

## Breaking the cycle: sleep disturbance as a target for remedying the ‘cycle of distress’ in osteoarthritis

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### Prevalence & consequences of osteoarthritis

Osteoarthritis is the most prevalent of the musculoskeletal disorders [1] and affects approximately 10% of men and 13% of women over the age of 60 years [2]. Given the aging of the population and rising obesity rates, the prevalence of osteoarthritis, particularly in weight-bearing joints, can only be expected to increase. The consequences of osteoarthritis can be devastating, including an increased risk for developing physical and mental disabilities and decreased quality of life [3,4]. Innovative approaches are needed to better understand and remedy the cycle of distress that is osteoarthritis.

Sleep is one health behavior that increasingly shows promise as an intervention point in the treatment of osteoarthritis. In addition to the frequent co-occurrence of sleep difficulties and osteoarthritic pain, sleep is a highly attractive point of intervention within this population given that it is a modifiable behavior for which effective treatments exist [5]. In this editorial we will first summarize the literature on the co-occurrence of sleep disturbance and pain, then present promising theoretical models linking sleep and pain, and end with a discussion of next steps for future research and treatment.

### Sleep as a potential intervention target in the treatment of osteoarthritic pain

We spend over a third of our day sleeping, and sleep will account for approximately 34 years of our lives by the time we reach age 96 [6]. Despite devoting a substantial portion

of our lives to sleep, almost 50% of Americans report sleep problems; approximately half of those report that sleep difficulties interfere with their mood, daily activities, enjoyment of life, relationships and work [7].

In the context of pain, these sleep complaints increase. In 2015, the National Sleep Foundation selected ‘Sleep and Pain’ for the focus of their annual Sleep in America Poll [7]. The poll found that only 37% of people experiencing chronic pain report good or very good sleep quality, compared with 65% of those with no pain [7]. Additionally, the average sleep debt (the difference between desired and actual sleep amount) for people with chronic pain was 45 min compared with no sleep debt for those without pain. Last, the consequences of sleep difficulties are exacerbated in those experiencing chronic pain, with 52% reporting that sleep problems interfered with their ability to enjoy life compared with 23% of those without pain [7]. These numbers reflect accumulating evidence of the frequent comorbidity of sleep problems with osteoarthritis [8,9].

### Conceptual models linking sleep disturbance & osteoarthritic pain

Conceptual models support empirical evidence linking sleep with pain. The model of chronic insomnia proposed by Spielman *et al.* [10] describes the development of insomnia in the presence of stressors such as pain. According to this ‘3P’ model, predisposing, precipitating and perpetuating factors work in concert in the development and maintenance of insomnia. Certain characteristics such as older age and female gender can



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predispose a person to developing insomnia. However, a precipitating event, such as the onset of pain, is frequently necessary to trigger the experience of disrupted sleep. The resulting sleep disturbance can be short-lived and is primarily tied to the precipitating event (e.g., problems sleeping only when pain is present). Unfortunately, the sleep problem becomes chronic and is maintained through perpetuating behaviors. For example, in response to chronic pain, a person may become more inactive and experience presleep cognitive rumination [11], both of which serve to perpetuate poor sleep. It is also important to note that predisposing and perpetuating factors may exist outside the ‘traditional’ realm of physiological cause and effect in the sleep-pain cycle. Personality and cognitive processes – for example, a predisposition toward catastrophic thinking [11] – may heighten the risk of falling into a ‘vicious cycle’ of sleep disruption and exacerbated pain.

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In addition to Spielman *et al.*'s behavioral model of insomnia, a mechanistic model proposed by Smith and colleagues illustrates the role of disrupted sleep in the central processing of pain [12]. Specifically, sleep disruption is hypothesized to contribute to both hyperalgesia and impaired endogenous pain modulation. Although Smith acknowledges that research on the comorbidity of sleep complaints and pain is relatively nascent in persons with osteoarthritis, he nonetheless suggests that the “aggressive management of sleep disorders should be a critical component of the comprehensive treatment of rheumatologic patients and older adults.” (page 452) [12].

In sum, sleep disturbance is a common complaint of persons with osteoarthritis and several conceptual models have been proposed to explain this association. Given what we know, what are the next steps in investigating sleep as a means of breaking the vicious cycle of distress in osteoarthritis?

### Next steps in understanding the association between sleep & pain

#### Investigating the directionality of the sleep & pain association

In their recent review paper, Finan and colleagues offer several excellent suggestions for moving the sleep and pain research agenda forward [9]. After reviewing longitudinal studies published since 2005 and experimental studies published since 2006, the authors suggest that we are ready to move beyond a focus on the recip-

rocal association between sleep and pain. New methodological advances in research on sleep and pain have emerged, such as:

- A greater inclusion of clinical samples;
- A mix of longitudinal and microlongitudinal designs which enable a deeper analysis of the mechanisms by which sleep and pain interact;
- A focus on the emergence of new instances of sleep disturbance and pain complaints;
- The use of large epidemiologic studies.

The authors conclude that although a reciprocal association between sleep and pain exists, recent findings suggest that sleep disturbance predicts pain to a greater extent than pain predicts sleep disturbance [9]. This stronger temporal effect of sleep on pain provides further support for focusing on sleep as an intervention target in the treatment of osteoarthritic pain.

#### Use of more ecologically valid experimental paradigms

From their review of recent experimental studies, Finan and colleagues further conclude that even a single night of disrupted sleep is sufficient to increase both clinical pain and responses to quantitative sensory tests [9]. Going forward, they advocate for more ecologically valid experimental paradigms. For example, instead of manipulating sleep through total sleep deprivation, or deprivation of specific stages of sleep, researchers may consider applying partial sleep deprivation approaches. Partial sleep deprivation approaches such as curtailing sleep or disrupting sleep can provide a model that better mirrors the natural sleep of people with osteoarthritis. Additionally, the use of clinical samples can provide greater generalizability compared with the traditional reliance on healthy individuals.

#### Identifying new mechanisms underlying the association between sleep & pain

Although strides have been made in trying to understand the sleep-pain association, several mechanisms and moderators have been overlooked. Finan and colleagues suggest that we need to move beyond asking whether sleep and pain are associated to trying to understand how they are associated. In particular, investigation of factors such as dopamine and opioid systems, positive and negative affect, protective factors and sociodemographic factors is warranted [9].

- Dopaminergic signaling plays a key role in the fore-brain's reward system and the maintenance of arousal. Further research is needed to understand how sleep

disturbance disrupts reward processing – which may, in turn, affect the ability to cope with pain;

- Opioid peptides mediate pain modulatory systems and sleep disruption is shown to dysregulate these systems. New research is investigating whether the effectiveness of exogenously administered opioids is affected by sleep disruption [9];
- Sleep, pain and negative affect are shown to have complex associations [13]. Less is known about the role of positive affect as a moderator of the sleep and pain association. As positive affect is distinct from negative affect, future research is needed to investigate the benefits of positive affective experiences (e.g., work by Zautra and colleagues [14]);
- Importantly, not all individuals with chronic pain experience sleep disruption [7]. Therefore, it is necessary to expand our understanding of protective psychosocial factors, such as pain-related cognitions (e.g., pain acceptance, pain self efficacy and coping) or social network characteristics, in the sleep-pain association;
- The experience of sleep and pain is known to vary by sociodemographic factors such as age, sex and ethnicity. Further research is needed to add to our understanding of how sociodemographic factors moderate the association between sleep and pain.

Sleep is increasingly being examined in the context of osteoarthritis, both as a correlate and intervention

target. The application and development of conceptual models linking sleep and pain provides a framework for understanding this association. New methodological advances and the identification of mechanisms underlying the sleep-pain association will facilitate future research in this area.

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Meanwhile, we need to take care in treating sleep disorders and osteoarthritis pain, with a clear eye toward their interrelationship. Pharmacologic interventions are available for both problems, and tend to be the treatment of choice for persons presenting in primary care settings. However, these treatments are ‘serious medicine’, not without their hazards both independently and, particularly, in combination. Where sleep and osteoarthritis pain co-exist, proven behavioral interventions for both disorders should be included in first-line treatment strategies.

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