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The multidimensionality of sleep quality and its relationship to fatigue in older adults with painful osteoarthritis

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SUMMARY

Objective: To evaluate subjective sleep quality and its relationship to fatigue in older adults with osteoarthritis (OA).

Method: In a community cohort with hip/knee OA, subjective sleep quality was assessed using the Pittsburgh Sleep Quality Index (PSQI) and fatigue was measured by the Profile of Mood States – Fatigue subscale (POMS-F). Correlates of sleep quality and fatigue were determined by standardized interviews including socio-demographics, OA severity (Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) summary score), comorbidity, depression (Center for Epidemiologic Studies Depression Scale, CES-D), stressful life events, daytime napping, symptoms of restless legs syndrome (RLS) and prior sleep disorder diagnoses. Logistic regression examined correlates of poor sleep (PSQI score > 5). Linear regression evaluated the relationship between poor sleep and fatigue, and the effect of napping on this relationship.

Results: In 613 respondents, mean age was 78 years, 78% were female, 11% had concomitant fibromyalgia, and 26% had 3+ comorbid conditions. Responses indicated moderate OA severity. Seventy percent reported poor sleep; 25% met criteria for RLS and 6.5% reported a diagnosed sleep disorder. Independent correlates of poor sleep were: greater arthritis severity (adjusted odds ratio (OR) per unit increase in WOMAC score = 1.03, $P<0.0001$), 3+ comorbid conditions (adjusted OR = 1.88; $P = 0.03$), depressed mood (adjusted OR per unit increase in CES-D score = 1.09, $P < 0.0001$), and RLS (adjusted OR = 1.87; $P = 0.02$). Controlling for previously reported fatigue correlates, poor sleep was significantly associated with greater fatigue (parameter estimate = 1.63, $P = 0.0003$) and napping did not moderate this relationship ($P = 0.55$ for the interaction between napping and poor sleep).

Conclusions: Among older people with OA, poor sleep is highly prevalent and significantly linked with fatigue. Identifying the nature of sleep disturbances in OA is important as treatment of sleep disturbances may reduce OA-related fatigue.

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Introduction

Individuals with osteoarthritis (OA) have identified fatigue as a key concern[1]. In contrast to inflammatory forms of arthritis, like rheumatoid arthritis (RA), OA has traditionally been considered 'non-inflammatory'; thus, fatigue has not generally been ascribed to OA or routinely assessed clinically or in research. Few studies have examined fatigue in older adults with OA. Those that have, found that similar proportions of patients with RA and OA reported 'clinically important' fatigue[2–6] and have variably linked OA-related fatigue with older age[7], greater pain and disability[2,6,7], worse health status[8] and psychosocial factors, including depression[2,7,9], and stressful interpersonal life events[10].

Another important factor contributing to fatigue may be poor sleep quality, which may be particularly relevant in the OA population. Sleep disturbances, such as insomnia, sleep disordered

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breathing and restless legs syndrome (RLS), are common among older persons, women, and those who are obese, the same groups most often affected by OA, and may be exacerbated by medications used to treat OA pain (e.g., opioid analgesics). Although no study has evaluated sleep disturbances in older adults with painful OA using objective measures, including overnight polysomnography, prior research has shown that self-reported sleep disturbances, including problems with sleep onset, maintenance and early morning awakenings, are commonly reported by people with OA[11–13], in women more so than men[6,14–18]. Despite this, little has been done to characterize these sleep complaints, and to examine the extent to which underlying sleep disturbances explain OA-related fatigue, controlling for other factors[6,19,20]. Additionally, we lack information about the role of other personal and health factors, like stressful life events, comorbidities and daytime napping, on sleep in OA.

The objectives of this study were to determine, among older adults living with painful OA: the prevalence and key correlates of subjective sleep quality; the relationship between self-reported poor sleep and fatigue, controlling for previously identified correlates of OA-related fatigue; and the effect of regular daytime napping on the relationship between sleep quality and fatigue.

Methods

Study population

Participants were part of a longitudinal cohort study of individuals with moderate-to-severe hip or knee OA. Details of cohort recruitment have been published previously[21–23]. In brief, participants were recruited between 1995 and 1997 through a screening survey of 100% of the population 55+ years of age residing in two regions of Ontario, Canada, one rural and one urban. From 28,451 respondents, individuals were selected for cohort inclusion if they: (1) reported difficulty in the last 3 months with each of stair climbing, rising from a chair, standing and walking and (2) swelling, pain or stiffness in any joint lasting at least 6 weeks; and (3) indicated on a diagram that a hip or knee had been 'troublesome'. Ninety-six percent of those who met screening criteria had hip or knee arthritis on examination. Based on these criteria, a cohort of 2,411 individuals was established. Follow-up has been conducted by standardized telephone interview annually since inception; data for the present study are based on Year 2007 interviews, which, for the first time, incorporated a detailed assessment of subjective sleep quality and fatigue.

Assessments

Participants provided information about their age, sex, marital status, education, annual household income, living circumstances (independent alone, independent with others, nursing home/residential care facility), body mass index (BMI), severity of hip/knee symptoms and disability (Western Ontario McMaster Universities OA Index [WOMAC] pain and function subscales and summary score)[24], and arthritis treatments ever/currently used. Comorbidities were identified using a list of 18 health conditions and diseases, including fibromyalgia syndrome (FMS), for which participants had received treatment or had seen a physician in the past year. Depressive symptoms were assessed by the Center for Epidemiologic Studies Depression Scale (CES-D)[25]. Life events were assessed by a modified Life Experiences Survey (LES)[9,26], which measures the number of positive and negative life events in the past year. Items irrelevant to an older population were omitted (e.g., became pregnant) and one item was added (death of a pet). Items pertaining to major changes in sleeping habits were excluded as they may relate to sleep disturbance and thus may confound the relationships under examination.

Fatigue was measured using the Profile of Mood States – Fatigue scale (POMS-F)[27]. The POMS-F evaluates overall fatigue; respondents rate the extent to which they have felt worn out, fatigued, exhausted, sluggish, and weary in the past month (0 = not at all; 4 = extremely).

Perceived sleep quality was assessed using the Pittsburgh Sleep Quality Index (PSQI)[28,29]. The PSQI assesses seven sleep quality domains: sleep duration and latency, habitual sleep efficiency, sleep disturbances, use of sleep medication, daytime dysfunction and subjective sleep quality over the prior month. Each domain is scored from 0–3; domains are summed to yield a global score from 0–21, where higher scores indicate worse sleep quality. The PSQI has been shown to be reliable and valid[28,29] with stable scores over time[30]; a global score of >5 is associated with 98.7% sensitivity and 84.4% specificity to discriminate individuals with insomnia from controls[31]. We also included three questions recommended for diagnosis of RLS in epidemiologic studies by the International Restless Legs Syndrome Study Group[32]. An affirmative response to each of: 'Do you have unpleasant sensations in your legs combined with an urge or need to move your legs?', 'Do these feelings or symptoms occur mainly or only at rest and do they improve with movement?' and 'Are these feelings or symptoms worse in the evening or night than in the morning?' is associated with 87.5% sensitivity and 96% specificity for RLS compared to diagnostic interviews[32]. Average number of days/week with naps and average minimum duration of naps were also assessed. Finally, participants were asked if they had ever received a physician diagnosis of a sleep disorder, and if so, whether they were currently being treated for this condition.

Statistical analysis

All analyses were performed using the Statistical Analysis System (SAS) Version 9.1 (SAS Institute, Cary, NC). Statistical significance was considered at a two-tailed level of 0.05. Descriptive statistics were performed on all data. Logistic regression was used to determine the correlates of 'poor sleep', defined as a PSQI global score >5. Variables of interest were: socio-demographics (age, sex, income); arthritis pain and disability (WOMAC scores); obesity (BMI > 30 kg/m^2); comorbidity (self-reported diagnosis of FMS; number of *other* comorbid conditions – 0–1, 2, 3+); depressed mood (CES-D scores), positive and negative life events, RLS, and napping (<4 vs 4+ times/week). As the frequency of life events was non-normally distributed, negative and positive life events were dichotomized at the median, thus as ≤2 vs >2 and 0 vs 1+, respectively. Each correlate was examined bivariately; those associated with poor sleep at a *P*-value ≤ 0.10 were then evaluated simultaneously in multivariable regression analysis to determine independent correlates. As WOMAC subscale and summary scores were highly correlated, subsequent multivariable analysis used the WOMAC summary score as the measure of arthritis severity. Due to the known relationship between sleep and FMS, we conducted a sensitivity analysis in which we excluded individuals with co-occurring FMS.

T-tests were used to compare mean values for self-reported fatigue for those with vs without 'poor sleep'. The independent relationship of 'poor sleep' to self-reported fatigue was then evaluated using linear regression, controlling for the following previously identified correlates of fatigue: age, sex, arthritis severity (WOMAC summary scores), number of comorbid conditions, FMS, depressed mood, and stressful life events. We then tested for an interaction between poor sleep and regular daytime napping (defined as napping ≥4 times/week vs less often) to examine whether regular napping moderated the effect of poor sleep on fatigue. We hypothesized that the effect of poor sleep on fatigue

would be less among regular vs less frequent nappers, suggesting a restorative effect.

Ethics

The procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (Women's College Hospital Research Ethics Board, Toronto, Canada) and with the Helsinki Declaration of 1975, as revised in 2000. All subjects gave informed consent to participate in this research.

Results

Sample characteristics

Of the original cohort of 2,411, 805 were deceased, 470 were ineligible or unable to participate, 370 had refused further follow-up and 93 were lost to follow-up, leaving 673 individuals. These individuals were approached for participation in 2007. Of these, eight had died, one was ineligible, 24 were unable to participate due to illness, 29 could not be located and 14 refused. As well, 16 new participants were added to the cohort; these individuals were acquaintances of the original cohort participants, met eligibility criteria and had similar demographic characteristics as the original cohort (data not shown), and requested participation in the study, providing a sample of 613 for this analysis. Compared with the original cohort, the 613 participants were younger, more likely to be female and living with others, and had higher income and education.

Participant characteristics are shown in Table I. Mean age was 77.8 years (range 59–98) three-quarters were female and 37.7% had an annual income ≤$20,000. Mean WOMAC scores indicated moderate-to-severe OA; 39% had undergone hip or knee joint replacement surgery. Twenty-six percent reported 3+ comorbid conditions, 10.8% reported physician-diagnosed FMS (65/66 were female), and 23% had CES-D scores ≥16 indicating possible clinical depression. Few participants reported 1+ positive life events in the prior year (11.7%), whereas 42.7% reported > two negative life events.

Table I
Characteristics of respondents ($n = 613$*)

Characteristic	Total cohort ($n = 613$)
Age (years) – mean (SD)	77.82 (6.95)
Female – *n* (%)	476 (77.7)
Level of education – *n* (%)	
≤ High school	463 (75.53%)
Post-secondary	150 (24.47%)
Annual household income – *n* (%)	
≤$20,000	221/586 (37.71%)
$21,000–$40,000	306 (52.22%)
>$40,000	59 (10.07%)
Living circumstances – *n* (%)	
Living alone, independently	230/591 (38.92%)
Living with others, independently	343 (58.04%)
Institution (e.g., long term care, etc.)	18 (3.05%)
BMI (kg/m^2) – mean (SD)	28.61 (5.81)
Obese (BMI > 30 kg/m^2) – *n* (%)	188 (33.16%)
OA Severity – mean (SD)	
WOMAC pain scale/20	9.01 (3.93)
WOMAC physical function scale/68	34.53 (14.18)
WOMAC summary score/96	46.09 (19.30)
Undergone total hip or knee joint replacement	237 (38.66%)
Comorbid medical conditions – *n* (%)	
Number of comorbidities	
None	77/590 (13.05%)
1–2	359 (60.84%)
3+	154 (26.10%)
Physician-diagnosed FMS	66 (10.77%)
LES – *n* (%)	
Positive life events: ≥1 event	72 (11.75%)
Negative life events: >2 events	262 (42.74%)
Depressed mood (CES-D score)/20 – mean (SD)	11.35 (8.64)
Score ≥16 indicating possible depression – *n* (%)	141 (23.0%)

* The denominator is provided when less than 613.

Self-reported sleep quality, fatigue, sleep disorders and napping

Participants' mean global PSQI score was 8.0/21 (range 1–19); 70% had a global score >5 indicating poor sleep quality (Table II). PSQI subscale scores were highest for sleep latency (difficulty falling asleep) followed by sleep disturbances (interrupted sleep). Participants' mean fatigue score was 11.6/20 (Standard deviation (SD) 5.8). One-quarter of participants met criteria for RLS and 159 (25.9%) reported currently using medications for sleep. Only 39/596 (6.5%) reported a physician-diagnosed sleep disorder; of these, 26 (66.7%) were receiving treatment. Most participants napped at least once/week (433/510, 84.9%); 218 (42.7%) napped 4+ times weekly.

Correlates of poor sleep quality

In unadjusted analyses, the odds of reporting poor sleep was greater among those who were female, had lower income, greater arthritis pain or disability, greater comorbidity, higher BMI, a diagnosis of FMS, greater scores for depressed mood and negative life events, RLS symptoms, and reported napping 4+ times/week (Table III). In multivariable analyses, independent correlates of poor sleep were: greater arthritis severity (WOMAC summary score; adjusted odds ratio (OR) = 1.03, $P < 0.0001$), having 3+ comorbid conditions (adjusted OR = 1.88; $P = 0.03$), depressed mood (CES-D score; adjusted OR = 1.09, $P < 0.0001$), and symptoms of RLS (adjusted OR = 1.87; $P = 0.02$) (Table III). Adjusting for use of sleep medications, or excluding individuals with concomitant FMS or those who were taking sleep medications, did not substantively alter our results (data not shown).

Table II
Self-reported sleep quality, fatigue, sleep disorders and napping in 613* cohort participants

Characteristic	Total cohort ($n = 613$)
Self-reported fatigue (POMS-F)/20	11.59 (5.80)
Met criteria for RLS	152 (24.80%)
Using medications for sleep	159 (25.98%)
Napping	
No	77/510 (15.10%)
Yes, once a week on average	40 (7.84%)
Yes, 2–3 times a week on average	175 (34.31%)
Yes, 4+ times a week on average	218 (42.75%)
Self-reported diagnosis of a sleep disorder	39/596 (6.54%)
Currently receiving treatment	26/39 (66.67%)
PSQI	
Global score,/21, Mean (SD), median	7.95 (3.94), 8
Poor sleep (score >5)	429 (69.98%)
Sleep latency,/3, Mean (SD), median	1.71 (0.94), 2
Sleep duration,/3, Mean (SD), median	0.84 (0.80), 1
Sleep duration >7 h	222 (36.22%)
Habitual sleep efficiency,/3, Mean (SD), median	1.17 (1.13), 1
Sleep efficiency >85%†	225 (36.70%)
Sleep disturbances,/3, Mean (SD), median	1.42 (0.50), 1
Sleep medications,/3, Mean (SD), median	0.72 (1.20), 0
Daytime dysfunction,/3, Mean (SD), median	0.90 (0.82), 1
Subjective sleep quality,/3, Mean (SD), median	1.19 (0.84), 1

* Denominators are provided when less than 613.
† Sleep efficiency refers to the proportion of time spent in bed that is spent asleep.

Table III
Correlates of poor global sleep quality as determined by multivariable logistic regression ($n = 577$)

Independent variable	Dependent variable = poor vs normal sleep quality (Pittsburgh Global Sleep Quality Score >5 vs ≤5)			
	Unadjusted OR (95 % Confidence interval)	*P* value	Adjusted OR (95% Confidence interval)	*P* value
Age (per year)	1.03 (1.00–1.05)	0.07	0.99 (0.96–1.03)	NS
Sex (female)	2.27 (1.53–3.37)	<0.0001	1.59 (0.94–2.68)	NS
Annual household income				
≤$20,000 (reference)	–		–	
$21,000–$40,000	0.53 (0.36–0.79)	0.002	0.98 (0.60–1.58)	NS
>$40,000	0.245 (0.13–0.45)	<0.0001	0.94 (0.43–2.09)	NS
WOMAC pain score (per unit increase)	1.25 (1.19–1.32)	<0.0001*	–	–
WOMAC physical function score (per unit increase)	1.07 (1.05–1.09)	<0.0001*	–	–
WOMAC summary score (per unit increase)	1.05 (1.04–1.06)	<0.0001	1.03 (1.01–1.04)	<0.0001
Comorbidity				
<2 conditions (reference)	–		–	
Two comorbid conditions	1.70 (1.14–2.54)	0.01	1.33 (0.82–2.14)	NS
3+ comorbid conditions	3.14 (1.92–5.12)	<0.0001	1.88 (1.06–3.33)	0.03
Obese (yes)	1.28 (0.87–1.90)	NS	–	–
BMI (per unit increase)	1.03 (1.00–1.07)	0.04	1.02 (0.98–1.06)	NS
FMS diagnosis (yes)	3.38 (1.58–7.23)	0.002	1.83 (0.79–4.27)	NS
CES-D Depression score (per unit increase)	1.15 (1.11–1.19)	<0.0001	1.09 (1.05–1.13)	<0.0001
Positive life events (≥1 event)	0.67 (0.40–1.12)	NS	–	–
Negative life events (>2 events)	2.63 (1.80–3.84)	<0.0001	1.38 (0.88–2.16)	NS
RLS (yes)	1.98 (1.27–3.09)	0.003	1.87 (1.13–3.12)	0.02
Napping (≥4 times per week)	2.40 (1.61–3.57)	<0.0001	1.35 (0.83–2.19)	NS

C Statistic for the final model = 0.80; Hosmer and Lemeshow Goodness of Fit test Chi Square 4.11, df = 8, $P = 0.85$.
NS: not statistically significant at two-tailed *P*-value ≤ 0.10.
* WOMAC pain and disability sub-scores highly correlated with summary score; summary score used in multivariable analysis.

Relationship between poor sleep quality and fatigue

Mean fatigue scores were significantly higher among those with vs without 'poor sleep' (13.1 vs 8.1, $P < 0.0001$). Adjusting for age, sex, arthritis severity, depressed mood, concomitant FMS, and comorbidity, poor sleep was independently associated with greater fatigue (parameter estimate 1.63, SE 0.45, $P = 0.0003$) (Table IV). Further adjustment for regular daytime napping showed that napping was also significantly and independently associated with greater fatigue (adjusted parameter estimate 1.48, $P = 0.0003$) (Table IV). However, we did not find that regular napping moderated the relationship between poor sleep and fatigue (*P* value for the interaction between poor sleep and napping = 0.55, adjusted for all other variables).

Table IV
Relationship between perceived 'Poor Sleep' and Self-Reported Fatigue: results of linear regression analyses ($n = 581$)

Independent variable	Dependent variable = POMS-Fatigue Score			
	Adjusted Parameter Estimate* (*P* value)	R^2	Parameter estimate further adjusted for napping (*P* value)	R^2
Age (per year)	0.04 (NS)†	0.44	0.03 (NS)	0.455
Sex (female)	1.87 (<0.0001)		2.02 (<0.0001)	
WOMAC summary score (per unit increase)	0.10 (<0.0001)		0.09 (<0.0001)	
Comorbidity				
<2 conditions (reference)	Reference		Reference	
2 comorbid conditions	0.02 (NS)		−0.15 (NS)	
3+ comorbid conditions	0.77 (NS)		0.56 (NS)	
FMS diagnosis (yes)	1.83 (0.003)		1.91 (0.0015)	
CES-D Depression score (per unit increase)	0.14 (<0.0001)		0.13 (<0.0001)	
Negative life events (>2 events)	0.72 (NS)		0.74 (NS)	
Napping (≥4 times per week)	–		1.48 (0.0003)	
Poor sleep (PSQI global score >5 vs ≤5)	1.63 (0.0003)		1.57 (0.0005)	

* Adjusted for all other variables. The cross-product interaction term between poor sleep and regular daytime napping was not significant ($P = 0.55$), thus for simplicity not included in the model.
† NS = not statistically significant ($P > 0.05$).

Discussion

This study is the first, to our knowledge, to comprehensively evaluate the multidimensionality of sleep quality and its independent contribution to fatigue among older adults with painful OA. Our study has documented a high prevalence of poor sleep quality and has shown that, controlling for a number of other factors, including arthritis severity, FMS, depressed mood, stressful life events and daytime napping, poor sleep and self-reported fatigue are independently and significantly linked in this population. Using a published cut-point on the PSQI that has been used by others[31], we found that two-thirds of older people living with painful, disabling hip/knee OA had 'poor sleep'. This estimate is consistent with the few other studies that have evaluated self-reported sleep quality in OA. Among participants of the Johnston County Osteoarthritis Project[12], 76.4% of 759 subjects with hip/knee OA reported any sleep problem, while in a large community sample of 429 adults aged 65+ years with knee pain, 31% reported problems with sleep onset, 81% with sleep maintenance and 51% with early morning awakenings at least weekly[33]. A third study reported a lower prevalence of sleep problems (insomnia in 25% and unrefreshing sleep in 11%) in a large nationally representative sample of Canadians who self-reported 'arthritis' or 'rheumatism'[34]. However, this sample included a broad age range (18 and older) and did not distinguish between types of arthritis or symptom severity. Our study also confirmed previously reported cross-sectional relationships between poor sleep and both arthritis pain and depressed

mood[2,3,12,33–37], and documented additional independent relationships with both greater comorbidity and symptoms of RLS.

Fatigue has been documented as a common complaint in many medical conditions[6,38,39], including more recently OA[1,2,6–10,40,41]. In addition to its link with poor sleep quality, our study documented significant independent relationships between greater OA-related fatigue and female sex, greater OA pain and disability, concomitant FMS, and depressed mood. Controlling for these factors, we found no independent effect of older age or greater comorbidity.

Previous research has shown a relationship between stressful life events and both fatigue[10] and depressed mood in OA[9]. However, no study has previously examined the impact of stressful life events on sleep in this population. Few of our participants had experienced positive life events over the prior year, whereas negative life events were relatively common and, as expected, associated with both greater fatigue and poor sleep. However, these relationships became non-significant after controlling for depressed mood, suggesting that mood mediates the effect of stressful life events on both fatigue and sleep. These findings underscore the importance of contextual factors on the complex relationships among mood, sleep and fatigue in older peoples' lives.

RLS has been estimated to affect 10–35% of individuals aged 65+ years, with women more often affected than men[37]. Consistent with these estimates, and using a recommended and validated algorithm to diagnose RLS in epidemiologic studies[32], 24.8% of our study participants were found to have RLS. However, compared with diagnostic interview, the sensitivity of this approach to identify RLS has been shown to be 87.5%; thus, we may have underestimated the true prevalence in study participants. Among specialty sleep clinic patients, it has been shown that sleep quality is related not only to the presence of RLS, but also to the severity of the RLS symptoms[37,42]. Despite the high prevalence of RLS and associated poor sleep, and the availability of safe and effective therapies to treat most common sleep disturbances in older individuals[43–45], few participants had been diagnosed with a sleep disorder or were receiving treatment, suggesting a health care gap.

As noted in other studies of older adults, daytime napping was commonly reported[46–48]. Individuals who reported napping had worse self-reported sleep quality and higher levels of fatigue than those who napped less frequently. This suggests that napping may be used to combat fatigue related to poor sleep and/or that napping is simply a manifestation of high levels of fatigue. Furthermore, we found no evidence to suggest that regular napping had a restorative effect among those with poor sleep. It has been suggested that daytime napping may adversely impact nighttime sleep[49,50]. However, after we controlled for other factors, we found no cross-sectional independent relationship between regular daytime napping and self-reported sleep quality. Picarsic *et al* found that 54% of 414 older adults napped at least once weekly; napping was associated with greater fatigue and male sex, but not with sleep efficiency or sleep latency[46]. Others have also reported the lack of an association between napping and sleep parameters[37,46], suggesting that while napping is common it doesn't appear to adversely affect nighttime sleep. One explanation may be that the quality of daytime sleep while napping may also be poor, and therefore non-restorative, due to the presence of an intrinsic sleep disturbance such as obstructive sleep apnea. Or, it may be that the effect of napping on sleep depends on the timing and duration of the naps. For example, napping late in the day has been shown to have a particularly negative impact on nighttime slow wave sleep[51]. Prospective studies, with attention to the timing, duration and frequency of naps, are needed to further elucidate the negative/positive impact of napping on sleep and fatigue among older adults.

There is a known association between obesity and obstructive sleep apnea[52]. Two studies[12,33] previously examined the relationship between BMI and sleep quality in OA and found no association. Our study similarly found no relationship between poor sleep, measured using the global PSQI score, and BMI or obesity after controlling for arthritis severity. However, the use of a global sleep score may obscure important patterns of subjective sleep problems that may provide clues to the presence of underlying sleep disturbances. For example, sleep disordered breathing would be expected to particularly impact sleep maintenance while RLS might prolong sleep initiation. Alternatively, the predominantly female study population (in whom the relationship between BMI and OSA has been shown to be less strong[53–55]) and/or a high prevalence of mild sleep apnea may explain this finding. Further research is warranted to evaluate the underlying sleep disturbances in OA using objective measures, such as polysomnography.

Strengths of our study were our large community-based cohort of older individuals with symptomatic OA unselected for sleep problems or fatigue, and the comprehensive assessment of sleep quality and fatigue controlling for key covariates, including stressful life events, concomitant FMS, and napping. However, there are also some potential weaknesses. First, the complex causal relationships among the variables considered cannot be fully appreciated in a cross-sectional study. Whether poor sleep leads to fatigue can only be elucidated through longitudinal research. Based on our findings, future longitudinal studies should incorporate the role of contextual factors, such as stressful life events, in triggering sleep problems, and take into consideration the impact of sleep medications on subjective sleep quality and on OA pain and disability. Second, our assessment of sleep quality was based on self-report. It is unclear to what extent self-reported sleep disturbances accurately predict findings on objective measures of sleep, such as overnight polysomnography. Research is needed to elucidate the nature of underlying sleep disturbances in OA using such measures, as well as their relationship with measures of subjective sleep quality. Third, the occurrence of napping was also based on self-report, which may underestimate both the frequency and duration of naps, potentially biasing against finding an association, positive or negative, between napping and sleep. Fourth, we did not evaluate the impact of physical activity, alcohol or caffeine consumption on self-reported sleep quality. Finally, we did not exclude individuals with concomitant FMS; FMS is known to be associated with fatigue and poor sleep[56]. However, in a sensitivity analysis in which we excluded these individuals, our results were unchanged.

In conclusion, in a large community cohort with symptomatic hip/knee OA self-reported poor sleep was highly prevalent and independently and significantly linked to self-reported fatigue. Despite this, few participants had been diagnosed, or treated, for an underlying sleep disturbance or sleep disorder. Greater attention to the determinants and consequences of poor sleep in people living with painful OA is warranted, particularly among vulnerable subgroups such as women and those with severe OA, so that underlying causes can be identified and appropriate interventions provided. In particular, studies are needed to characterize the sleep disturbances and disorders underlying these sleep complaints using physiologic measures, including overnight polysomnography. Identifying the nature of sleep disturbances in OA is extremely important as most sleep disturbances are directly amenable to effective therapies[57]. Furthermore, should longitudinal studies identify a causal relationship between sleep disturbances and OA-related fatigue, this will lay the foundation for clinical trials of interventions directed at ameliorating identified sleep disturbances, e.g., use of medications for the treatment of RLS and periodic limb movements during sleep, as a strategy for relieving OA-related fatigue.

Declaration of authors' contributions

All authors have significantly contributed to (1) the conception and design of the study or acquisition of data or analysis and interpretation of data, (2) drafting the article and revising it critically for important intellectual content and (3) final approval of the manuscript as follows:

Conception and design (GAH, MAMG), analysis and interpretation of data (GAH, MRF, EJW, MAMG, CC, BJM), drafting of the article (GAH, EJW), critical revision of the article for important intellectual content (GAH, MRF, EJW, MAMG, CC, BJM), final approval of the article (GAH, MRF, EJW, MAMG, CC, BJM), provision of study material or patients (GAH), statistical expertise (GAH, EJW), obtaining funding (GAH, MAMG), administrative, technical or logistic support (GAH, MRF, CC, BJM), collection and assembly of data (GAH, MRF, MAMG, BJM). On behalf of all authors, Dr. Gillian A. Hawker (g.hawker@utoronto.ca) takes public responsibility for the integrity of the work as a whole, from inception to finished article.

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Conflict of interest

None of the authors have any financial or personal relationships with other people or organizations that could potentially and inappropriately influence their work and conclusions.

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