limb movements in periodic limb movement sequences, and apneas/hypopneas (AHI) were obtained for the recording night. All indexes are denoted as the number of events per hour of sleep. The distribution of sleep stages during a night of PSG recording is illustrated in Figure 3.

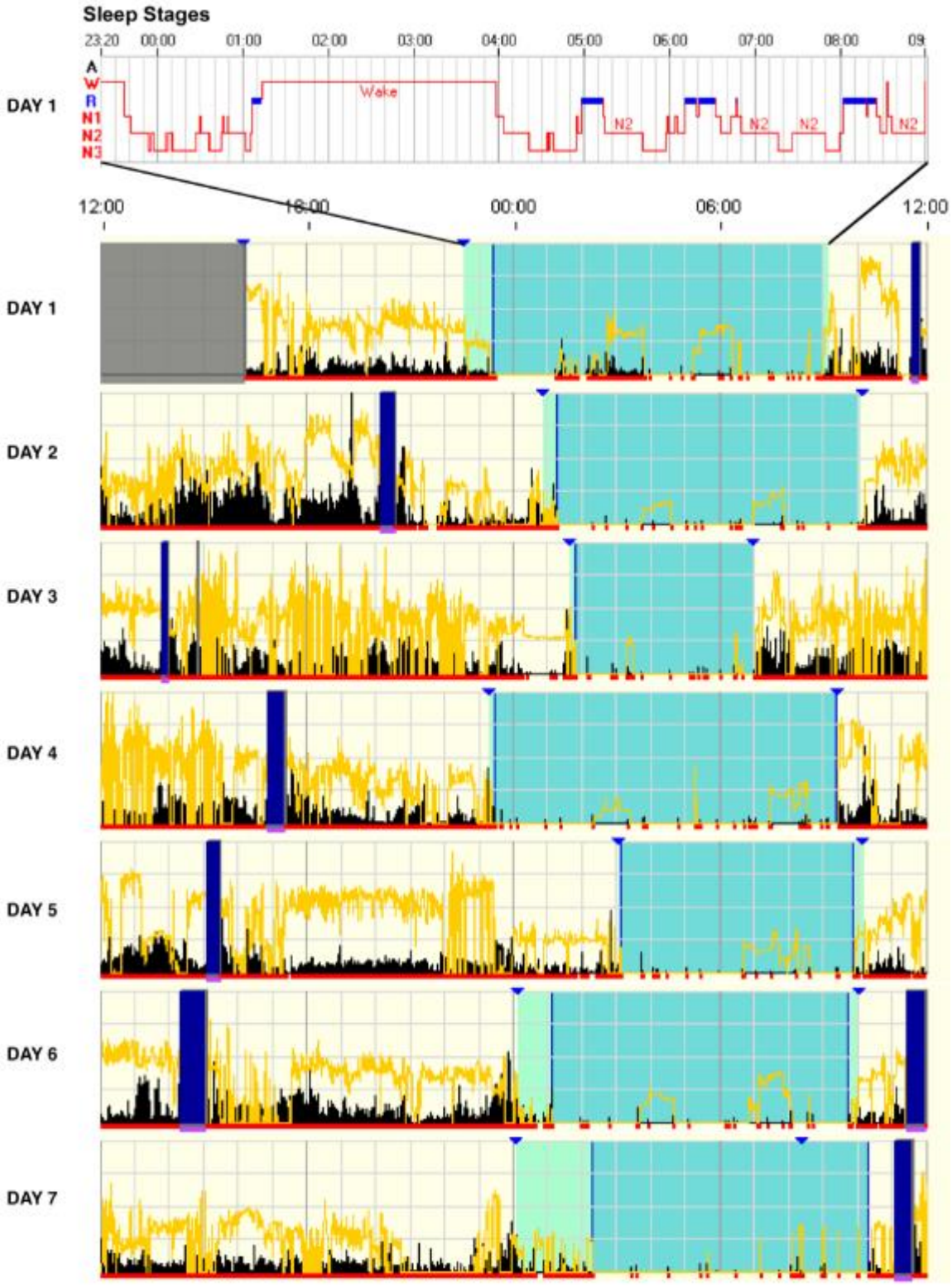

Figure 3 Hypnogram (PSG, top panel) with red line indicating wake at the top level, and consecutively deeper non-REM sleep at lower levels. Blue indicates REM sleep. In the actogram (actigraphy, lower panel) each bar represents a 24-hour period. The blue and green blocks indicate the time in bed, where blue represents the sleep period and green represents the wake time before sleep onset and after sleep offset. The black areas represent the activity counts, and the yellow line represents the ambient white light. The dark blue areas represent off-wrist periods, and the small triangles at the top of the bars indicate patient marker button.

4.6 Blinding

Actigraphy and PSG studies were equipped with dummy identification, by a member of our research group who was not involved in this study, before scoring. The scorer was blinded to identity and group affiliation. To improve the blinding, scoring of all PSG and actigraphy recordings was performed after all data acquisition was complete.

4.7 Statistical analyses

IBM SPSS 25 was used for all analyses. Group differences were assessed using Student's t-tests and chi-square tests for continuous and dichotomous variables, respectively. Effect sizes of mean differences were reported as Hedge's g (between groups, Paper I) and Cohen's d (using the *estimated* marginal mean difference between two observations divided by their *observed* pooled standard deviation, Paper II).

The two-sided alpha level was set to $p < 0.05$ for statistical significance.

Paper I: To estimate the contribution of mental distress and pain catastrophizing to sleep functions, correlation coefficients and multiple linear regression models were estimated separately for the patient and control groups. The various sleep variables were dependent variables, while mental distress and pain catastrophizing were independent variables. These regression models were additionally adjusted for sociodemographic variables and AHI. As a sensitivity test, the regression analyses were replicated (without AHI as a covariate) after removing participants with AHI > 15.

To test whether mental distress and pain catastrophizing could explain group differences in sleep indices, their indirect effects were assessed. For this purpose, the mediation Model 4 (applied for simple and multiple mediation) of the SPSS plugin PROCESS version 3 macro

by Hayes (2018) was applied. This model partitions the total effect (Y = icept + *c*X) in two underlying components: the indirect or mediating effect (*M* = icept + *a*X) and the adjusted direct effect (Y'= icept + *c'*X + *bM*). Here, the indirect effect runs from group (X) through mental distress/pain catastrophizing (M: path *a*) to sleep as outcome (Y: path *b*), and is thus estimated as the product of *a* and *b* (Figure 4). If the indirect path (*a***b*) explains all variability in the outcome measure, the adjusted direct effect (*c'*) will turn non-significant. The size of the mediation effect is represented by the ratio between indirect (a*b) and total effect (*c*).

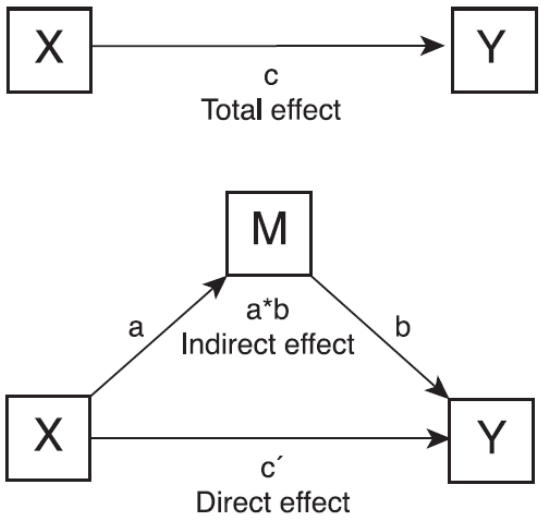

Figure 4 Schematic representation of a mediation model

We used a bootstrapping technique with 5000 resamplings to construct 95% confidence intervals (CIs). Bootstrapping provides empirical CIs for the indirect pathway (product term, a*b) that are also independent of normal-theory distributional assumptions. Thus, bootstrapping is also suitable for samples that are not normally distributed.

Paper II: To assess seasonal variations in a longitudinal design, estimated marginal means during summer and winter were estimated by linear mixed regression models, which model the intercept and/or beta slope of the regression models independently as random factors.

These factors are thus allowed to differ between subjects (Twisk, 2019). In Paper II, a random intercept factor was added, which was sufficient to account for the dependency in the repeated seasonal data. The residual covariance matrix was estimated as a variance component matrix. This model was applied with pain severity and pain dissemination as well as psychological variables, sleep, and activity as dependent variables. Additionally, we examined whether the association between season and pain was modified by the self-report (ISI, HSCL, CFS, PSQI) and actigraphy measures (SOL, SE, TST, midsleep weekdays, and physical activity). Because of the high correlations between these variables, and to reduce the number of interaction analyses, a principal component analysis was conducted, which extracted three optimal linear combinations of these scores, which replaced the nine moderator variables (Table 2). The Kaiser Meyer Olkin (KMO) test had an acceptable score of 0.648, and Bartlett's test of sphericity was significant ($p<0.001$).

Table 2 Principal component scores

	Components		
	C1	C2	C3
Insomnia Severity Index	**0.910**	-0.043	-0.015
Pittsburgh Sleep Quality Index	**0.842**	-0.068	-0.111
Hopkins Symptom Checklist	**0.876**	-0.002	0.083
Chalder Fatigue Scale	**0.818**	0.247	0.028
Total sleep time	0.096	**0.454**	**0.588**
Sleep onset latency	0.057	**-0.847**	0.294
Sleep efficiency	-0.080	**0.907**	0.098
Midsleep	-0.102	-0.113	**0.832**
Activity	-0.177	**-0.475**	-0.220

Note: Total sleep time, sleep onset latency, sleep efficiency, midsleep and activity were derived from actigraphy.

The self-report measures clustered together (ISI, PSQI, HSCL, and CFS) as indicated by C1,

the actigraphy measures SOL and SE clustered on C2, and midsleep and TST on C3. Activity and TST also shared variance with C2. These component scores (C1, C2, C3) were added as covariates, and subsequently tested separately as moderator variables of the season–pain relationship (season*C1/C2/C3). The models were adjusted for sequence of enrollment, age, sex, education, employment, perceived financial status, and marital status. Residual scores were saved and inspected for non-normality and heteroscedasticity.

Paper III: To examine the association between the bidirectional day-to-day sleep and pain observations, generalized linear mixed regression models with an identity link function were fit. This module allows for the estimation of robust standard error parameters that tolerate deviations from normal theory distributional assumptions. The data were organized as a series of seven daily measures at two time points (T1 and T2); therefore, two random intercept parameters were tested: a single (common) intercept for both seven-day periods, or, if substantially contributing, two separate intercepts for each seven-day period (both T1 and T2). A reduction in the Bayesian Information Criterion (BIC) was deemed necessary to retain the second random intercept effect. We additionally estimated, if statistically significant, a first-order autoregressive covariance matrix for the fitted residual scores, which accounted for any left-over declining dependency. This was plausible because the correlation between neighboring days was expected to be higher than between days spaced further apart, for which the random intercepts do not account for. We fitted separate regression models with the daily sleep measures sleep quality, TST, SE, and midsleep as independent variables and the next day pain level as dependent variables as well as models with daily pain level as the independent variable and the same sleep variables the following night as dependent variables. The models were adjusted for the covariates age, sex, education, data-collection period, season, and daily mental distress. The models with sleep as outcomes were additionally adjusted for weekdays vs. weekends. The modifying effect of mental distress and season on

the sleep-pain associations was assessed by sequentially including the interaction term predictor × HSCL and predictor × season. These higher-order interaction terms were only retained if statistically significant.

Power estimation: A pre-study power calculation was performed to estimate an adequate sample size that might detect statistically significant effects. We expected to recruit 100 patients with chronic musculoskeletal pain and a control group of 40 controls, which seemed realistic considering the number of patients visiting the recruiting departments yearly. With this sample size, the study would have a power of 80% ($\alpha = 0.05$) to detect small between-group effects (Cohen's d=0.21).

The power calculations for day-to-day longitudinal analyses were originally performed for a cross-lagged analysis in Mplus, where a sample size of 100 would be sufficient to reject the null hypothesis (power 80%) if correlations exceeded r = 0.26. However, these calculations were futile as the sample size turned out to be too small for estimating cross-lagged correlations as planned, and we thus had to convert to a mixed model approach.

A summary of the materials and methods for the three papers is presented in Table 3.

Table 3 Summary of materials and methods

	Paper I	**Paper II**	**Paper III**
Title	Sleep characteristics in adults with and without chronic musculoskeletal pain. The role of mental distress and pain catastrophizing	Seasonality in pain, sleep, and mental distress in patients with chronic musculoskeletal pain at 69 °N	Daily associations between sleep and pain in patients with chronic musculoskeletal pain
Design	Observational, cross-sectional, case-control.	Observational, prospective repeat measure at two seasons. Patients only.	Observational prospective daily repeat measures. Patients only.
Data structure	Baseline data, averaged 1-week actigraphy data.	Baseline data, averaged 1-week actigraphy data at two seasons.	7 daily measures at T1 and T2, respectively.
Statistical methods	Between group differences, multiple linear regression, bootstrapped mediation modelling.	Linear mixed model with random intercept. Estimated marginal means at two seasons.	Generalized linear mixed models with random intercept, autoregressive covariance matrix and robust error estimation.
Self-report instruments	BPI, ISI, PSQI, HSCL-25, PCS	BPI, ISI, PSQI, HSCL-25, CFS	BPI, sleep quality-VAS, HSCL-10
Objective sleep modalities	Actigraphy (sleep continuity) Polysomnography (sleep continuity and architecture)	Actigraphy (sleep continuity and timing, daytime activity level)	Actigraphy (sleep continuity and timing)

Notes: BPI: Brief Pain Inventory, ISI: Insomnia Severity Index, PSQI: Pittsburgh Sleep Quality Index, HSCL: Hopkins Symptom Checklist, PCS: Pain Catastrophizing Scale, CFS: Chalder Fatigue Scale, VAS: Visual Analog Scale

4.8 Ethical considerations

The study was approved by the Regional Ethics Committee (REK) (reference number 2015/ 2473 / REK nord). All participants, patients, and controls alike provided written informed consent before inclusion in the study. The study was also approved by the data protection official at the UNN. Patients were invited from the UNN, and the response was sent to the researcher at UiT The Arctic University of North Norway. This procedure ascertained for the patient that their treatment was not influenced by the choice of participation. Participants were informed about the option of withdrawing and have their data deleted from the study at any point. Data were stored as required, with separate locations for the identity-key and the research data. Sleep recordings and data files were stored at the Service for Sensitive Data (Tjeneste for Sensitive Data, TSD), a platform for storing sensitive data in compliance with Norwegian privacy regulations, at the University of Oslo.

As this was an observational study, participants were not exposed to any potential adverse effects from any experimental condition. However, they were informed about possible discomfort by the PSG equipment which may be experienced during the recording night. Patients were offered a gift voucher of 250 NOK at attendance for the second data collection. All participants received written reports with results of their sleep recordings and were referred for treatment if necessary.

5 Results

5.1 Sample

A total of 401 patients were invited to participate, of whom 91 responded. Based on the exclusion criteria, 28 patients were excluded and seven patients either moved or withdrew. A flowchart of the recruitment process is presented in Figure 5.

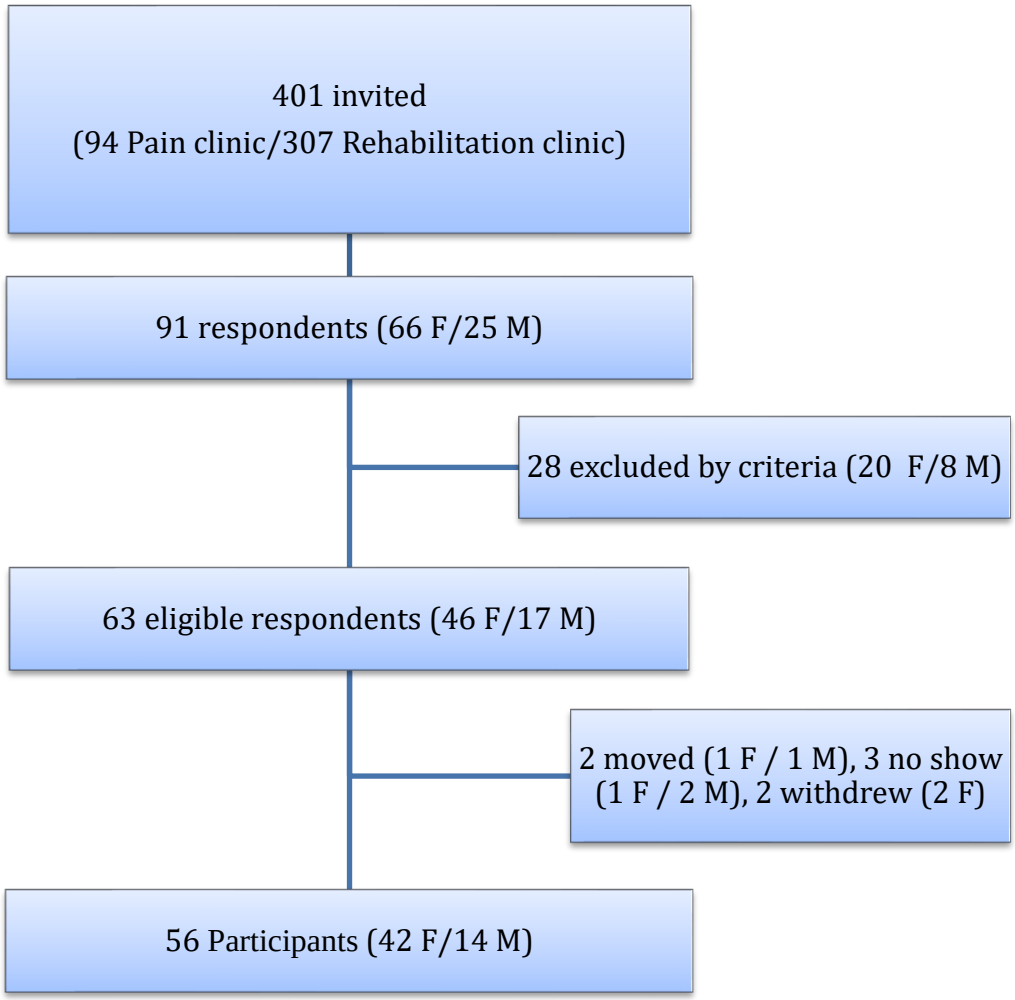

Figure 5 Flowchart showing inclusion of pain patients. F=female, M=Male

The exclusion criteria are presented in Table 4. Note that some respondents fulfilled more than one criterion.

Table 4 Registered exclusion criteria

	n
Other pain	15
Inflammatory condition	7
Psychological condition	4
Hypothyroidism, hypoparathyroidism	3
Opioid overuse	3
Sleep apnea	1
Emphysema	1
Polyneuropathy	1
Myalgic encephalopathy	1
Non-Norwegian speaker (Farsi, need for a translator)	1
Age over 65 years	1

Notes: Other pain: migraine, headache, complex regional pain syndrome, gastritis, neuropathic pain, radiculopathy, and periostitis. Inflammatory condition: Graves' disease, Crohn's disease, Sjogren's syndrome, hepatitis, and Coeliac disease. Psychological condition: ECT-treated depression, ADHD (stimulant use), and psychotic disorder

The final sample consisted of 56 patients, of whom 31 were enrolled during the summer of 2016 (follow-up during the winter of 2016/2017) and 25 during the winter of 2016/2017 (follow-up during the summer of 2017). The distribution of diagnoses in the final patient sample is presented in Table 5.

Table 5 Distribution of pain diagnoses

	n
M54.2 Cervicalgia	12
M54.5 Low back pain	11
M54.9 Dorsalgia, unspecified	11
M79.1 Myalgia	10
M79.7 Fibromyalgia	6
M79.6 Pain in limb	3
M54.8 Other dorsalgia	2
M54.6 Pain in thoracic spine	1

Three participants from the summer-enrollment did not attend the follow-up, and did not undergo PSG recording. The PSGs of two control participants were technically unsuccessful. There were artifacts in respiratory leads in 4 participants (1 control, 3 pain patients) as well as in the leg-movement leads in 6 participants (4 controls, 2 pain patients), and they were excluded from analyses using these variables.

Relatively more females enrolled during summer than winter, whereas other demographic variables did not differ between the enrollment groups.

5.2 Paper I

There were significant demographic group differences, such that fewer pain patients had higher education, whereas more were unemployed, received social benefits, and had a poor or

medium self-assessed financial situation compared to controls. There was no difference in age, sex, or cohabitation between the groups.

As expected, patients reported significantly more pain symptoms, pain catastrophizing, mental distress, insomnia, and reduced sleep quality than healthy controls, and group differences were of large effect sizes.

The actigraphy data showed significant group differences of medium effect sizes including increased SOL and WASO, and reduced SE among patients compared to controls. No significant group difference was observed for TST. The PSG data showed group differences in sleep stage distribution with less SWS (N3) and more intermediate sleep (N2) in patients compared to controls.

Regression analyses were performed separately for patient and control groups. Mental distress, but not pain catastrophizing, was identified as a significant predictor for insomnia and reduced global sleep quality in both groups. Pain catastrophizing was a significant negative predictor of SWS among patients solely. Neither mental distress nor pain catastrophizing significantly predicted SE (actigraphy) in any of the groups.

Mental distress partially explained the group differences in the ISI and PSQI outcome variables, thus indicating a mediation effect of mental distress. No comparable mediation effect of mental distress or pain catastrophizing was observed for the group differences in the SE (actigraphy) or SWS measures.

5.3 Paper II

Seasonality was evident for pain severity, with less pain in winter compared to summer, whereas a seasonal effect of pain dissemination was not observed. These results remained after adjusting for sociodemographic variables and the principal component scores

representing the questionnaire- and actigraphy-based sleep and activity data. Moreover, the component scores did not moderate any season-pain relations. Statistically significant seasonal effects with regard to advanced sleep timing on weekdays and lower levels of physical activity during winter compared to summer, were observed. Patients were exposed to substantially reduced light exposure during winter (Cohen's d 1.36), as a marker of season itself.

No seasonal variations were observed in any of the self-reported measures of insomnia, sleep quality, mental distress, fatigue, or in any of the actigraphy measures of sleep continuity (SOL, SE, WASO) or sleep duration.

5.4 Paper III

Increased levels of pain during the day were associated with worse self-reported sleep quality during the following night. Conversely, self-reported sleep quality was associated with pain levels on the following day in the crude model, but not after adjustment for covariates.

Among the actigraphy measures of sleep, there was only an association between daytime pain and the next night TST in the crude, but not in the adjusted, model. There was no statistically significant association between SE or sleep timing and daily pain.

Mental distress was the single most important variable predicting pain levels, but neither mental distress nor season moderated the sleep-pain associations.

A summary of the results and significance of the three papers is presented in Table 6.

Table 6 Summary results and implications

	Paper I	**Paper II**	**Paper III**
Title	Sleep characteristics in adults with and without chronic musculoskeletal pain. The role of mental distress and pain catastrophizing	Seasonality in pain, sleep, and mental distress in patients with chronic musculoskeletal pain at 69° N	Daily associations between sleep and pain in patients with chronic musculoskeletal pain
Results	Patients had worse sleep by self-reported and objective measures compared to controls. Mental distress was strongly associated with worse self-reported sleep, and partly explained group differences. Pain catastrophizing was associated with reduced SWS among patients only.	Small seasonal variation with increase in pain severity in summer. Significantly more physical activity and later sleep timing in summer. No seasonal variation in pain dissemination, sleep (self-report or objective), fatigue or mental distress.	Daytime pain severity was reciprocally weakly associated with self-reported sleep quality. There were no statistically significant adjusted associations between pain and sleep timing, TST or SE.
Significance	Insomnia and sleep quality are probably best addressed in context with mental distress also in a clinical setting. Increased pain catastrophizing may be associated with reduced restorative properties of sleep among patients with chronic pain.	Clinical impression of seasonal variations in pain was not reflected in repeated measures. Seasonality in pain may be a more complex construct, which needs further exploration.	Weak day-to day associations between pain and self-reported sleep quality were observed, but are probably of little significance in a day-to-day perspective. Potential implications in a longer timeframe may be further studied.

Notes: SWS: slow wave sleep, TST: total sleep time, SE: sleep efficiency

6 Discussion

6.1 Discussion of main results

6.1.1 Pain and disturbed sleep

There is ample evidence for the effect of sleep on chronic pain in cross-sectional and longitudinal studies as well as in experimental studies involving sleep restriction or pain modulation testing in healthy and clinical samples (Alfoldi et al., 2014; Bonvanie et al., 2016; Canivet et al., 2008; Mundal et al., 2014b; Nitter et al., 2012; Odegard et al., 2015; Schuh-Hofer et al., 2013; Simpson et al., 2018; Tang et al., 2007; Uhlig et al., 2018). Sleep disturbance among patients with chronic pain is also of interest on its own right, as patients consider sleep itself a function of importance in the rehabilitation of chronic pain (Hush et al., 2009).

Our study corroborates findings of comorbidity as the prevalence rates of reduced sleep quality and insomnia, based on cut-off scores for PSQI and ISI, was significantly higher among patients than controls. The prevalence of insomnia was somewhat lower in this study than reported by others (Abeler, Friborg, Engstrom, Sand, & Bergvik, 2020; Alfoldi et al., 2014; Tang et al., 2007), of notice is also that the prevalence of reduced global sleep quality (based on PSQI) was more than twice as high as the prevalence of insomnia (based on ISI), indicating that non-specific sleep disturbance may be even more common than insomnia. Reduced sleep quality among pain patients was also reflected in the objective sleep measures, yet group differences were relatively smaller for the objective actigraphy and PSG measures of sleep continuity, and PSG measures of sleep architecture. Although the group differences in sleep continuity were comparable between actigraphy and PSG, they were only significant for actigraphy, possibly due to the smaller variance by this averaged modality. We did not aim to compare self-reported to objective sleep measures in this study; however, there was no significant bivariate correlation between ISI or PSQI with any of the actigraphy or PSG

measured sleep variables, among patients and controls alike, except between PSQI and SOL among controls (Abeler, Friborg, et al., 2020). Previous studies have also observed a lack of correlation between self-reported and actigraphy or PSG sleep measures (Buysse et al., 1989; Morin et al., 2011; Wilson, Watson, & Currie, 1998). Typically, poor sleepers tend to self-report relatively larger sleep disturbances than what is observed by objective sleep measures, and similar findings have also been reported in patients with musculoskeletal pain (Wilson et al., 1998). It has been observed that items concerning worry and dissatisfaction with sleep may contribute more to the ISI total score than items concerning initiation and maintenance of sleep (Gagnon, Belanger, Ivers, & Morin, 2013). Thus, sleep misperception as well as worry and dissatisfaction with sleep may influence this self-reported measure of insomnia, thereby contributing to the larger group differences in the self-reported sleep measures observed in the current study. Such mechanisms also suggest a complementary role of objective sleep measures.

In Paper III, we examined the bidirectional daily associations between sleep and pain in patients with chronic musculoskeletal pain. A few previous daily studies have reported an effect of sleep quality on next day pain more consistently than the opposite, and more often non-significant associations were observed with actigraphy measures of sleep continuity than with self-reported sleep quality. (Alsaadi, McAuley, Hush, Lo, et al., 2014; Gerhart et al., 2017; O'Brien et al., 2011; Tang, Goodchild, Sanborn et al., 2012; Whibley et al., 2019). In our study, the only association that retained significance after adjusting for confounders was the effect of pain during the day on subsequent sleep quality rated the next morning, such that persons with more severe pain reported lower sleep quality the next night. The opposite direction of association between the same variables was not statistically significant in the adjusted model. These associations were small, and it is questionable if they are of clinical interest from a day-to-day perspective (Abeler, Bergvik, Sand, & Friborg, 2020). However, it

is conceivable that such an association may add up over time to have stronger long-term effects. Such hypotheses remain to be tested. It is also possible that associations may be stronger in subgroups of the sample, which could not be examined due to the small sample size. Indeed, a study of low back pain, otherwise comparable to our study, observed significant bidirectional associations between pain and actigraphy measures of SE and WASO (but not TST or SOL) (Alsaadi, McAuley, Hush, Lo, et al., 2014).

We also observed a tendency towards an association between daytime pain and TST, such that increased pain would be associated with increased sleep duration, which in turn would be associated with reduced pain levels (Abeler, Bergvik et al., 2020). Such dynamics could indicate some compensatory mechanism by sleep; however, these relations remain tentative, as they were not significant. As daily associations are generally of small size, future studies should aim to include a larger sample size to ensure sufficient power, particularly when including objective sleep measurements.

6.1.2 The role of affective and cognitive processes

Affective and cognitive processes, sleep, and pain are closely related, as discussed in sections 2.2 and 2.3. As most studies apply self-report measures of sleep, there is a need for studies using objective sleep recordings to examine the relationships between these constructs. Among studies applying objective sleep measures, one reported actigraph measured TST and WASO, in addition to ISI, as predictors of pain in patients with major depression (Chung & Tso, 2010), whereas another observed PSG-measured SE as a mediator of the effect of pain on depression in fibromyalgia (Diaz-Piedra et al., 2014).

Mental distress, but not pain catastrophizing, was a significant predictor of the self-reported sleep variables ISI and PSQI, both among patients and controls, and a mediator of the group difference (Abeler, Friborg, et al., 2020). In the mediation model, mental distress and pain

catastrophizing were assessed simultaneously, such that the common effect of both predictors was removed from their separate effects (Abeler, Friborg, et al., 2020). As this approach rendered pain catastrophizing non-significant, mental distress seems more clinically important for insomnia. This finding is in contrast to previous studies showing a stronger relationship between insomnia and pre-sleep cognitive arousal (excessive mental activity at bedtime) than with affective measures (Byers et al., 2016; Palermo et al., 2011; Smith et al., 2000). This finding underscores the close relationship and possible overlap of constructs between affect and self-reported sleep, and in a clinical context, this comorbidity is probably best managed concomitantly.

Pain catastrophizing was a significant predictor of SWS in the patient group (Abeler, Friborg, et al., 2020). This was a novel finding, suggesting that cognitive processes revolving around pain may contribute to reduced SWS, which is observed in chronic pain (Wu et al., 2017). Since SWS seems to contribute to subjective sleep quality through its restorative properties (Akerstedt et al., 1997; Krystal & Edinger, 2008; Ohayon et al., 2017), this association proposes a potential physiological link between cognitive pain processes and reduced sleep quality, which should be subject to further scrutiny.

In this study, mental distress was the strongest predictor of daily pain, thereby weakening the day-to-day effects of sleep variables on pain (Abeler, Bergvik, et al., 2020). It may have strengthened the relationship between mental distress and pain that they were both rated at the same time, before bedtime in the evening (common methods bias, further discussed in section 5.2.3). Mental distress also significantly predicted self-reported sleep quality, but no objective sleep parameter, in agreement with previous discussion. Interestingly, the associations between sleep and pain were stable across levels of mental distress.

The observations in this study affirm the strong associations between pain and affective and cognitive processes that are incorporated in the IASP and ICD-11 definitions of chronic pain, and also links affective processes to self-reported sleep quality and insomnia. The objective sleep parameters seem less affected by affective processes and may represent distinct dimensions of sleep.

6.1.3 Common neurobiology

The discussed clinical evidence for a conjunction between pain, sleep, and affective processes, underpinned by the current study, could suggest some degree of common or overlapping etiological pathways. After observing patients with bodily pain after traumatic spinal cord transections and phantom limb phenomena, Melzack proposed that the experience of pain may emerge from a central pain matrix comprising a network of defined brain areas (Melzack, 1999). He hypothesized that the central nervous system not only modulates painful stimuli from peripheral tissues, but that the brain is capable of producing a sensation of pain and other sensory qualities autonomously, without any sensory input, by involving loops between the thalamus, cortical areas, and limbic structures (Melzack, 1999). In addition to primary and secondary sensory cortical regions, the brain areas involved in pain processing seem to include the prefrontal cortex and areas involved in emotions such as the anterior cingulate cortex, hippocampus, and amygdala, which are also involved in the development of depression (Boakye et al., 2016). Results from insomnia studies appear less conclusive but indicate involvement of prefrontal cortical areas as well as the amygdala, hippocampus, and cingulate cortex (Boakye et al., 2016; Riemann et al., 2010). In addition to topographical overlap, neurobiological pathways, possibly shared between all three conditions, may include abnormal activation of stress responses (hypothalamus-pituitary-adrenal, HPA-axis), neuro-inflammatory responses, and monoaminergic pathways (Boakye et al., 2016). Hypothetically, it is thus plausible that a structural, connective, and/or neurochemical pain matrix overlaps

with a “depression matrix” and an “insomnia matrix” which may be separately or jointly triggered to a variable extent, thereby explaining the clinical overlap between these conditions. To further study such hypotheses, one would have to include structural and functional imaging measures as well as neurobiological indicators in the study of the clinical trajectories and overlap between pain, sleep, and depression.

6.1.4 Seasonal variations

This northernmost study of seasonality in pain was conducted in a subarctic location during a period without daylight in winter and a period with continuous daylight in summer. Clinical experience in Tromsø suggests that patients with chronic pain are more troubled by their pain condition in winter, an impression also communicated from Canada (Owen, 1995). However, in our study, we observed an increase in pain severity in summer rather than winter, which may be related to higher expectations of performance during summer (Abeler, Sand, Friborg, & Bergvik, 2020). Previous observations suggest disparity between seasonal variation assessed by repeated measures using specific questionnaires (slight increase in pain in summer) and patients’ recollection of seasonal impact on pain (increased pain in winter) (Hardt & Gerbershagen, 1999; Hawley & Wolfe, 1994; Hawley et al., 2001; Iikuni et al., 2007; Moldofsky, 1994). Similar discrepancies have been noticed in reports of sleep complaints and symptoms of anxiety and depression in a large Norwegian population study where participants contributed data at one occasion during the year (Oyane, Bjelland, et al., 2008; Oyane, Ursin, Pallesen, Holsten, & Bjorvatn, 2008). Moderate or high global seasonality scores, tapping sleep and behavior, were reported by 33% of the population sample, yet no main effect of season of participation on a range of sleep outcomes or symptoms of anxiety or depression was observed in either of three seasonality groups (low, middle, high) (Oyane, Bjelland, et al., 2008; Oyane et al., 2005; Oyane, Ursin, et al., 2008). However, the high seasonality group reported significantly more psychological and sleep

symptoms throughout the year than the low and middle seasonality groups (Oyane, Bjelland, et al., 2008). In a population study conducted in Tromsø, participants enrolled in winter reported significantly more current sleep difficulties, and self-reported somewhat later sleep-wake rhythm than participants during other seasons, but no seasonal variation in mental distress was observed; consequently, the authors refer to seasonality in mental distress as "more a myth than a fact" (Johnsen et al., 2013; Johnsen et al., 2012). Persons reporting high seasonality thus seem to suffer generally higher symptom load, but low to non-existent seasonal variation in specific measurements in mood or sleep, as a possible parallel to the observations of pain in the current study. Negative appraisal and intrinsic illness attitudes as well as seasonality of a diffuse and multidimensional character may possibly contribute to this apparent contradiction, as discussed in Paper II (Abeler, Sand, et al., 2020)

The finding of delayed sleep timing in summer was unexpected because previous studies from the general population in Tromsø and Japan and from personnel at research stations in the Antarctic reported delayed sleep timing in winter, presumably due to lack of the entraining effect of sunlight in the morning (Arendt, 2012; Johnsen et al., 2013; Suzuki et al., 2019). The study from Tromsø notes that this finding was contrary to a widespread myth claiming that people in Northern Norway go to bed much later in summer since the sun is still shining in the evening and people need less sleep during summer (Johnsen et al., 2013). Studies from the Antarctic suggest that the delayed sleep wake rhythm in winter may be part of a general delay of the circadian rhythm, as the other chronobiologic biomarkers melatonin and core body temperature also displayed a delay in winter (Arendt, 2012). To the best of our knowledge, it has not yet been tested whether chronotypical subgroups may react differentially to seasons. Intrinsic late chronotypes with evening preferences may enjoy bright evenings and thus delay sleep times in summer, or on the contrary, may be more dependent on bright morning light to prevent delay of sleep times and thus delay in winter. These are two hypothetical mechanisms

which would have opposite effects on sleep wake rhythms. For patients with pain, avoidance of going to bed, possibly brought about by apprehension regarding pain or sleep, possibly in combination with an evening preference, may prompt a later bedtime in summer, with an ensuing delaying effect of light as described. It would be of interest to follow-up these results with further studies of chronotype, morning and evening preferences, and possibly a qualitative study exploring the construct of seasonality.

6.2 Methodological considerations

6.2.1 Measures of main constructs

Pain: As pain is a subjective experience, it may primarily be assessed by self-report. Factor analyses of the BPI consistently identify two separate factors: pain intensity and pain-related functional impairment (interference), where the interference factors may be further decomposed into affective and activity subscales (Cleeland, 1991; Klepstad et al., 2002). In the current study, we chose to only apply the pain severity scale, which has been separately validated (Tan et al., 2004), and the body map, and did not include the pain interference scale. As one of the interference sub-factors is an activity subscale, the inclusion of the pain interference scale could possibly have shed light on the unexpected finding of increased pain in the summer season in Paper II (Abeler, Sand, et al., 2020). However, since we aimed to explore the associations of pain with sleep and mood, including interference items covering affective dimensions and sleep, could have inflated (biased) associations of the pain measure with the sleep and mood measures. The choice of not including it still seems reasonable. However, future studies of seasonal variations in pain could profit from including instruments covering broader aspects of pain.

Sleep measures: Insomnia is defined by diagnostic criteria in the ICSD-3 (AASM, 2014). The construct of sleep quality lacks a clear definition. In day-to-day studies of sleep and pain,

single-item assessment of sleep quality is typically applied, by rating statements like “last night I would describe as a good - poor night’s sleep” as we did in Paper III (Abeler, Bergvik, et al 2020). The multifactorial nature of sleep quality is reflected in the widely applied PSQI (described in section 4.3). Although mostly applied as a subjective measure, objective measures of sleep quality have been proposed (described in section 2.2). Self-reported sleep quality may be biased by pain as pain patients tend to build an appraisal of sleep quality partly on pain levels (Blagestad, Pallesen, Gronli, Tang, & Nordhus, 2016; Ramlee, Afolalu, & Tang, 2018). In Paper I, a strong bivariate correlation of self-reported sleep measures with pain catastrophizing and mental distress, and moderate correlation with pain severity was observed. There was no correlation between self-reported sleep and sleep indices derived by actigraphy or PSG (Abeler, Friborg, et al., 2020). This corroborates, as previously discussed, that self-report, actigraphy, and PSG measure distinct components of sleep, and their combination provides an integrated insight into the construct of sleep. The application of a comprehensive sleep assessment array is one of the considerable strengths of this study.

PSG: PSG is the only mode of sleep recording that permits objective measurement of sleep architecture, including SWS, REM, sleep stage shifts, and arousal. However, a general problem with PSG is the intrusiveness of the equipment combined with the unfamiliar sleep environment in a sleep lab, which may contribute to altered sleep due to the circumstances of the recording, referred to as the first-night effect (Edinger et al., 1997). To handle the first-night effects, many studies include one or several adaptation nights that are not used for analyses (Wu et al., 2017). In our study, we were concerned that introducing several nights of PSG recording would result in attrition of participants as well as reducing the capacity to include participants due to twice the occupation of the PSG devices per participant. We expected our home-recording procedure and mounting the device in the afternoon, allowing several hours of adaptation to minimize first-night effects (Edinger et al., 1997). Additionally,

we applied identical procedures for patients and controls, and therefore assumed the potential first-night effects would be introduced equally in the two groups. In support of this view, a meta-analysis of controlled PSG studies in chronic pain detected group differences irrespective of adaptation nights (Wu et al., 2017).

Actigraphy: A considerable challenge with actigraphic recording has been the lack of consensus concerning instrumentation, algorithms, software, and reporting of actigraphy, as different procedures may provide significant differences in the estimated sleep parameters (Berger et al., 2008; Boudebesse et al., 2013). In 2015, the SBSM published a guide to actigraphy monitoring, recommending the use of information from sleep logs, patient markers, activity measures, and light levels in the scoring of rest intervals (Ancoli-Israel et al., 2015). The guide points out that even when considering this information, scoring may be challenging (Ancoli-Israel et al., 2015). The recommended SBSM procedure was implemented in the current study, which is an effort to increase consistency in actigraphy scoring and reporting.

In addition to using actigraphy data for sleep monitoring, we also used daytime activity measures to quantify seasonal differences in physical activity (Abeler, Sand, et al., 2020). The average activity throughout the wake period was the only activity-parameter available. Such an average measure has been applied to monitoring physical activity in patients with depression, fibromyalgia, and seasonal variability in the elderly (Brychta et al., 2016; Korszun et al., 2002). Although, a measure of time spent in various activity levels (vigorous, moderate, sedentary) has been reported to better discriminate fibromyalgia patients from healthy controls (Kop et al., 2005), the objective activity measurement in this study is a strength.

6.2.2 Statistical considerations

Causality in cross-sectional design: In this study, we collected observational data for 1 week in two seasons in pain patients and at one time point in matched healthy controls.

The cross-sectional design of Paper I precludes any causal inferences based on the observed associations in this study, according to common rules of causality where the cause must appear before the effect (Hill, 1965). In mediation analyses, mediators are often described as being on a causal path from X to Y. Yet, causal implication of the mediator may be inferred if the predictor, mediator, and outcome variable succeed each other, or if the direction of associations may be assumed by logic or biological knowledge (e.g., physical exercise may not be caused by high pulse). When mediation models are applied in cross-sectional designs, a significant mediation effect implies shared variance, but not necessarily causal relations (Hayes, 2018, pp 113-145). Due to the cross-sectional design, we could not establish whether the group differences in insomnia and sleep quality are caused by mental distress, or alternatively, if the group difference in mental distress is caused by insomnia or reduced sleep quality. The proposed mechanisms are thus tentative and should be further explored in future longitudinal repeat measures studies, where a succession of symptoms in time can be assessed.

Case-control matching: Matching cases and controls on selected variables may be a way of dealing with potential confounding. In our study, we selected age, sex, and season as matching variables, since we regarded them as potential confounders for group differences in pain, sleep, and psychological factors. However, our recruitment procedure for controls, with announcements among university, hospital employees, and at the blood bank, selected controls that scored higher on several sociodemographic variables (education, employment, income satisfaction) and lower on others (social benefit), which may also be related to chronic

pain, sleep, and mental distress. This was handled by adjusting for demographic variables in the statistical tests. In future studies, it may be preferable to recruit controls that are more comparable to a clinical pain sample, for example, by using a broader recruitment procedure (media and social media).

6.2.3 Bias

Non-response-bias (self-selection-bias): In the current study, only 22.7% of the invited patients responded, which clearly elicits concerns regarding selection bias and representativeness of the sample. Due to patient privacy regulations, we did not have access to any information concerning the non-responding patients, but previous studies have observed significant differences in socioeconomic and lifestyle factors between responders and non-responders (Abel, Saunders, & Lyratzopoulos, 2016; Christensen, Ekholm, Gray, Glumer, & Juel, 2015). With the intention of counteracting a low response rate, we offered personal feedback concerning the sleep recordings, compensation for transportation costs, and a gift voucher when attending the second data-collection period. Despite these efforts, the response rate was lower than expected. As we did not have access to information regarding the non-responders, we compared the available data from the general pain populations at the two recruiting departments, although these pertain to broader patient groups than musculoskeletal pain. Such data suggest that our sample has similar age, levels of mental distress and cohabitation, but somewhat lower pain severity, higher education, larger female ratio, and higher employment rate (Danielsson, Kvarstein, & Bergvik, 2020; NNRR, 2016).

Another major problem concerning non-response, and perhaps the weakness of most concern for this study, was the resulting sample size. The sample size was lower than required by the initial power calculation, which may have compromised the power of the study. This may have had an effect on the day-to-day associations analyzed in Paper III (Abeler, Bergvik, et

al., 2020), where effect sizes were small, and possibly on the mediation models involving PSG-variables in Paper I (Abeler, Friborg, et al., 2020). Nevertheless, the sample size was sufficient to detect significant between-group differences, seasonal variation in pain, and daily associations of pain and sleep quality.

Observer expectation bias: This is a type of information bias that may arise when the person collecting data is aware of the study aim and participant's group affiliation. The data recording may be influenced by the way information and help is given or questions are explained (Delgado-Rodriguez & Llorca, 2004). In this project, the two investigators conducting all data collection (research assistant and PhD candidate) were both aware of the participant's group affiliation. To ensure that the same procedure was followed by both investigators for all participants, a checklist for administering data collection and providing information was prepared. A folder, containing the same information, was handed out to all participants to bring home to further reinforce the information. To provide minimal interference by the investigator, the participant was left alone in the room to complete the paper and pencil questionnaires. The completed questionnaires were read optically to produce a statistical data file. Another main action taken to prevent observer expectation bias was blinding of all PSG and actigraphy recordings before scoring. The scorer was thus unaware of subject identity and group affiliation while scoring PSG and actigraphy. The blinding procedure was performed by a member of the research group not involved in this study, once data collection was completed. This effectively nullifies the risk of observer expectation bias influencing PSG and actigraphy data.

Common method bias: Common method bias pertains to the correlation between measures on grounds of being collected by the same method, which may inflate the strength of associations between variables. Contributing factors are individual response style, proximity of

instruments in time and space, wording of items, and item context (Podsakoff, MacKenzie, & Podsakoff, 2012). In the current study, pain, insomnia, sleep quality, mental distress, and pain catastrophizing were assessed by self-report, and the same scale (Likert scale and numeric rating scale) were applied in several instruments. Thus, there is a risk of increased strength of association between these variables, attributable to common methods. Measures that could have been taken to prevent common method bias are to collect data on predictors and outcomes by different sources, at different times or supply distance between instruments and items in a questionnaire, prevent common scales, and balance positive and negative items. However, the strength of the study in this respect is that sleep data were obtained by several different measurement modalities, preventing this type of bias in analyses including PSG and actigraphy measures.

Confounding: Confounders are variables that are associated with both the predictor and the outcome variable and may therefore distort their apparent association. In our study, we had several potential confounders such as age, sex, and socioeconomic status, which we could handle by the matched design and by inclusion as control variables in multivariate regression models. Potential confounders were also handled by the exclusion criteria (rheumatic disease, endocrinological disease). There were, however, also possible confounders (associated with pain, sleep and psychological distress) which were not measured, and could not be controlled for, such as, previous life events / trauma, personality traits, chronotypical traits, medication and shiftwork.

6.2.4 External validity

In this study, we recruited a selected patient group with chronic primary musculoskeletal pain among patients receiving interdisciplinary pain treatment at a university hospital. Combined with a low response rate and exclusion of patients with comorbid conditions, which is

common in chronic pain, caution is warranted regarding generalizability to all patients with primary musculoskeletal pain in pain clinics or primary health care.

7 Conclusion and future perspectives

This study corroborates previous findings of a strong association between self-reported measures of sleep and mental distress among patients with chronic primary musculoskeletal pain and healthy controls. Self-reported sleep disturbance is therefore probably best interpreted in a broader context, considering symptoms of depression. In a clinical setting, comorbid insomnia and depression may be best managed concurrently in patients with chronic pain. The reciprocal daily associations of sleep quality and pain were small, and the strongest predictor of daily pain was the level of mental distress. Pain catastrophizing, possibly by contributing to pre-sleep cognitive arousal, may be related to lower levels of restorative SWS. This novel finding should be replicated in future studies, and potential effects of cognitive treatment for pain catastrophizing on sleep architecture are among future perspectives. The study illustrates the complementary role of self-reported and objective sleep measurement modalities. In a clinical setting, adding objective sleep assessment, at least in selected patients, may add valuable clinical information that may be addressed in a multidisciplinary rehabilitation context. Finally, seasonal variation in pain (small effect) and sleep timing (medium effect) was in the opposite direction to that hypothesized. These novel findings should be further studied, possibly by a more comprehensive assessment of circadian rhythm with biological markers as well as by qualitative research designs. Problematic circadian variations may be targets for treatment such as sleep schedules, light, and melatonin treatment.

The collected data are rich and have potential for further studies, particularly the PSG-data. It would be of interest to perform more detailed EEG-frequency analyses to examine whether

brain activity during SWS differs between persons with chronic pain and pain-free controls, which could affect the restorative properties of SWS. The hypothesis would be that persons with chronic pain have decreased slow frequencies and increased fast frequencies during SWS, corresponding to less restorative sleep (Blagestad et al., 2012).

An interesting methodological issue would be to investigate the first-night effect of unattended home PSG. The data would allow the comparison of actigraphy recordings from the night where PSG was performed with the nights without PSG, and to compare the first-night effects in patients with chronic pain to healthy controls.

It would also be of interest to examine heart rate variability from the PSG as a measure of sympathetic/parasympathetic tone during sleep. The hypothesis is that patients with chronic pain have reduced heart-rate variability during non-REM sleep signifying reduced parasympathetic/sympathetic tone (Mork et al., 2013).

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Paper I

Abeler, K., Friborg, O., Engstrøm, M., Sand, T. & Bergvik, S. (2020).

Sleep characteristics in adults with and without chronic musculoskeletal pain: The role of mental distress and pain catastrophizing.

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Paper II

Abeler, K., Sand, T., Friborg, O. & Bergvik, S. (2020).

Seasonality in pain, sleep and mental distress in patients with chronic musculoskeletal pain at latitude 69°N.

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Paper III

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Daily associations between sleep and pain in patients with chronic musculoskeletal pain

Karin Abeler[1,2] | Svein Bergvik[1] | Trond Sand[3,4] | Oddgeir Friborg[1]

[1]Department of Psychology, Faculty of Health Sciences, The Arctic University of Norway, Tromsø, Norway

[2]Department of Neurology and Neurophysiology, University Hospital of North Norway, Tromsø, Norway

[3]Department of Neuromedicine and Movement Science, Faculty of Medicine and Health Sciences, NTNU - Norwegian University of Science and Technology, Trondheim, Norway

[4]Department of Neurology and Clinical Neurophysiology, St. Olavs Hospital, Trondheim University Hospital, Trondheim, Norway

Correspondence
Karin Abeler, Department of Psychology, The Arctic University of Norway, Huginbakken 32, 9037 Tromsø, Norway.
Email: karin.abeler@uit.no

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Abstract

Patients with chronic pain commonly report sleep problems, and the evidence for a relationship between sleep disturbance and pain seems robust. The day-to-day associations between these constructs are less well studied, particularly with objective sleep measures such as actigraphy. Moreover, the concurrent presence of negative affective symptoms, as well as seasonality effects at extreme latitudes may complicate it further. Here, we studied 56 patients with chronic primary musculoskeletal pain conditions, contributing data in two separate 7-day data-collection periods during the summer and winter, respectively. The effect of self-reported sleep quality, and actigraphy measured sleep duration, efficiency and timing on next-day pain, as well as the effect of pain on the same sleep indices were estimated by generalised linear mixed regression models. The models were additionally adjusted for age, sex, education, data collection period, weekend, season and mental distress, with the latter two also specified as moderators. We observed a significant effect of pain as a predictor of next-night sleep quality ($p = .003$) and marginally of next-night sleep duration ($p = .079$). Conversely, sleep quality tentatively predicted next-day pain ($p = .063$). No other day-to-day associations were present. Mental distress was the strongest predictor of pain, but it did not modify the sleep–pain associations, nor did season. In conclusion pain, sleep quality and mental distress are closely related, underscoring the importance of encompassing this complexity in assessment and treatment of patients with chronic pain.

KEYWORDS

actigraphy, chronic musculoskeletal pain, insomnia, mental distress, multilevel modelling, season

1 | INTRODUCTION

The evidence for a bidirectional pain–sleep relationship seems robust (Alfoldi et al., 2014; Gerhart et al., 2017; Tang et al., 2007), yet the strength and direction of such associations within a shorter daily time-frame among pain patients are less well studied. Studies examining day-to-day associations between sleep and pain, suggest a dynamic relationship where worse pain may undermine next-night sleep, and poor sleep may aggravate pain the following day, most consistently reported for the effect of self-reported sleep quality (SQ) on next-day pain (Alsaadi, McAuley, Hush, Lo et al., 2014; Bromberg et al., 2012; Edwards et al., 2008; Gerhart et al., 2017; Lewandowski et al., 2010; O'Brien et al., 2011; Tang et al., 2012; Valrie et al., 2008; Whibley et al., 2019). Studies assessing sleep with actigraphy, indicate minor to non-existent effects of pain on next-night total sleep time (TST), sleep efficiency (SE), wake after sleep onset (WASO), and sleep-onset latency (SOL) (Lewandowski et al., 2010; O'Brien et al., 2011; Tang et al., 2012;

Whibley et al., 2019). An exception is a study by Alsaadi, McAuley, Hush Lo et al. (2014) where increased pain during the day predicted increased WASO and reduced SE the following night. Conversely, the effect of actigraphy-recorded sleep measures on pain levels the following day seems more variable, as effects of TST, SE and/or WASO have been reported by some (Alsaadi, McAuley, Hush, Lo et al., 2014; Lewandowski et al., 2010; Tang et al., 2012), but not by others (O'Brien et al., 2011; Whibley et al., 2019).

Previous studies of daily sleep–pain associations have, to our knowledge, not included measures of sleep timing, although delayed sleep timing, as a trait, has been associated with increased pain (Merikanto et al., 2014; Zhang et al., 2018). In the present study, we included the midpoint of sleep as a measure of sleep timing, and a variable of interest. Sleep timing in the general population may be delayed in winter at higher latitudes (Friborg et al., 2014; Johnsen et al., 2012), which is relevant for the present study conducted in the sub-arctic. In a recently published study based on the same dataset as the present study, we unexpectedly observed a delay in sleep timing and mild increases in pain levels in summer compared to winter. (Abeler et al., 2020). The role of seasonality is in general an understudied factor in the associations between sleep and pain in pain populations.

A further complicating factor in studies of pain and sleep, is the substantial comorbidity of depression in chronic pain (Bair et al., 2003), to date the role of affective symptoms in day-to-day sleep–pain associations seems inconclusive, as some studies find a contribution of depressed mood to daily sleep and/or pain (Bromberg et al., 2012; Edwards et al., 2008; Lewandowski et al., 2010; Tang et al., 2012), whereas others do not (Alsaadi, McAuley, Hush, Lo et al., 2014; Whibley et al., 2019). Studies examining if affective symptoms may modify any day-to-day associations have reported moderating effects in one or both directions (Bromberg et al., 2012; O'Brien et al., 2011; Valrie et al., 2008), or no moderation (Lewandowski et al., 2010). We therefore included affective symptoms both as a covariate and as a moderator in order to examine these potential respective directions.

The aim of the present study was to examine day-to-day bidirectional relationships between sleep and pain among patients with chronic primary musculoskeletal pain by actigraphy and self-report sleep measures. More specifically, the objectives were to estimate whether daytime pain predicts self-reported SQ and actigraphy-recorded TST, SE and sleep-timing the following night, and whether the same sleep indices predict next-day pain levels. A second objective was to examine whether such day-to-day relationships were modified by season or daily fluctuations in mental distress.

2 | METHODS

2.1 | Study sample

Patients attending the outpatient clinic at the Rehabilitation Department or the Pain Clinic, both at the University Hospital of North Norway (UNN), and residing in the sub-arctic municipality of Tromsø (69° North), were invited by mail. Patients aged 18–65 years and diagnosed with chronic primary musculoskeletal pain (CMP), defined by selected International Classification of Diseases 10th Revision (ICD-10) codes, at the respective clinics during the last 18 months were included. As these conditions are usually treated in primary healthcare, the patients referred to specialist clinics are expected to be those with more persistent and longstanding (chronic) conditions. Patients were excluded if they had a major medical condition (cancer, inflammatory, symptomatic heart or lung, metabolic or endocrine disease), neurological condition, mental health condition, were drug abusers, pregnant or participated in ongoing intervention studies. Patients diagnosed with sleep disorders other than insomnia were also excluded.

2.2 | Procedure

All participants provided data during two separate data-collection periods; summer (May–July, 2016 and 2017) and winter (November–February, 2016–2017). A non-randomised counterbalancing scheme was employed, with half of participants entering the first data-collection period during the summer and the other half during the winter. Each data-collection period entailed 1 week of continuous actigraphy recording combined with daily paper and pencil questionnaire registrations (the first and the second data-collection periods are entitled T1 and T2, respectively). Perceived SQ the previous night was scored upon awakening in the morning, whereas mental distress and pain intensity experienced during the day were scored at bedtime in the evening. The first visit was scheduled at the UNN, where subjects received detailed information, completed baseline questionnaires, and had the actigraph attached. Participants returned the actigraph and the completed questionnaires after 7 days. Participants were instructed to conduct their daily life as usual during the study periods without restrictions to sleep schedule, habitual medication or daily activities.

2.3 | Measurements

2.3.1 | Baseline measurements

Demographic variables: Age, gender, educational level (high school versus higher education), marital status (single versus married/cohabiting), employment (no, yes), receiving social benefit (no, yes), and self-rated perceived financial situation (poor/medium versus good) were registered.

Insomnia Severity Index (ISI): The ISI includes seven items assessing problems with sleep onset, maintenance and early morning awakening, as well as daytime functioning, sleep satisfaction and worrying about sleep during the previous 14 days (Morin, 1993). Items are rated on a 5-point Likert scale (0–4), with higher scores indicating worse insomnia (total range 0–28). A cut-off score

of >14 suggests clinical insomnia (Morin et al., 2011), and ISI is a recommended research measure of insomnia symptoms (Buysse et al., 2006).

Pittsburgh Sleep Quality Index (PSQI): The PSQI comprises 19 items probing SQ and disturbance during the previous month across seven components: (a) subjective SQ, (b) sleep latency, (c) sleep duration, (d) habitual SE, (e) sleep disturbance, (f) sleep medication, and (g) daytime dysfunction. Each component receives a score of 0–3 based on a scoring algorithm, yielding a global score with a range of zero to 21 (higher scores indicate more disturbed sleep), where a value >5 indicates poor SQ (Buysse et al., 1989). The PSQI is a recommended research measure of global SQ (Buysse et al., 2006).

Brief Pain Inventory (BPI): The pain severity items of the BPI-short form were applied (Cleeland, 1991; Klepstad et al., 2002). Participants estimated their worst, least and average pain during the last week, as well as their current pain. Each of the four items is rated on an 11-point numeric rating scale (NRS) (from zero = no pain to 10 = worst imaginable pain). We used the mean score of these four items in the analyses of pain severity.

Hopkins Symptom Checklist 25 (HSCL-25): The HSCL-25 is a self-report inventory designed to screen for symptoms of depression and anxiety, indicating mental distress in the last 14 days (Derogatis et al., 1974). The 25 items are rated on a 4-point Likert scale (from 1 = not at all to 4 = very much), from which a global average score is calculated (range 1–4).

2.3.2 | Daily measurements

Sleep quality: Self-reported SQ the previous night was rated on a visual analogue scale (VAS) in the morning ('last night I would describe as a good [0] - poor [100] night sleep'). The term 'SQ' will pertain to this self-reported measure throughout the rest of this paper.

The BPI: Similar to the baseline measures, the BPI severity items with the timespan modified from 'last week' to 'today' were applied for the daily measures. Participants estimated their worst, least, and average pain during that day, as well as their current pain before bedtime in the evening. We used the mean score of these four items in the analyses of pain severity.

The HSCL-10: The HSCL-10 comprises 10 of the original depression and anxiety items of the HSCL with good score reliability (Strand et al., 2003). Patients rated their mood according to the current day (modified from last week). The scoring was similar as for the HSCL-25.

Actigraphy: The Actiwatch Spectrum Plus device, which is validated in patients with musculoskeletal pain (Alsaadi, McAuley, Hush, Bartlett et al., 2014), was used to register movement, and post-processing of the raw actigraphy data was conducted using Actiware version 6.0.9 software (both Philips Respironics, Inc., Murrysville, PA, USA). The Actiwatch was worn on the non-dominant wrist, only to be removed shortly during showering or if required at work (e.g. due to hygiene or safety considerations). Off-wrist periods were excluded from the analyses. The participants were instructed to register time of first sleep attempt and final morning awakening in the accompanying sleep diary and by pushing an event button on the actigraph. Rest intervals were scored by a trained research assistant (psychology student) supervised by a specialist in clinical neurophysiology (first author). Both were blinded to participant identity. A significant sustained reduction or increase in activity defined the start and end of a rest interval, respectively. If these two primary criteria were insufficient to define the rest interval, the event marker, sleep diary information and light intensity were additionally consulted. Sleep was scored automatically by the software within the defined rest interval, with the specification of 30-s epochs, medium sensitivity (40 activity counts/epoch) for activity detection and an inactivity threshold of 10 min to define sleep onset and offset. The variables TST (duration of sleep within the sleep interval) and SE (total sleep time/time in bed) were recorded for each night. The midpoint of sleep $\left(\frac{sleeponset-sleepoffset}{2}\right)$ was calculated as a measure of sleep timing (Roenneberg et al., 2004).

2.4 | Statistical procedure

The IBM Statistical Package for the Social Sciences (SPSS®, version 25) was used for all analyses. Summary statistics were used to present demographic and baseline characteristics, separately for the first and second attendance.

Generalised linear mixed regression models were fit to examine the association between the bidirectional day-to-day observations. The dataset was rearranged such that each participant's daily measurements for the same and the next day appeared on the same row, thus allowing analyses of the temporal correlations between the current and the next day measures. The repeated data included several layers of dependency that was accounted for by including random coefficient variables in addition to an estimation of any remaining residual correlational patterns. Two random intercept parameters were added: one for the 7-day repeated measures for each subject, and another, if substantially contributing, for the dependency in these measures across the two data-collection periods, T1 and T2. A reduction in the Bayesian information criterion (BIC) was deemed necessary to retain the second random intercept effect. We additionally estimated, if significant, a first-order autoregressive covariance matrix for the fitted residual scores accounting for any left-over declining dependency. The standard errors were estimated using the robust sandwich estimator due to some heteroscedasticity in the error scores. The alpha level was set to 0.05.

We fitted separate regression models for the effects of the daily sleep measures (SQ, TST, SE and mid-sleep) on the next-day pain level, as well as models for the effect of daily pain level on the same sleep variables the following night. The crude models were adjusted for the covariates age, sex, education, data-collection period, season, and daily mental distress. The models with sleep as the outcome were additionally adjusted for weekday versus weekend. Season could be included as a covariate adjustment factor due to the seasonal study design, and the modifying effect of mental distress and

season on the sleep–pain associations were assessed by sequentially including the interaction term predictor × HSCL and predictor × season. These higher-order interaction terms were only kept in the models if statistically significant.

2.5 | Ethical approval

The study was approved by the Regional Committee for Medical and Health Research Ethics, Office North (reference number 2015/2473). Written informed consent was obtained from all participants.

3 | RESULTS

A total of 401 patients were invited to participate, of whom 91 responded. Based on criteria, 28 patients were excluded and seven patients either moved or withdrew. The final sample comprised 56 patients, of whom 53 participated at both data-collection periods. The repeated data collection yielded 763 individual observations for the SQ–pain and pain–actigraphy analyses (seven per participant/week), and 654 observations for the actigraphy–pain and pain–SQ analyses (six per participant/week).

The sociodemographic characteristics are presented in Table 1, and the distribution of pain diagnoses is shown in Table 2. Table 3 presents descriptive data for the baseline, daily questionnaire, and actigraphy recordings collected at T1 and T2 separately. Seasonality in this patient group has been described in a previous paper (Abeler et al., 2020) The ISI cut-off score indicated possible clinical insomnia in 23 (41.1%) and 13 (24.5%) patients, and the PSQI indicated poor SQ in 43 (76.8%) and 41 (77.4%) patients at T1 and T2, respectively.

The effect of daytime pain on the next-night SQ and TST are presented in Table 4. An increase of 1 point on the pain severity scale was associated with a close to 3-point deterioration in the SQ scale the next night (p adjusted = .003). Higher daytime pain ratings marginally predicted a longer TST the following night (a 1-point increase in pain associated with about 4 min longer TST, p crude = .015); however, it became non-significant in the full model (p = .079) model. There were no significant effects of daytime pain on sleep timing or SE the next night (Table S1). To assess whether the effect of daytime pain was still detectable on SQ 2 nights later, a post hoc test was conducted. In this analysis the effect was attenuated, but still statistically significant (beta 1.98, 95% confidence interval [CI] 0.60–3.36; p = .005).

The effects of SQ and TST on next day pain are presented in Table 5. Poorer SQ was associated with increased pain the next day; however, a 10-point change on the 100-point VAS of SQ was associated with a minute 0.03-point change on the 11-point scale for pain severity. The effect was significant in the crude (p = .015), but not in the full model (p = .063). There was a non-significant trend towards a negative association between TST and next-day pain (p crude = .078, and p adjusted = .112). Sleep timing and SE were not associated with pain levels the next day (Table S2). Taken together,

TABLE 1 Sociodemographic characteristics, n = 56

Characteristic	Value
Age, years, mean (*SD*)	41.7 (10.8)
Female, *n* (%)	42 (75.0)
Co-habitation, *n* (%)	35 (62.5)
Higher education, *n* (%)	35 (62.5)
Employment, *n* (%)	42 (75.0)
Social benefit, *n* (%)	28 (50.0)
Good financial situation, *n* (%)	16 (28.6)

TABLE 2 Distribution of ICD-10 diagnoses in pain sample

ICD-10 diagnosis	*N*
M54.2 Cervicalgia	12
M54.5 Low back pain	11
M54.6 Pain in thoracic spine	1
M54.8 Other dorsalgia	2
M54.9 Dorsalgia, unspecified	11
M79.1 Myalgia	10
M79.6 Pain in limb	3
M79.7 Fibromyalgia	6

TABLE 3 Sleep, pain and mood characteristics, separate for each study period (T1 and T2)

Characteristic, mean (*SD*)	T1 (n = 56)	T2 (n = 53)
Baseline		
BPI, NRS 0–10	4.2 (1.4)	4.1 (1.5)
ISI, score-range 0–28	12.4 (7.1)	10.6 (6.5)
PSQI, score-range 0–21	10.0 (4.5)	9.2 (4.0)
HSCL-25, Likert 0–4	1.8 (0.5)	1.7 (0.6)
Average daily self-report measures scores		
BPI, NRS 1–10	3.41 (1.91)	3.41 (2.0)
SQ, VAS 0–100	36.3 (28.7)	31.9 (27.8)
HSCL-10, Likert 0–4	1.48 (0.51)	1.56 (0.61)
Average daily actigraphy measures		
TST, hr	6.60 (1.45)	6.58 (1.32)
SOL, min	19.0 (35.7)	12.5 (18.5)
WASO, min	36.3 (22.3)	38.7 (24.2)
SE, %	85.8 (9.4)	86.8 (6.7)
Mid-sleep, hours:min	04:24 (01:36)	04:20 (01:29)

BPI, Brief Pain Inventory; HSCL(-10)(-25), Hopkins Symptom Checklist with (10 items) (25 items); ISI, Insomnia Severity Index; NRS, numeric rating scale; PSQI, Pittsburgh Sleep Quality Index; SE, sleep efficiency; SOL, sleep-onset latency; SQ, sleep quality; TST, total sleep time; WASO, wake after sleep onset

TABLE 4 Daytime pain as predictor of the next-night sleep quality (SQ) and total sleep time (TST)

	Outcome variable: SQ[a] (range 0–100)			Outcome variable: TST (hr)		
Pain as predictor						
Fixed effects	**Beta**	**95% CI**	***F* (*p*)**	**Beta**	**95% CI**	***F* (*p*)**
Pain (0–10)[b]	2.81	0.98–4.63	9.15 (.003)	0.07	−0.01 to 0.14	3.09 (.079)
Covariates						
Sex	5.46	−2.42 to 13.34	1.85 (ns)	−1.09	−1.43 to −0.74	38.37 (< .001)
Age	0.23	−0.01 to 0.47	3.59 (ns)	−0.01	−0.02 to 0.01	0.55 (ns)
Education	−3.23	−9.87 to 3.42	0.09 (ns)	0.31	−0.02 to 0.64	3.49 (.062)
Data-collection period	−4.32	−8.80 to 0.16	3.58 (ns)	0.01	−0.17 to −0.20	0.021 (ns)
Weekend	−5.22	−8.34 to −2.10	10.81 (.001)	0.59	0.36 to 0.81	25.99 (< .001)
Season	0.44	−4.00 to 4.88	0.04 (ns)	−0.00	−0.19 to 0.19	0.00 (ns)
HSCL	9.16	3.16 to 15.17	8.98 (.003)	0.063	−0.21 to 0.33	0.21 (ns)
Random effects	**Estimate**	***SE***	***Z* (*p*)**	**Estimate**	***SE***	***Z* (*p*)**
Intercept (subject)	103.44	36.94	2.80 (.005)	0.30	0.08	3.68 (< .001)
AR1 variance	578.93	38.43	15.06 (< .001)	1.51	0.08	18.44 (< .001)
AR1 correlation	0.21	0.054	3.83 (< .001)	−0.03	0.04	−0.78 (ns)

[a]SQ was rated on a visual analogue scale (VAS) in the morning ('last night I would describe as a good [0] - poor [100] night sleep').

[b]Average of current pain before bedtime and worst, least and average pain during that day rated on a numeric rating scale (0–10). TST was measured by actigraphy. Sex: female = 0, male = 1. Education: ≤10 years = 0, >10 years = 1. Data collection period: T1 = 0, T2 = 1. Weekend: weekday = 0, weekend = 1. Season: summer = 0, winter = 1. AR1, residual covariance matrix estimated as first-order autoregressive; CI, confidence interval; HSCL, Hopkins Symptom Checklist; ns, non-significant. Crude beta for SQ regressed on pain was 3.47 (95% CI 1.75 to 5.18; $F = 15.74$, $p < .001$), and for TST regressed on pain was 0.09 (95% CI 0.02 to 0.16; $F = 5.98$, $p = .015$)

sleep variables predicted only a minor part of the pain reported the next day.

None of the interaction terms in any models revealed a significant modifying effect of season or mental distress. The observed bidirectional associations were thus comparable across season (summer and winter) and across different levels of mental distress.

4 | DISCUSSION

The present study assessed the strength and direction of daily associations between sleep indices (SQ, SE, TST, and mid-sleep) and pain measures in patients with chronic primary musculoskeletal pain through a repeated measures design. Our main finding includes a clear observation of current pain as a predictor of next-night poorer SQ. Daily pain measures also predicted increases in next-night increased TST in the crude model, but became a marginal and non-significant effect in the fully adjusted model. A small effect of SQ on pain was found in the crude model, but became non-significant after adjustment. Another main finding was that bidirectional sleep–pain associations were not modified by daily mental distress or by season.

In the analyses of daily associations between SQ and pain, mental distress was the single variable responsible for weakening this relationship, confirming its common role in both sleep and pain. It is worth mentioning that the magnitude of this adjusted association, i.e. the beta coefficient, was not much different from the crude magnitude; hence, the relatively small sample size may have rendered this test underpowered, thus missing this effect as significant. An effect of SQ on next day pain seems to be the most consistently reported effect in previous studies of adults with chronic pain, adjusting for baseline affective symptoms (Alsaadi, McAuley, Hush, Lo et al., 2014; O'Brien et al., 2011; Whibley et al., 2019) or not adjusted for such symptoms (Gerhart et al., 2017). In the present study, adjusting for daily level of mental distress rendered SQ non-significant as a predictor of next-day pain. Additionally, cognitive processes in patients with pain, such as tendencies to build appraisal of SQ in part on current pain levels and attribute SQ to preceding pain more strongly than the opposite (Blagestad et al., 2016; Ramlee et al., 2018), may influence associations between self-reported sleep and pain.

Sleep duration was the only actigraphy measure with a tendency to exhibit associations with pain, such that an increased level of pain during the day was followed by increased TST the next night and increased sleep duration was followed by reduced pain the next day. These tentative associations could allude to a beneficial compensatory mechanism; however, this result remains exploratory and suitable for a future pain study that is better powered by recruiting more patients. Similar findings have been reported in perimenopausal women, where pain experienced during the course of the night was associated with increased sleep duration, albeit in combination with reduced SE (Kravitz et al., 2015). Other studies did not find an association between daily sleep duration and pain (Alsaadi, McAuley, Hush, Lo et al., 2014; O'Brien et al., 2011; Whibley et al., 2019), except in a study of adolescents that reported increased pain after

TABLE 5 Sleep quality (SQ) and total sleep time (TST) as predictors of next-day pain

	Outcome variable: Next-day pain (0–10)[a]		
	Beta	**95% CI**	***F* (*p*)**
SQ as predictor			
Fixed effects			
SQ (range 0–100)[b]	0.003	0.000 to 0.005	3.47 (.063)
Covariates			
Sex	−0.26	−1.05 to 0.53	0.43 (ns)
Age	0.02	−0.02 to 0.05	1.10 (ns)
Education	−0.32	−1.08 to 0.43	0.70 (ns)
Data-collection period	−0.07	−0.34 to 0.20	0.26 (ns)
Season	−0.06	−0.34 to 0.21	0.20 (ns)
HSCL	1.30	0.93 to 1.66	48.26 (< .001)
Random effects	**Estimate**	**SE**	***Z* (*p*)**
Intercept (subject)	1.70	0.39	4.33 (< .001)
Intercepts (subject*visit)	0.35	0.11	3.18 (.001)
AR1 variance	0.90	0.06	15.53 (.001)
AR1 correlation	0.16	0.05	3.05 (< .002)
TST as predictor			
Fixed effects	**Beta**	**95% CI**	***F* (*p*)**
TST (hr)	−0.04	−0.10 to 0.01	2.53 (.11)
Covariates			
Sex	−34	−1.18 to 0.51	0.60 (ns)
Age	0.02	−0.02 to 0.06	1.30 (ns)
Education	−0.38	−1.14 to 0.39	0.94 (ns)
Data-collection period	0.01	−0.26 to 0.27	0.00 (ns)
Season	−0.03	−0.29 to −24	0.04 (ns)
HSCL	1.19	0.78 to 1.60	32.16 (< .001)
Random effects	**Estimate**	***SE***	***Z* (*p*)**
Intercept (subject)	1.89	0.41	4.59 (< .001)
AR1 variance	1.14	0.08	13.52 (< .001)
AR1 correlation	0.37	0.05	7.78 (< .001)

[a]Average of current pain before bedtime and worst, least and average pain during that day, rated on numeric rating scale (0–10).

[b]SQ was rated on a visual analogue scale (VAS) in the morning ('last night I would describe as a good [0] - poor [100] night sleep'). TST was measured by actigraphy. Sex: female = 0, male = 1. Education: ≤10 years = 0, >10 years = 1. Data collection period: T1 = 0, T2 = 1. Season: summer = 0, winter = 1. AR1, residual covariance matrix estimated as first-order autoregressive; CI, confidence interval; HSCL, Hopkins Symptom Checklist; ns, non-significant. Crude beta for pain regressed on SQ was 0.004 (95% CI 0.001 to 0.007, $F = 5.9$, $p = .015$) and on TST were −0.05 (95% CI −0.10 to 0.01, $F = 3.12$, $p = .078$)

longer sleep duration (Lewandowski et al., 2010). Taken together, there thus does not seem to be strong evidence for daily associations between actigraphy measured sleep duration and pain levels in adult patients with chronic pain.

Sleep timing has, to our knowledge, not previously been probed in day-to-day studies of sleep and pain. In the present study, sleep timing, assessed by the mid-point of sleep, was not associated with next-day pain, or vice versa. Circadian rhythms are gaining attention in the field of sleep and pain research, as both processes are under circadian control (Palada et al., 2020), and late chronotype is considered a trait feature that is supposedly associated with musculoskeletal pain conditions (Kantermann et al., 2012; Knutson & von Schantz, 2018; Merikanto et al., 2014; Zhang et al., 2018). Seasonal rhythms with delay of sleep–wake timing in winter are reported in healthy and general populations (Arendt, 2012; Friborg et al., 2014; Johnsen et al., 2013); however, in a previous study of the present clinical sample we observed a phase delay and concurrent slight increase in pain severity in the summer (Abeler et al., 2020). In the present study, we could not confirm a modifying effect of season on daily sleep–pain associations, yet the association between sleep timing and pain severity in clinical samples, and the possible benefits of targeting sleep timing in sleep behavioural approaches in pain patients, seem understudied.

In the present study, the daily level of mental distress, explained unique variance in daily pain severity and self-reported SQ; however, none of the bidirectional sleep–pain associations were modified by levels of mental distress. Symptoms of depression are common in patients with chronic pain, correlating with both sleep disturbance and pain severity This refers to (Abeler, Friborg, et al., 2020; Alfoldi et al., 2014; Bair et al., 2003; Bonvanie et al., 2016; Bromberg et al., 2012; Lewandowski et al., 2010). In corroboration with the present study, most day-to-day studies that include psychological distress as a covariate, suggest associations with next-day SQ and/or pain (Bromberg et al., 2012; Lewandowski et al., 2010; O'Brien et al., 2011; Tang et al., 2012; Valrie et al., 2008), but not with objective sleep measures (Alsaadi, McAuley, Hush, Lo et al., 2014; Lewandowski et al., 2010), thus pointing to the different features of these measurement modalities (objective versus subjective). The studies probing psychological distress as a moderator have observed such effects on bidirectional SQ–pain associations (O'Brien et al., 2011), solely on the association of SQ on next-day pain (Bromberg et al., 2012; Valrie et al., 2008) or on neither (Lewandowski et al., 2010), as in the present study. A potential moderating effect thus needs to be substantiated in future clinical studies.

There are several limitations to the present study. The study may have been underpowered to show effects of clinical significance also as statistically significant. Another limitation is that participants only reported pain and mood in the evening. We may thus have missed potential effects as other studies have shown that mood and pain may be differentially associated with sleep at different time points during the day (Gerhart et al., 2017; Tang et al., 2012; Whibley et al., 2019). This procedure also prevented assessment of night pain, which may have contributed to the observed association between daytime pain and SQ. Finally, daily medication use was not recorded and thus unavailable as an adjustment variable.

Strengths of the present study include the fairly homogenous pain sample and the inclusion of both self-report and actigraphy sleep measures, as the sleep–pain association may differ between pain conditions (Bonvanie et al., 2016) and there may be discord between sleep measurement modalities (Wilson et al., 1998). Additionally, we could control for several possible confounders to the sleep–pain association, where mental distress seems to be of particular importance. Finally, we assessed the bidirectional sleep–pain association at two time points enabling assessment of the stability of associations over time and season.

5 | CONCLUSION

Sleep problems and negative affect are well-known complicating issues in the treatment of patients with chronic pain. The present study provides evidence for a significant effect of pain on the next-night SQ, and less convincing evidence for an effect of sleep on next-day pain. Mental distress was the most robust predictor of pain severity, but did not modify the sleep–pain associations. Sleep function seems to be an important aspect of improvement in quality of life in patients with chronic pain in its own right (Hush et al., 2009); yet, according to our present results, an effect on pain following treatment of insomnia may be less likely. A meta-analysis of cognitive behavioural treatment for insomnia found only a marginal improvement in pain after treatment and no improvement at follow-up (Tang et al., 2015), which converges with our present finding. The strong association with pain supports that clinicians should be aware of the close interrelations between sleep, negative affect, and pain, and provide treatment that encompasses the complexity of these interrelations in chronic pain.

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CONFLICT OF INTEREST

The authors report no conflict of interest.

AUTHOR CONTRIBUTIONS

KA, OF, SB, TS study design. KA: data collection, scoring of actigraphy. KA, OF: statistical analyses. KA: drafting the manuscript. All authors reviewed and contributed to the final manuscript.

ORCID

Karin Abeler https://orcid.org/0000-0003-3348-6716
Svein Bergvik https://orcid.org/0000-0003-1829-2518
Trond Sand https://orcid.org/0000-0002-9755-8187
Oddgeir Friborg https://orcid.org/0000-0001-6629-0782

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section.

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Supplementary Table 1
Daytime pain as predictor of next-night sleep timing (midsleep) and sleep efficiency (SE)

	Outcome variable: Midsleep (hours)			Outcome variable: SE (%)		
Pain as predictor						
Fixed effects	*beta*	95% *CI*	*F*	*beta*	95% *CI*	*F*
Pain (0-10)*	**.00**	**-.06 - .07**	**.02 ns**	**-.11**	**-.55 - .34**	**ns**
Covariates						
Sex	-.15	-.83 - .53	.19 ns	-4.18	-8.45 - .09	(p=.055)
Age	-.01	-.03 - .02	.29 ns	.11	.01 - .20	(p= .034)
Education	.08	-.54 - .71	.07 ns	1.72	-1.14 - 4.57	ns
Data-collection period	-.03	-.22 - .16	.08 ns	1.28	.13 - 2.43	(p = .029)
Weekend	1.31	1.07 - 1.54	26.57 (p < .001)	-56	-.83 - 1.95	ns
Season	-.47	-.65 - -.29	118.87 (p < .001)	-.14	-1.25 - .96	ns
HSCL	-.02	-.32 - .29	ns	-.78	-2.59 - 1.03	ns
Random effects	Estimate	*SE*	*Z*	Estimate	*SE*	*Z*
Intercept (subject)	1.01	.22	4.59 (p < .001)	22.35	5.04	4.44 (p < .001)
AR1 variance	1.02	.06	17.05 (p < .001)	40.54	2.22	18.26 (p < .001)
AR1 correlation	.20	.04	4.73 (p < .001)	.02	.04	.51 ns

Notes: *Average of current pain before bedtime and worst, least and average pain during that day rated on a numeric rating scale (0-10). Midsleep and SE was measured by actigraphy. Sex: female=0, male=1. Education: 10 years or less=0, <10 years=1. Data collection period: T1=0, T2=1. Weekend: weekday=0, weekend=1. Season: summer=0, winter=1. HSCL=Hopkins Symptom Checklist, AR1=Residual covariance matrix estimated as first-order autoregressive. Crude beta for midsleep regressed on pain was .03 (95% *CI* = -.03 - .09, *F* = .83, *p* = ns), and for SE regressed on pain was -.11 (95% *CI* = -.55 - .33 , *F* = .23, *p* = ns).

Supplementary Table 2
Sleep timing (midsleep) and sleep efficiency (SE) as predictors of next-day pain

	Outcome variable: Next-day pain (0-10)*		
Midsleep as predictor			
Fixed effects	*beta*	95% *CI*	*F*
Midsleep (hours)	**-.02**	**-.09 - .04**	**.47 ns**
Covariates			
Sex	-.29	-1.13 – .56	.44 ns
Age	.02	-.02 - .06	1.29 ns
Education	-.38	-1.15 - .38)	.97 ns
Data-collection period	.00	-.26 - .27	.00 ns
Season	-.04	-.31 - .23	.08 ns
HSCL	1.19	.78 – 1.60	32.27 (p < .001)
Random effects	Estimate	*SE*	*Z*
Intercept (subject)	1.88	.41	4.60 (p < .001)
AR1 variance	1.14	.08	13.55 (p < .001)
AR1 correlation	.37	.05	7.70 (p < .001)
SE as predictor			
Fixed effects	*beta*	95% *CI*	*F*
SE (%)	**-.004**	**-.02 - .01**	**.39 ns**
Covariates			
Sex	-.30	-1.14 - .54	.50 ns
Age	.02	-.01 - .06	1.37 ns)
Education	-.38	-1.14 - .38	.95 ns
Data-collection period	.01	-.26 - .27	.00 ns
Season	-.03	-.29 - .23	-06 ns
HSCL	1.19	.78 – 1.60	32.44 (p < .001)
Random effects	Estimate	*SE*	*Z*
Intercept (subject)	1.87	.41	4.60 (p < .001)
AR1 variance	1.14	.08	13.56 (p < .001)
AR1 correlation	.36	.05	7.64 (p < .001)

Notes: *Average of current pain before bedtime and worst, least and average pain during that day, rated on numeric rating scale (0-10). Midsleep and SE were measured by actigraphy. Sex: female=0, male=1. Education: 10 years or less=0, <10 years=1. Data collection period: T1=0, T2=1. Season: summer=0, winter=1. HSCL= Hopkins Symptom Checklist. AR1= Residual covariance matrix estimated as first-order autoregressive. Crude beta for pain regressed on midsleep was -.03 (95% *CI*= -.08 - .03 *F*=.74, *p*= ns), and on SE was -.01 (95% *CI*= -.02 - .01, *F*= .61, *p*= ns)

Questionnaires

Søvn og smerter

Skjema 1

Løpenr: ☐☐☐☐

Vær vennlig å lese spørsmålene nøye før du svarer, og marker det svaret som passer best.

Initialer: ☐☐☐☐

Informasjon om utfylling av skjemaet:

Skjemaet skal leses maskinelt, så du må bruke blå eller svart penn. Vennligst bruk blokkbokstaver og skriv så tydelig som mulig.
Det er også viktig at du krysser av presis inni rutene.

Slik: ☒ Ikke slik: ☐X

Skriv tallet 1 som en rett strek. Slik: 1 Skriv tallet syv slik: 7

Hvis du har skrevet feil tall, korriger ved å sette en strek over tallet som er feil og skriv det riktige tallet over eller ved siden av. Eksemplet nedenfor viser at riktig tall er 3.

3
~~2~~

Dato for utfylling: ☐☐.☐☐.☐☐☐☐
dag måned år

Kjønn: ☐ Mann ☐ Kvinne

Fødselesår: ☐☐☐☐

Sivilstand: *(Sett bare ett kryss)* ☐ Ugift ☐ Gift ☐ Samboer ☐ Enke/enkemann ☐ Skilt ☐ Separert

Bor du alene: ☐ Ja ☐ Nei

Har du barn: ☐ Ja ☐ Nei

Hvis ja, hvor mange: ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ Flere

Barnas alder: ☐☐ ☐☐ ☐☐ ☐☐ ☐☐ ☐☐ ☐☐ ☐☐ ☐☐ ☐☐

Bor du sammen med barna? ☐ Ja, 100% ☐ Ja, delt omsorg ☐ Nei

Høyeste utdanning: *(Sett bare ett kryss)*

- ☐ Grunnskole
- ☐ Videregående skole
- ☐ Fagbrev/fagutdanning
- ☐ Høyskole/universitet inntil 4 år
- ☐ Høyskole/universitet over 4 år
- ☐ Påbegynt/ikke fullført utdanning
- ☐ Annet: ☐

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Yrke og arbeidsliv

Ansettelsesforhold:
(Mulighet for flere kryss)

- ☐ Hjemmeværende med omsorgsarbeid
- ☐ Heltidsjobb
- ☐ Deltidsjobb
- ☐ Under utdanning
- ☐ Ukjent/ Annet
- ☐ Trygdeytelser (spesifiser på neste spørsmål)

Mottar du noen av følgende ytelser?
(Mulighet for flere kryss)

- ☐ Alderstrygd, førtidspensjon (AFP) eller etterlattepensjon
- ☐ Sykepenger helt (er helt sykemeldt)
- ☐ Sykepenger delvis (er delvis sykemeldt)
- ☐ Arbeidsavklaringspenger
- ☐ Uføreytelser/pensjon, hel
- ☐ Uføreytelse/pensjon, delvis
- ☐ Dagpenger under arbeidsledighet
- ☐ Sosialhjelp
- ☐ Svangerskapspenger

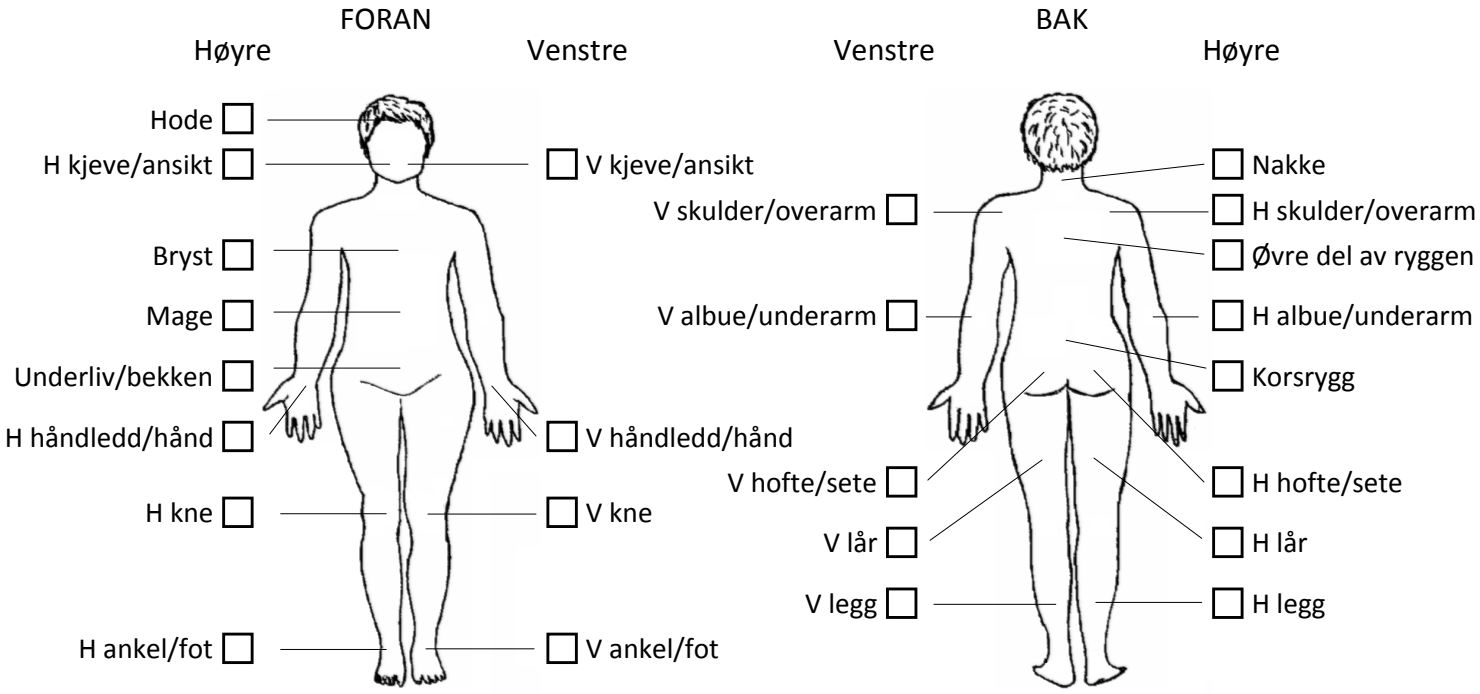
Hvordan vurderer du din økonomi? ☐ God ☐ Middels ☐ Dårlig

Vennligst sett kryss ved de svarene som passer best for deg.
(Ett kryss for hvert spørsmål)

	Helt galt	Nokså galt	Nokså riktig	Helt riktig
1. Jeg klarer alltid å løse vanskelige problemer hvis jeg prøver hard nok	☐	☐	☐	☐
2. Hvis noen motarbeider meg, så kan jeg finne måter og veier for å få det som jeg vil	☐	☐	☐	☐
3. Det er lett for meg å holde fast på planene mine og nå målene mine	☐	☐	☐	☐
4. Jeg føler meg trygg på at jeg ville kunne takle uventede hendelser på en effektiv måte	☐	☐	☐	☐
5. Takket være ressursene mine så vet jeg hvordan jeg skal takle uventede situasjoner	☐	☐	☐	☐
6. Jeg kan løse de fleste problemer hvis jeg går tilstrekkelig inn for det	☐	☐	☐	☐
7. Jeg beholder roen når jeg møter vanskeligheter fordi jeg stoler på mestringsevnen min	☐	☐	☐	☐
8. Når jeg møter et problem, så finner jeg vanligvis flere løsninger på det	☐	☐	☐	☐
9. Hvis jeg er i knipe, så finner jeg vanligvis en vei ut	☐	☐	☐	☐
10. Samme hva som hender, så er jeg vanligvis i stand til å takle det	☐	☐	☐	☐

Smerter

Dersom du har hatt smerter siste uken, hvor har du hatt disse plagene? Vennligst sett ett eller flere kryss.



Vennligst sett et kryss under det tallet som best beskriver de sterkeste smertene du har hatt i løpet av den siste uka.

0 1 2 3 4 5 6 7 8 9 10

Ingen smerter — Verst tenkelige smerter

Vennligst sett et kryss under det tallet som best beskriver de svakeste smertene du har hatt i løpet av den siste uka.

0 1 2 3 4 5 6 7 8 9 10

Ingen smerter — Verst tenkelige smerter

Vennligst sett et kryss under det tallet som best angir hvor sterke smerter du har i gjennomsnitt.

0 1 2 3 4 5 6 7 8 9 10

Ingen smerter — Verst tenkelige smerter

Vennligst sett et kryss under det tallet som best beskriver smertene du har nå.

0 1 2 3 4 5 6 7 8 9 10

Ingen smerter — Verst tenkelige smerter

Hvor mye plager smertene deg? Marker hvor mye smertene plager deg.

0 1 2 3 4 5 6 7 8 9 10

Ikke plaget — Verst tenkelig plaget

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Har du en pågående erstatningssak med utgangspunkt i det aktuelle smerteproblemet?

☐ Har ikke smerter ☐ Ja ☐ Nei

Har du søkt om eller planlegger du å søke om uførepensjon? ☐ Ja ☐ Nei

Når startet smertetilstanden?

☐ Har ikke smerter

☐ 0 - 3 måneder siden

☐ 4 - 6 måneder siden

☐ 7 - 12 måneder siden

☐ 1 - 2 år siden

☐ 2 - 4 år siden

☐ 4 - 6 år siden

☐ 6 - 10 år siden

☐ Mer enn 10 år siden

Hvor lenge har smertetilstanden vært på samme nivå som nå?

☐ Har ikke smerter

☐ 0 - 3 måneder

☐ 4 - 6 måneder

☐ 7 - 12 måneder

☐ 1 - 5 år

☐ 6 år eller mer

FYSISK AKTIVITET

Angi bevegelse og kroppslig anstrengelse i din fritid. Hvis aktiviteten varierer meget f. eks. mellom sommer og vinter, så ta et gjennomsnitt. Spørsmålet gjelder bare det siste året. (Sett kryss i den ruta som passer best)

☐ Leser, ser på fjernsyn eller annen stillesittende beskjeftigelse

☐ Spaserer, sykler eller beveger deg på annen måte minst 4 timer i uken
(her skal du også regne med gang eller sykling til arbeidsstedet, søndagsturer med mer)

☐ Driver mosjonsidrett, tyngre hagearbeid, snømåking e.l.
(merk at aktiviteten skal vare minst 4 timer i uka)

☐ Trener hardt eller driver konkurranseidrett regelmessig og flere ganger i uka

Søvn

1. Vær vennlig å angi hvor store vansker du har med søvnen nå for tiden (de siste 2 ukene)?

	Ingen	Milde	Moderate	Alvorlige	Veldige
a) Vansker med å sovne inn:	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4
b) Vansker med å holde meg sovende:	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4
c) Vansker med at jeg våkner for tidlig:	☐ 0	☐ 1	☐ 2	☐ 3	☐ 4

2. Hvor fornøyd/misfornøyd er du med ditt nåværende søvnmønster?

Veldig fornøyd	Fornøyd	Nøytral	Misfornøyd	Veldig misfornøyd
☐ 0	☐ 1	☐ 2	☐ 3	☐ 4

3. I hvilken grad mener du at ditt søvnproblem forstyrrer din daglige fungering (for eksempel tretthet på dagtid, evne til å fungere på arbeid/daglige gjøremål, konsentrasjon, hukommelse, humør, etc)?

Forstyrrer ikke i det hele tatt	Litt	Noe	Mye	Forstyrrer i veldig stor grad
☐ 0	☐ 1	☐ 2	☐ 3	☐ 4

4. Hvor synlig tror du det er for andre at du har søvnproblemer som svekker din livskvalitet?

Ikke synlig i det hele tatt	Litt	Noe	Mye	Synlig i veldig stor grad
☐ 0	☐ 1	☐ 2	☐ 3	☐ 4

5. Hvor bekymret/plaget er du over ditt nåværende søvnproblem?

Ikke bekymret i det hele tatt	Litt	Noe	Mye	Bekymret i veldig stor grad
☐ 0	☐ 1	☐ 2	☐ 3	☐ 4

Følgende spørsmål har med ditt vanlige søvnmønster *den siste måneden* å gjøre. Du skal svare på hva som er mest riktig for *de fleste* dager og netter den siste måneden. Vennligst svar på alle spørsmål.

1. I løpet av den siste måneden, når har du vanligvis lagt deg om kvelden?

VANLIG LEGGETID ☐☐:☐☐ (klokkeslett)

2. I løpet av den siste måneden, hvor lang tid (i minutter) har det vanligvis tatt deg å sovne om kvelden?

ANTALL MINUTTER ☐☐☐

3. I løpet av den siste måneden, når har du vanligvis stått opp om morgenen?

VANLIGVIS STÅTT OPP KL ☐☐:☐☐ (klokkeslett)

4. I løpet av den siste måneden, hvor mange timer søvn har du *faktisk* fått om natten? (Dette kan være forskjellig fra hvor mange timer du oppholdt deg i sengen.)

ANTALL TIMER SØVN HVER NATT ☐☐ timer ☐☐ minutter

For hvert av de følgende spørsmål, kryss av for best svar. Vennligst svar på *alle* spørsmålene.

5. I løpet av den siste måneden, hvor ofte har du hatt problemer med søvnen fordi du ...

a) ikke klarer å sovne i løpet av 30 minutter

Ikke i løpet av den siste måneden ☐ Mindre enn en gang i uken ☐ En eller to ganger i uken ☐ Tre eller flere ganger i uken ☐

b) våkner opp midt på natten eller tidlig om morgenen

Ikke i løpet av den siste måneden ☐ Mindre enn en gang i uken ☐ En eller to ganger i uken ☐ Tre eller flere ganger i uken ☐

c) må opp for å gå på toalettet

Ikke i løpet av den siste måneden ☐ Mindre enn en gang i uken ☐ En eller to ganger i uken ☐ Tre eller flere ganger i uken ☐

d) ikke klarer å puste ordentlig

Ikke i løpet av den siste måneden ☐ Mindre enn en gang i uken ☐ En eller to ganger i uken ☐ Tre eller flere ganger i uken ☐

e) hoster eller snorker høyt

Ikke i løpet av den siste måneden ☐ Mindre enn en gang i uken ☐ En eller to ganger i uken ☐ Tre eller flere ganger i uken ☐

f) føler deg for kald

Ikke i løpet av den siste måneden ☐ Mindre enn en gang i uken ☐ En eller to ganger i uken ☐ Tre eller flere ganger i uken ☐

g) føler deg for varm

Ikke i løpet av den siste måneden ☐ Mindre enn en gang i uken ☐ En eller to ganger i uken ☐ Tre eller flere ganger i uken ☐

h) har vonde drømmer

Ikke i løpet av den siste måneden ☐ Mindre enn en gang i uken ☐ En eller to ganger i uken ☐ Tre eller flere ganger i uken ☐

i) har smerter

Ikke i løpet av den siste måneden ☐ Mindre enn en gang i uken ☐ En eller to ganger i uken ☐ Tre eller flere ganger i uken ☐

j) andre grunner, vennligst beskriv:

Hvor ofte, i løpet av den siste måneden, har du hatt problemer med søvnen på grunn av dette

Ikke i løpet av den siste måneden ☐ Mindre enn en gang i uken ☐ En eller to ganger i uken ☐ Tre eller flere ganger i uken ☐

6. I løpet av den siste måneden, hvordan vil du bedømme søvnkvaliteten din totalt sett?

Veldig bra ☐ Ganske bra ☐ Ganske dårlig ☐ Veldig dårlig ☐

7. I løpet av den siste måneden, hvor ofte har du tatt medisin (med eller uten resept) som hjelp til å sove?

Ikke i løpet av den siste måneden ☐ Mindre enn en gang i uken ☐ En eller to ganger i uken ☐ Tre eller flere ganger i uken ☐

8. I løpet av den siste måneden, hvor ofte har du hatt problemer med å holde deg våken under bilkjøring, måltider eller når du holder på med sosiale aktiviteter?

Ikke i løpet av den siste måneden ☐ Mindre enn en gang i uken ☐ En eller to ganger i uken ☐ Tre eller flere ganger i uken ☐

9. I løpet av den siste måneden, hvor stort problem har det vært for deg å ha overskudd nok til å få ting gjort?

Ikke noe problem i det hele tatt ☐ Bare et lite problem ☐ Et visst problem ☐ Et stort problem ☐

10. Deler du seng eller rom med noen?

☐ Deler ikke seng eller rom med noen
☐ Partner/romkamerat i annet rom
☐ Partner i samme rom, men ikke i samme seng
☐ Partner i samme seng

Hvis du har en partner eller romkamerat, har han/hun i løpet av den siste måneden fortalt at du har hatt ...

a) høy snorking

Ikke i løpet av den siste måneden ☐ Mindre enn en gang i uken ☐ En eller to ganger i uken ☐ Tre eller flere ganger i uken ☐

b) lange pustestopp under søvnen

Ikke i løpet av den siste måneden ☐ Mindre enn en gang i uken ☐ En eller to ganger i uken ☐ Tre eller flere ganger i uken ☐

c) rykninger eller sammentrekninger i beina under søvnen

Ikke i løpet av den siste måneden ☐ Mindre enn en gang i uken ☐ En eller to ganger i uken ☐ Tre eller flere ganger i uken ☐

d) episoder med desorientering eller forvirring under søvnen

Ikke i løpet av den siste måneden ☐ Mindre enn en gang i uken ☐ En eller to ganger i uken ☐ Tre eller flere ganger i uken ☐

e) annen type uro under søvnen; vennligst beskriv:

Ikke i løpet av den siste måneden ☐ Mindre enn en gang i uken ☐ En eller to ganger i uken ☐ Tre eller flere ganger i uken ☐

Hvordan har du det?

Når smerter og andre plager har vart en tid, blir en gjerne sliten og oppgitt. Dette gir ofte slike plager som nevnt nedenfor. Samlet blir disse her brukt som mål på at en er legemlig og psykisk presset. Vurder hvor mye hvert symptom har vært til plage eller ulempe for deg de siste 14 dagene (til og med i dag). Sett et kryss ved det tallet som passer best. Husk å sette et kryss ved aktuelt tall for hver plage/hvert symptom.

	Ikke i det hele tatt	Litt	En god del	Svært mye
1. Plutselig skremt uten grunn.	☐ 1	☐ 2	☐ 3	☐ 4
2. Føler du deg engstelig.	☐ 1	☐ 2	☐ 3	☐ 4
3. Føler du deg svimmel eller kraftløs.	☐ 1	☐ 2	☐ 3	☐ 4
4. Nervøs eller urolig.	☐ 1	☐ 2	☐ 3	☐ 4
5. Hjertebank.	☐ 1	☐ 2	☐ 3	☐ 4
6. Skjelving.	☐ 1	☐ 2	☐ 3	☐ 4
7. Føler deg anspent eller opphisset.	☐ 1	☐ 2	☐ 3	☐ 4
8. Hodepine.	☐ 1	☐ 2	☐ 3	☐ 4
9. Anfall av redsel eller panikk.	☐ 1	☐ 2	☐ 3	☐ 4
10. Rastløshet, kan ikke sitte rolig.	☐ 1	☐ 2	☐ 3	☐ 4
11. Føler deg slapp og uten energi.	☐ 1	☐ 2	☐ 3	☐ 4
12. Anklager deg selv for ting.	☐ 1	☐ 2	☐ 3	☐ 4
13. Har lett for å gråte.	☐ 1	☐ 2	☐ 3	☐ 4
14. Tap av seksuell interesse/opplevelse.	☐ 1	☐ 2	☐ 3	☐ 4
15. Dårlig appetitt	☐ 1	☐ 2	☐ 3	☐ 4
16. Vanskelig for å sove.	☐ 1	☐ 2	☐ 3	☐ 4
17. Følelse av håpløshet mht. framtiden.	☐ 1	☐ 2	☐ 3	☐ 4
18. Føler deg nedfor.	☐ 1	☐ 2	☐ 3	☐ 4
19. Føler deg ensom.	☐ 1	☐ 2	☐ 3	☐ 4
20. Har tanker om å ta ditt eget liv.	☐ 1	☐ 2	☐ 3	☐ 4
21. Følelse av å være fanget.	☐ 1	☐ 2	☐ 3	☐ 4
22. Bekymrer deg for mye.	☐ 1	☐ 2	☐ 3	☐ 4
23. Føler ikke interesse for noe.	☐ 1	☐ 2	☐ 3	☐ 4
24. Føler at alt krever stor anstrengelse.	☐ 1	☐ 2	☐ 3	☐ 4
25. Føler at du ikke er noe verdt.	☐ 1	☐ 2	☐ 3	☐ 4

Utmattelse

Vi vil gjerne vite om du har følt deg sliten, svak eller i mangel av overskudd den siste måneden. Vennligst besvar ALLE spørsmålene ved å krysse av for det svaret du synes passer best for deg. Vi ønsker at du besvarer alle spørsmålene selv om du ikke har hatt slike problemer. Vi spør om hvordan du har følt deg i det siste og ikke om hvordan du følte deg for lenge siden. Hvis du har følt deg sliten lenge, ber vi om at du sammenlikner deg med hvordan du følte deg sist du var bra. (Ett kryss for hver linje)

1. Har du problemer med at du føler deg sliten?

☐ Mindre enn vanlig ☐ Ikke mer enn vanlig ☐ Mer enn vanlig ☐ Mye mer enn vanlig

2. Trenger du mer hvile?

☐ Nei, mindre enn vanlig ☐ Ikke mer enn vanlig ☐ Mer enn vanlig ☐ Mye mer enn vanlig

3. Føler du deg søvnig eller døsig?

☐ Mindre enn vanlig ☐ Ikke mer enn vanlig ☐ Mer enn vanlig ☐ Mye mer enn vanlig

4. Har du problemer med å komme i gang med ting?

☐ Mindre enn vanlig ☐ Ikke mer enn vanlig ☐ Mer enn vanlig ☐ Mye mer enn vanlig

5. Mangler du overskudd?

☐ Ikke i det hele tatt ☐ Ikke mer enn vanlig ☐ Mer enn vanlig ☐ Mye mer enn vanlig

6. Har du redusert styrke i musklene dine?

☐ Ikke i det hele tatt ☐ Ikke mer enn vanlig ☐ Mer enn vanlig ☐ Mye mer enn vanlig

7. Føler du deg svak?

☐ Mindre enn vanlig ☐ Som vanlig ☐ Mer enn vanlig ☐ Mye mer enn vanlig

8. Har du vansker med å konsentrere deg?

☐ Mindre enn vanlig ☐ Som vanlig ☐ Mer enn vanlig ☐ Mye mer enn vanlig

9. Forsnakker du deg i samtaler?

☐ Mindre enn vanlig ☐ Ikke mer enn vanlig ☐ Mer enn vanlig ☐ Mye mer enn vanlig

10. Er det vanskeligere å finne det rette ordet?

☐ Mindre enn vanlig ☐ Ikke mer enn vanlig ☐ Mer enn vanlig ☐ Mye mer enn vanlig

11. Hvordan er hukommelsen din?

☐ Bedre enn vanlig ☐ Ikke verre enn vanlig ☐ Verre enn vanlig ☐ Mye verre enn vanlig

12. Hvis du føler deg sliten for tiden, omtrent hvor lenge har det vart? (Ett kryss)

Mindre enn en uke ☐ Mindre enn tre måneder ☐ Mellom tre og seks måneder ☐ Seks måneder eller mer ☐

13. Hvis du føler deg sliten for tiden, omtrent hvor mye av tiden kjenner du det? (Ett kryss)

☐ 25 % av tiden ☐ 50 % av tiden ☐ 75 % av tiden ☐ Hele tiden

Alle opplever smerter på et eller annet tidspunkt i livet. Slike smerteopplevelser kan være hodepine, tannverk, ledd- og muskelsmerter. Folk er ofte utsatt for situasjoner som kan forårsake smerter, slik som sykdom, skade, tannbehandling og kirurgi.
Vi er interessert i hva slags tanker og følelser du har når du har smerter. Nedenfor står det 13 utsagn som beskriver ulike tanker og følelser som kan være forbundet med smerte. Bruk følgende skala og indiker i hvilken grad du har slike tanker og følelser når du opplever smerte.

Når jeg har smerter ...	Ikke i det hele tatt	Litt	I moderat grad	I stor grad	Hele tiden
1. Jeg er hele tiden bekymret for at smertene ikke vil gi seg	☐	☐	☐	☐	☐
2. Jeg føler at jeg ikke klarer å fortsette	☐	☐	☐	☐	☐
3. Det er forferdelig og jeg tror at det aldri vil bli bedre	☐	☐	☐	☐	☐
4. Det er fryktelig, og jeg føler at det overvelder meg	☐	☐	☐	☐	☐
5. Jeg føler at jeg ikke holder ut det lenger	☐	☐	☐	☐	☐
6. Jeg blir redd for at smertene skal bli verre	☐	☐	☐	☐	☐
7. Jeg tenker stadig på andre smertefulle opplevelser	☐	☐	☐	☐	☐
8. Jeg ønsker desperat at smertene skal forsvinne	☐	☐	☐	☐	☐
9. Det virker som jeg ikke klarer å få det ut av hodet	☐	☐	☐	☐	☐
10. Jeg tenker stadig på hvor vondt det er	☐	☐	☐	☐	☐
11. Jeg tenker stadig på hvor inderlig jeg vil at smertene skal gi seg	☐	☐	☐	☐	☐
12. Det er ingenting jeg kan gjøre for å redusere smertenes intensitet	☐	☐	☐	☐	☐
13. Jeg lurer på om noe alvorlig kan komme til å skje	☐	☐	☐	☐	☐

Årstidssvingninger

Hensikten med dette spørreskjemaet er å finne ut hvordan ditt stemningsleie og enkelte andre ting varierer med årstidene. Vi er interessert i hvordan du selv opplever dette, ikke hva andre mener å ha observert. Vennligst fyll ut skjemaet så fullstendig som det lar seg gjøre, selv om du på enkelte punkter kan være i tvil om hva du skal svare.

Hvor mange år har du bodd i den landsdelen som du nå bor i: ☐☐ år

1. I hvilken grad pleier de følgende tingene å endre seg med årstidene? Vennligst sett kryss ved ett av svaralternativene ved hvert spørsmål. Merk: Her skal ikke angis noe om når på året det går opp eller ned - det kommere senere.

	Ingen endring	Lett endring	Moderat endring	Markert endring	Ekstrem endring
A. Søvnlengde	☐	☐	☐	☐	☐
B. Sosiale aktiviteter	☐	☐	☐	☐	☐
C. Humør/stemning	☐	☐	☐	☐	☐
D. Vekt	☐	☐	☐	☐	☐
E. Matlyst	☐	☐	☐	☐	☐
F. Tiltakslyst, energi	☐	☐	☐	☐	☐

2. For de følgende spørsmål, sett et kryss for alle de aktuelle månedene. Dette kan være en enkelt måned, eller flere måneder. Månedene er anført i rekkefølge fra januar, men bare angitt med de to første bokstavene. Dersom det ikke er noen spesiell måned som kan peke seg ut, skal det ikke settes noen kryss for det spørsmålet.

Hvilken tid på året -	Ja	Fe	Ma	Ap	Ma	Ju	Ju	Au	Se	Ok	No	De
Føler du deg best	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Øker du mest i vekt	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Viser du størst sosial aktivitet	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Sover minst	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Spiser mest	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Tar av mest i vekt	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Viser minst sosial aktivitet	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Føler deg dårligst	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Spiser minst	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Sover mest	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

3. I det følgende spørres det etter hvordan forskjellige værforhold virker inn på deg. Skal besvares etter følgende skala:

-3 = Føler meg meget langt nede eller svært tiltaksløs
-2 = Moderat nedstemt eller tiltaksløs
-1 = Litt nedstemt eller tiltaksløs
0 = Ingen forandring
+1 = Litt bedre humør eller tiltakslyst
+2 = Moderat bedret humør eller tiltakslyst
+3 = Markert bedret humør eller tiltakslyst

Altså, hvordan virker dette på deg:	-3	-2	-1	0	+1	+2	+3
Kaldt vær	☐	☐	☐	☐	☐	☐	☐
Varmt vær	☐	☐	☐	☐	☐	☐	☐
Fuktig vær	☐	☐	☐	☐	☐	☐	☐
Solskinnsdager	☐	☐	☐	☐	☐	☐	☐
Tørt vær	☐	☐	☐	☐	☐	☐	☐
Grå, skyete dager	☐	☐	☐	☐	☐	☐	☐
Lange dager (om sommeren)	☐	☐	☐	☐	☐	☐	☐
Høyt polleninnhold i luften	☐	☐	☐	☐	☐	☐	☐
Tåkete dager	☐	☐	☐	☐	☐	☐	☐
Korte dager (om vinteren)	☐	☐	☐	☐	☐	☐	☐

4. Hvor mye pleier vekten din å variere i løpet av et år? Ca. ☐☐,☐ kg

5. Omtrent hvor mange timer i døgnet pleier du å sove i de forskjellige årstidene (inklusive middagshvil o.l.)?

Om vinteren (desember, januar, februar):	☐☐	timer	☐☐	minutter
Om våren (mars, april, mai):	☐☐	timer	☐☐	minutter
Om sommeren (juni, juli, august):	☐☐	timer	☐☐	minutter
Om høsten (september, oktober, november):	☐☐	timer	☐☐	minutter

6. Merker du noen forskjell i hva slags mat du foretrekker i løpet av året? (Merk: Her gjelder det ikke matlyst generelt, men om du noen tid på året har en spesiell trang etter fett, kullhydrater/søtsaker eller eggehvitestoffer (f.eks. kjøtt)). ☐ Ja ☐ Nei

Hvis ja, om (sett kryss ved det som passer) ☐ våren ☐ sommeren ☐ høsten ☐ vinteren har jeg spesielt sterk trang etter:

☐

7. Til slutt: Dersom noen av de tingene som er nevnt i dette spørreskjemaet varierer med årstidene, føler du at dette er et problem for deg? ☐ Ja ☐ Nei

Dersom ja, er dette problemet -	Av lett grad	Moderat	Markert	Alvorlig	Helt invalidiserende
	☐	☐	☐	☐	☐

17763

Takk for at du tok deg tid til å fylle ut skjemaet.

Søvn og smerter

Dag skjema _____ dag Dag: ☐ Løpenr: ☐☐☐☐

Vær vennlig å lese spørsmålene nøye før du svarer, og marker det svaret som passer best.

Initialer: ☐☐☐☐

Informasjon om utfylling av skjemaet:

Skjemaet skal leses maskinelt, så du må bruke blå eller svart penn. Vennligst bruk blokkbokstaver og skriv så tydelig som mulig.
Det er også viktig at du krysser av presis inni rutene.

Slik: ☒ Ikke slik: ☐X

Skriv tallet 1 som en rett strek. Slik: 1 Skriv tallet syv slik: 7

Hvis du har skrevet feil tall, korriger ved å sette en strek over tallet som er feil og skriv det riktige tallet over eller ved siden av. Eksemplet nedenfor viser at riktig tall er 3.

3
~~2~~

Fylles ut om morgenen. Dato for utfylling: ☐☐.☐☐.☐☐☐☐ (dag . måned . år)

Svar på de 5 spørsmålene nedenfor ved å sette et kryss på den vannrette linjen som best beskriver hvordan søvnen din var sist natt:

Eksempel:
X

1. Sist natt var min søvn

Dyp søvn — Lett søvn

2. Sist natt, da jeg sovnet første gang

Sovnet jeg nesten med en gang — Kunne jeg nesten aldri sovne

3. Sist natt var jeg

Veldig lite våken — Våken hele natten gjennom

4. Sist natt, når jeg våknet opp eller ble vekket, så klarte jeg å

Sovne igjen med en gang — Klarte jeg ikke å sovne igjen

5. Jeg vil beskrive søvnen min sist natt som:

En god natts søvn — En dårlig natts søvn

21568

Søvn og smerter

Dag skjema _____ dag Dag: ☐ Løpenr: ☐☐☐☐

Fylles ut på kvelden.

Vennligst sett et kryss under det tallet som best beskriver de sterkeste smertene du har hatt i løpet av dagen.

0	1	2	3	4	5	6	7	8	9	10
☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

Ingen smerter — Verst tenkelige smerter

Vennligst sett et kryss under det tallet som best beskriver de svakeste smertene du har hatt i løpet av dagen.

0	1	2	3	4	5	6	7	8	9	10
☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

Ingen smerter — Verst tenkelige smerter

Vennligst sett et kryss under det tallet som best angir hvor sterke smerter du har hatt i gjennomsnitt i dag.

0	1	2	3	4	5	6	7	8	9	10
☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

Ingen smerter — Verst tenkelige smerter

Vennligst sett et kryss under det tallet som best beskriver smertene du har nå.

0	1	2	3	4	5	6	7	8	9	10
☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

Ingen smerter — Verst tenkelige smerter

Hvor mye plager smertene deg? Marker hvor mye smertene plager deg.

0	1	2	3	4	5	6	7	8	9	10
☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

Ikke plaget — Verst tenkelig plaget

Når smerter og andre plager har vart en tid, blir en gjerne sliten og oppgitt. Dette gir ofte slike plager som nevnt nedenfor. Samlet blir disse her brukt som mål på at en er legemlig og psykisk presset. Vurder hvor mye hvert symptom har vært til plage eller ulempe for deg i dag. Sett et kryss ved det tallet som passer best. Husk å sette et kryss ved aktuelt tall for hver plage/hvert symptom.

	Ikke i det hele tatt	Litt	En god del	Svært mye
Plutselig skremt uten grunn.	☐ 1	☐ 2	☐ 3	☐ 4
Føler du deg engstelig.	☐ 1	☐ 2	☐ 3	☐ 4
Føler du deg svimmel eller kraftløs.	☐ 1	☐ 2	☐ 3	☐ 4
Føler deg anspent eller opphisset.	☐ 1	☐ 2	☐ 3	☐ 4
Anklager deg selv for ting.	☐ 1	☐ 2	☐ 3	☐ 4
Vanskelig for å sove.	☐ 1	☐ 2	☐ 3	☐ 4
Følelse av håpløshet mht. framtiden.	☐ 1	☐ 2	☐ 3	☐ 4
Føler deg nedfor.	☐ 1	☐ 2	☐ 3	☐ 4
Føler at alt krever stor anstrengelse.	☐ 1	☐ 2	☐ 3	☐ 4
Føler at du ikke er noe verdt.	☐ 1	☐ 2	☐ 3	☐ 4

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Takk for at du tok deg tid til å fylle ut skjemaet.