

The relationship among smoking, sleep, and chronic rheumatic conditions commonly associated with pain in the national health interview survey

Brooke A. Stipelman · Erik Augustson ·
Timothy McNeel

Received: September 8, 2011 / Accepted: July 20, 2012 / Published online: August 5, 2012
© Springer Science+Business Media, LLC (outside the USA) 2012

Abstract Chronic rheumatic conditions are typically characterized by chronic pain and are uniquely associated with increased rates of cigarette smoking and poor sleep quality. However, no study has examined the possible additive or interactive effects of these two health behaviors in individuals diagnosed with a chronic rheumatic condition. The goal of this study is to examine the relationship between cigarette smoking and sleep in a population sample of individuals diagnosed with a chronic rheumatic condition and related functional impairment. Cross sectional survey data was obtained from the 2007 National Health Interview Survey. Individuals diagnosed with a chronic rheumatic condition were more likely to be a former or current smoker compared to non-diagnosed individuals. Individuals with a chronic rheumatic condition were more likely to report <6 h of sleep per night and endorsed significantly more insomnia and daytime sleepiness. There was no interaction between diagnosis of a chronic rheumatic condition and smoking status on any of

the sleep outcomes assessed. Finally, an interaction was observed suggesting individuals with a chronic rheumatic condition who currently smoke are more likely to report averaging <6 h of sleep per night and frequent insomnia compared to individuals with a chronic rheumatic condition who never smoked. These results suggest both a unique and additive relationship between smoking and sleep in individuals with a chronic rheumatic condition. Findings can likely be generalized to other conditions commonly associated with chronic pain.

Keywords Cigarette · Smoking · Sleep · Chronic pain · Population · Rheumatology

Introduction

It has been well documented that the rates of smoking in individuals with chronic pain conditions are higher than that of the general population. This is particularly true of people with musculoskeletal and connective tissue disorders (Andersson et al., 1998; Brage & Bjerkedal, 1996; Leino-Arjas, 1998; Mitchell et al., 2011; Palmer et al., 2003; Scott et al., 1999; Strine et al., 2005; Ulrich et al., 2006; Yunus et al., 2002). Moreover, it has been shown that cigarette smoking is associated with exacerbated pain intensity and related symptoms (Biering-Sorensen & Thomsen, 1986; Eriksen et al., 1997; Goldberg et al., 2000; Jamison et al., 1991; Pamuk et al., 2009; Vogt et al., 2002). For example, Weingarten et al. (2009) compared tobacco users to nonusers seeking treatment for fibromyalgia and found that tobacco use was significantly associated with increased levels of pain intensity, higher scores on a measure of fibromyalgia symptoms, and greater work interference. Similar results have also been found using

B. A. Stipelman (✉)
Science of Research and Technology Branch, Behavioral
Research Program, Division of Cancer Control and Population
Sciences, National Cancer Institute, 6130 Executive Blvd.,
MSC 7326, Executive Plaza North, Room 4097, Rockville,
MD 20892-7326, USA
e-mail: stipelmanba@mail.nih.gov

E. Augustson
Tobacco Control Research Branch, Behavioral Research
Program, Division of Cancer Control and Population Sciences,
National Cancer Institute, 6130 Executive Blvd., MSC 7326,
Executive Plaza North, Room 4097, Rockville,
MD 20892-7326, USA

T. McNeel
Information Management Services, Inc., Silver Spring,
MD, USA

population-based samples. For instance, Jakobsson (2008) conducted a cross-sectional population study of Swedish residents and found that amongst respondents who endorsed experiencing chronic pain, current smokers reported greater levels of pain intensity. Despite the evidence suggesting this link between cigarette smoking and pain intensity, the mechanism driving this relationship is unclear and likely multifactorial.

In addition to cigarette smoking, chronic pain conditions are also associated with other negative health behaviors, such as poor sleep. Individuals with chronic pain report averaging less sleep efficiency (i.e. amount of restful sleep in proportion to time spent in bed (Buysse et al., 1989) compared to the general population. Specifically, pain is associated with fewer hours of sleep, insomnia, early waking, and general reports of poor sleep quality (Belt et al., 2009; Marty et al., 2008; Okura et al., 2008; Theadom et al., 2007). Furthermore, sleep laboratory studies have found that individuals with chronic pain experience less deep slow-wave sleep and more brief arousals and awakenings compared to those without pain Anch et al. (1991); Branco et al., 1994; Hirsch et al., 1994). This lack of restorative sleep is particularly detrimental to individuals with chronic pain as it is predictive of a number of negative outcomes including increased pain (Edwards et al., 2008; Tang et al., 2007), depressed mood, and poorer overall functioning (McCracken & Iverson, 2002; Naughton et al., 2007; Palermo et al., 2008; Pilowsky et al., 1985).

Cigarette smoking has also been shown to be related to sleep quality. Findings from clinical and population based studies have consistently found that smokers experience poorer sleep compared to nonsmokers (Conway et al., 2008; Lexcen & Hicks, 1993; Phillips & Danner, 1995; Soldatos et al., 1980, Wetter & Young, 1994; Wetter et al., 1994). For instance, Zhang et al. (2006) used polysomnography to examine differences in sleep architecture of smokers and nonsmokers in a large population study. They found that compared to nonsmokers, smokers tended to have longer initial sleep latency (i.e., amount of time in bed before falling asleep), less total sleep time, and more time in the lighter less restorative phases of sleep (i.e., more stage 1 and less slow wave sleep). While it not fully understood why cigarette smoking adversely affects sleeps, there is some data to suggest that one possibility may be related to both the stimulative effects of nicotine in the early part of the night and nicotine withdrawal occurring during the later part of the night (Zhang et al., 2008). As such, it is possible that frequency of cigarette use may be related to sleep quality, with heavy smoking associated with poorer sleep than light or intermittent smoking.

Given the individual relationships between chronic pain conditions, cigarette smoking, and sleep quality, it would be informative to understand whether or not an additive

effect exists, such that the presence of both a chronic pain condition and smoking predict even greater sleeping difficulties compared to either condition alone. One study that compared smokers and nonsmokers from a pain clinic on a number of health outcomes found that smokers were more likely to report greater sleep interference as a result of their pain (Weingarten et al., 2009). However, this study used a general one-item measure of sleep quality and instructed respondents to base their answers specifically within the context of their pain. Thus, to date, no study has explicitly examined the relationship between cigarette smoking, sleep quality, and chronic pain conditions. As such, the goal of this study is to provide an initial examination of these associations using a United States population based sample. Specifically, we expect to find that (1) individuals with a chronic rheumatic condition associated with pain will be more likely to smoke cigarettes compared to those without a chronic rheumatic condition; (2) individuals with a chronic rheumatic condition will report poorer overall sleep quality compared to those without a chronic rheumatic condition; (3) there will be an interaction between smoking and a chronic rheumatic condition on sleep where smoking status serves as moderator; and (4) there will be a relationship between smoking frequency and sleep such that those individuals with a chronic rheumatic condition who are heavy smokers will report greater sleep difficulties than those who are light/moderate smokers.

Method

Sample population

The current study included 22,850 individuals, aged 18–84 drawn from the 2007 National Health Interview Survey (NHIS; CDC, 2007). The NHIS is a nationwide population-based household health survey that has been conducted annually since 1957 by the Centers for Disease Control and Prevention. The survey includes approximately 30,000–40,000 households in the civilian, non-institutionalized population, and is used to track trends in illness and disability in the United States. The NHIS utilizes a complex survey design involving clustering, stratification, and multistage sampling. Each survey year represents a different sample and blacks and Hispanics are oversampled. The final response rate for the adult sample was approximately 68 % (National Center for Health Statistics, 2008).

Dependent variable

A chronic rheumatic condition was defined in this study as the presence of a current diagnosis of a rheumatological condition plus general functional impairment. This was

captured using the following questions from the NHIS: “Have you ever been told by a doctor or other health professional that you have some form of arthritis, rheumatoid arthritis, gout, lupus, or fibromyalgia?” and “Are you now limited in any way in any of your usual activities because of arthritis or joint symptoms?” A total of 2,176 (8.8 %) of the total sample met this criteria for chronic pain. The breakdown of the group by type of diagnoses was as follows: arthritis 79.5 %, rheumatoid arthritis 13.4 %, fibromyalgia 10.2 %, gout 4.6 %, lupus 1.7 %, and other 7.6 %. The mean age of the chronic rheumatic condition sample was 59.1 years and the average number of years since diagnosis was 13.9 (as defined by the question, “How long have you had arthritis or rheumatism?”). Approximately 89 % of the sample had been diagnosed with a rheumatological condition for at least 2 years, 10 % between 6 months and 2 years, and 1 % had been diagnosed less than 6 months.

Independent variables

Sociodemographic characteristics

Demographic variables included in these analyses consisted of age, gender, education level (<high school, high school diploma/equivalent, and >high school diploma), employment status (working, looking for work, and not working), marital status (married/living with partner, divorced/separated/widowed, and never married), and race/ethnicity (non-Hispanic White/Caucasian, non-Hispanic black/African American, Hispanic, non-Hispanic Asian, and non-Hispanic other).

Affective status

Measures of global depression and anxiety symptoms were assessed using two separate questions that asked respondents whether or not they had experienced frequent feelings of depression or anxiety over the past 12 months. Specifically, respondents were asked “During the past 12 months, have you been frequently depressed?” and “During the past 12 months, have you been frequently anxious?”

Smoking history

In this study, smoking status was determined using two questions which assessed whether or not the respondents had smoked at least 100 cigarettes in their lifetime and if he or she was currently smoking. Those respondents who endorsed current smoking were then asked a follow-up question to determine on average how many cigarettes they smoked per day. For the purpose of our analyses, those

individuals who reported smoking less than 100 cigarettes in their lifetime were classified as never smokers and those who had smoked more than 100 cigarettes in their lifetime but were not currently smoking were categorized as former smokers. However, for several of the analyses these two groups were collapsed together and the respondents were considered nonsmokers. For those individuals who were currently smoking, those consuming one pack or more of cigarettes per day (≥ 20 cpd) were classified as heavy smokers while those who smoked less one pack a day (< 20 cpd) were classified as moderate/light smokers.

Sleep quality

Three questions from the NHIS were used to capture the overall sleep quality of the respondents. Sleep duration was assessed using the question “On average, how many hours of sleep do you get in a 24-hour period?” Individuals who reported 6–9 h of sleep were considered normal sleepers, while those endorsing < 6 were categorized as “short” sleepers and those getting > 9 were considered “long sleepers”. Other measures of sleep quality were assessed using the following yes/no questions: “During the past 12 months, have you regularly had insomnia or trouble sleeping?” and “During the past 12 months, have you regularly had excessive sleepiness during the day?”

Statistics

Analyses were performed using SAS-callable SUDAAN, release 10.0.1, which corrects standard errors to account for the complex sampling design of the NHIS survey. Using classic contingency table analysis, we compared individuals with versus without a chronic rheumatic condition and individuals with a chronic rheumatic condition who smoked versus individuals with a chronic rheumatic condition who did not smoke and individuals without a chronic rheumatic condition who smoke. Reported *P* values are based on Chi-square using corrected standard errors derived from SUDAAN PROC CROSSTAB. A series of Logistic regressions were performed comparing sleep quality (i.e. average hours of nightly sleep, insomnia, and excessive daytime sleepiness) on smoking status, diagnosis of a chronic rheumatic condition, depressed mood, and anxious mood while also controlling for age, gender, race/ethnicity, education, employment status and marital status. Odds ratios and 95 % confidence intervals were calculated using the SUDAAN procedure PROC RLOGIST. Finally, Chi-square was used to make comparisons regarding sleep characteristics for individuals with a chronic rheumatic condition who were current versus never smokers, and individuals with a chronic rheumatic condition who were light/moderate smokers versus heavy smokers.

Results

Demographics, smoking, and sleep variables

Comparisons between individuals with and without a chronic rheumatic condition on a variety of sociodemographic characteristics are presented in Table 1. Specifically, individuals with a chronic rheumatic condition were much more likely to be older (65+ years), Caucasian, not working, less educated, divorced/separated/widowed, and have more current feelings of depression and anxiety compared to respondents without a chronic rheumatic condition.

Mean differences between those with a chronic rheumatic condition and those without on a number of sleep and smoking variables are also presented in Table 1. With respect to smoking history, individuals with a chronic rheumatic condition were significantly more likely to endorse being a current or former smoker compared to those without a chronic rheumatic condition ($P < 0.001$). Moreover, smokers with a chronic rheumatic condition reported smoking an average of 17 cigarettes compared to the 13.4 in the non-chronic rheumatic condition group. We found no significant difference in age of onset of regular smoking between the two groups. With respect to sleep, those with a chronic rheumatic condition were more likely to have reported being a short sleeper (i.e., <6) or long sleeper (>9) compared those without a chronic rheumatic condition ($P = 0.001$). Furthermore, individuals with a chronic rheumatic condition were significantly more likely to have endorsed regular insomnia and excessive daytime sleepiness, suggesting that these individuals may have poorer sleep quality compared to those without a chronic rheumatic condition (47.2 vs. 15.2 % and 28.9 vs. 8.2 %, respectively).

Individuals with a chronic rheumatic condition were then categorized into smokers and nonsmokers and their demographic comparisons are presented in Table 2. In particular, compared to nonsmokers with a chronic rheumatic condition, smokers were more likely to be male, younger, working or looking for work, and have less formal education. In addition, they endorsed much higher rates of feeling depressed (46.1 vs. 28.7 %) and anxious (42.7 vs. 25.4 %) compared to their nonsmoking counterparts. In order to examine whether these demographic differences are unique to smokers with a chronic rheumatic condition, we also compared smokers with a chronic rheumatic condition to smokers without a chronic rheumatic condition (data not shown). We found that smokers with a chronic rheumatic condition were significantly more likely to be female (55.1 vs. 44.4 %), over age 35 (91 vs. 60.3 %), not working (64.3 vs. 26.3 %), have less formal education (25.6 vs. 19.4 %), be divorced (34 vs. 18.3 %), and report

higher levels of depressed mood (46.1 vs. 15.5 %) and anxiety (42.7 vs. 15.8 %) compared to smokers without a chronic rheumatic condition.

Logistic regression

Results from multiple logistic regressions are presented in Table 3. After controlling for age, gender, ethnicity, education, employment, feelings of depression, and feelings of anxiety, individuals with a chronic rheumatic condition were more likely to have reported less than 6 h of sleep per night (OR = 1.98) compared to individuals without a chronic rheumatic condition. In addition, they were 2.4 and 2.6 times more likely to experience regular insomnia and excessive daytime sleepiness, respectively. Current smokers were also more likely to endorse less than >6 h of sleep per night (OR = 1.58) and experience regular insomnia (OR = 1.35) compared to nonsmokers. The interactions between the presence of a diagnosis of a chronic rheumatic condition and smoking status on sleep outcomes were not significant.

Relationship between smoking and sleep quality in individuals with CRP

In order to assess the unique contribution of smoking on sleep quality in individuals with a chronic rheumatic condition, analyses were conducted looking at the relationship between smoking status and sleep in individuals diagnosed with a chronic rheumatic condition (Table 4). Specifically, current smokers with a chronic rheumatic condition were significantly more likely to have endorsed less than 6 h of sleep (25.4 %) compared to individuals with chronic rheumatic condition who never smoked (15.2 %). They also experienced more frequent insomnia (61.1 vs. 40.9 %) and excessive daytime sleepiness (38.8 vs. 21.7 %). In order to address whether these differences in sleep quality were unique to smokers with a chronic rheumatic condition, we also compared smokers with a chronic rheumatic condition to smokers without (data not shown). Again, we found that smokers with a chronic rheumatic condition were significantly more likely to report less than 6 h of sleep (25.4 %) compared to smokers without (10.1 %), and also endorsed greater rates of insomnia (61.1 vs. 21.1 %) and excessive daytime sleepiness (38.8 vs. 11.5 %).

To examine the potential relationship between these sleep variables and amount of cigarettes smoked per day, Table 5 presents a second set of analyses that looked at the relationship between those individuals with chronic rheumatic pain who were heavy smokers (≥ 20 cpd) versus light/medium smokers (< 20 cpd). While we found no association between smoking level and average number of

Table 1 Comparisons between individuals with and without a chronic rheumatic condition on demographics, smoking, and sleep characteristics

Variable	Chronic rheumatic condition		Statistic	P
	Yes (n %)	No (n %)		
Gender				
Male	759 (38.7)	9,416 (49.4)	$\chi^2 = 64.95$	<0.001
Female	1,417 (61.3)	11,223 (50.6)		
Age				
18–34	91 (4.8)	6,594 (33.9)	$\chi^2 = 377.38$	<0.001
35–64	1,203 (59.7)	10,898 (53.4)		
65+	882 (35.6)	3,147 (12.6)		
Ethnicity				
Caucasian	1,456 (76.9)	12,141 (68.3)	$\chi^2 = 35.89$	<0.001
African American	398 (12.3)	3,247 (11.7)		
Hispanic	257 (8.3)	3,902 (14.1)		
Asian	36 (1.2)	1,177 (5.0)		
Other	29 (1.3)	172 (0.9)		
Employment type				
Working	549 (29.2)	13,312 (66.4)	$\chi^2 = 281.55$	<0.001
Looking for work	46 (2.0)	602 (2.9)		
Not working	1,581 (68.8)	6,692 (30.7)		
Education				
Less than HS diploma	568 (22.7)	3,473 (14.6)	$\chi^2 = 34.14$	<0.001
HS diploma/GED	662 (31.7)	5,682 (28.6)		
More than HS diploma	927 (45.6)	11,257 (56.8)		
Marital status				
Married/living with partner	994 (62.0)	10,877 (63.1)	$\chi^2 = 196.02$	<0.001
Divorced/separated/widowed	965 (30.9)	4,663 (14.8)		
Never married	207 (7.1)	4,985 (22.1)		
Frequently depressed (12 months)				
Yes	716 (32.7)	1,927 (8.6)	$\chi^2 = 298.17$	<0.001
No	1,454 (67.3)	18,684 (91.4)		
Frequently anxious (12 months)				
Yes	622 (29.4)	1,920 (9.0)	$\chi^2 = 197.19$	<0.001
No	1,547 (70.6)	18,694 (91.0)		
Smoking status				
Never	970 (43.5)	12,339 (60)	$\chi^2 = 75.56$	<0.001
Former	683 (33.2)	4,079 (20.2)		
Current (total)	469 (23)	3,799 (19.5)		
Light/moderate	252 (11.7)	2,550 (12.7)		
Heavy	217 (11.3)	1,249 (6.8)		
Average # cigs per day	17	13.4	$t = 5.33$	<0.001
Age of smoking regularly (years)	17.5	17.6	$t = -0.29$	0.770
Average hours of sleep per night				
<6	325 (16.2)	1,391 (6.5)	$\chi^2 = 66.40$	<0.001
6–9	1,607 (76.8)	18,083 (90.6)		
>9	158 (7)	632 (2.9)		
Regular insomnia (12 months)				
Yes	998 (47.2)	3,274 (15.2)	$\chi^2 = 343.03$	<0.001
No	1,174 (52.8)	17,344 (84.8)		
Regular excessive daytime sleepiness				
Yes	597 (28.9)	1,717 (8.2)	$\chi^2 = 222.85$	<0.001
No	1,573 (71.1)	18,900 (91.8)		

Table 2 Comparisons between smokers and nonsmokers with a chronic rheumatic condition on demographic characteristics

Variable	Current smoker		X^2	<i>P</i>
	Yes (<i>n</i> %)	No (<i>n</i> %)		
Gender				
Male	209 (44.9)	534 (36.6)	5.99	0.015
Female	270 (55.1)	1,119 (63.4)		
Age				
18–34	37 (9.0)	52 (3.4)	50.29	<0.001
35–64	352 (78.1)	826 (54.1)		
65+	90 (12.9)	775 (42.6)		
Ethnicity				
Caucasian	324 (78.9)	1,100 (76.1)	2.04	0.089
African American	101 (12.6)	289 (12.3)		
Hispanic	38 (5.6)	218 (9.3)		
Asian	5 (0.7)	28 (1.2)		
Other	11 (2.2)	18 (1.1)		
Employment type				
Working	123 (31.8)	414 (28.3)	5.43	0.005
Looking for work	22 (4.0)	23 (1.3)		
Not working	334 (64.3)	1,216 (70.4)		
Education				
Less than HS diploma	135 (25.6)	425 (21.9)	4.89	0.008
HS diploma/GED	166 (36.4)	488 (30.6)		
More than HS diploma	172 (37.9)	730 (47.6)		
Marital status				
Married/living with partner	182 (57.3)	792 (63.5)	1.88	0.155
Divorced/separated/widowed	238 (34.0)	144 (6.5)		
Never married	56 (8.8)	711 (30.0)		
Frequently depressed (12 months)				
Yes	225 (46.1)	475 (28.7)	34.59	<0.001
No	253 (53.9)	1,175 (71.3)		
Frequently anxious (12 months)				
Yes	197 (42.7)	410 (25.4)	26.96	<0.001
No	280 (57.3)	1,240 (74.6)		

hours of sleep per night or excessive daytime sleepiness, there was a significant relationship for frequent insomnia, with 68.7 % of heavy smokers endorsing this problem compared to 54.2 % of other smokers.

Discussion

Given the individual associations and negative outcomes of cigarette smoking and poor sleep on individuals with chronic rheumatic conditions, the purpose of this study was

to examine the relationships and possible interactive or additive effects of these variables in a nationally-representative health survey.

Consistent with previous research, we found that individuals with a chronic rheumatic condition were significantly more likely to smoke cigarettes compared to those without a diagnosis. Furthermore, those individuals with a chronic rheumatic condition endorsed smoking an average of 17 cigarettes per day as compared to 13.4 for those without a chronic rheumatic condition. These findings are in line with population estimates of smoking (16.8 cpd; CDC, 2005). While increased rates of cigarette smoking have been demonstrated in individuals with musculoskeletal and connective tissue disorders, the directionality and underlying mechanisms driving this relationship are unclear. For example, some studies support the notion that cigarette smoking may contribute to the onset of a number of chronic pain conditions (Feldman et al., 1999; Battie et al., 1991). Conversely, there is also evidence to suggest that many individuals with pain may use cigarette smoking as a coping mechanism (Ditre & Brandon, 2008). One study looking at smoking behavior in back pain patients found that 57 % of smokers reported an increased desire to smoke when they were in pain, despite the fact that the majority of these individuals (91 %) did not believe that smoking ultimately influenced their pain level (Jamison et al., 1991). Data on the physiological effects of smoking on pain have been mixed, as some studies found an antinociceptive effect of nicotine on pain (Fertig et al., 1986; Han et al., 2005; Jamner et al., 1998) and others found no evidence of decreased sensitivity to pain processing associated with cigarette use (Knott, 1990; Sult & Moss, 1986; Waller et al., 1983).

We found that individuals with a chronic rheumatic condition endorsed poorer sleep quality across all domains compared to individuals without a diagnosis. With respect to number of hours of sleep per night, those with a chronic rheumatic condition were almost twice as likely (OR = 1.98) to endorse being a short sleeper (i.e., <6 h of sleep per night), suggesting that these individuals are at a higher risk for not getting an adequate amount of rest each night. On a related note, we found that individuals with a chronic rheumatic condition endorsed significantly more insomnia (OR = 2.4) and excessive daytime sleepiness (OR = 2.6) than those without a chronic rheumatic condition. These findings are consistent with previous research which has found diminished sleep quality in individuals with chronic pain. Depending upon the nature of the source of pain, a number of hypotheses may help explain this association. However, one possibility that has grown out of basic research is that chronic long term pain may lead to functional changes in an area of the brainstem (raphe magnus) that is responsible for modulating pain during

Table 3 Logistic regression of smoking, chronic rheumatic condition, and affective variables on sleep characteristics

Variable	Average hours of sleep per night			Regular insomnia (12 months)			Daytime sleepiness (12 months)		
	>6 vs. ≤6			Yes vs. No			Yes vs. No		
	OR	CI	P	OR	CI	P	OR	CI	P
Smoking status									
Current	1.58	1.34–1.86	0.000	1.35	1.20–1.53	0.000	1.09	0.94–1.28	0.251
Never/former	1.00			1.00			1.00		
Diagnosis									
Chronic rheumatic condition	1.98	1.60–2.45	0.000	2.44	2.09–2.86	0.000	2.46	2.05–2.96	0.000
No chronic rheumatic condition	1.00			1.00			1.00		
Smoking diagnosis^a									
Yes/Yes	1.07	0.68–1.69	0.768	1.36	1.00–1.85	0.0517	1.08	0.71–1.62	0.724
Frequently depressed (12 months)									
Yes	2.32	1.92–2.81	0.000	3.69	3.23–4.21	0.000	3.96	3.32–4.72	0.000
No	1.00			1.00			1.00		
Frequently anxious (12 months)									
Yes	1.68	1.39–2.03	0.000	3.75	3.28–4.29	0.000	2.96	2.50–3.50	0.000
No	1.00			1.00			1.00		

^a Controlling for age, gender, ethnicity, education, employment, marital status, depression and anxiety

Table 4 Comparisons between current smokers and never smokers with a chronic rheumatic condition on sleep characteristics

Variable	Smoking status		X ²	P
	Current (n %)	Never (n %)		
Average hours of sleep per night				
<6	106 (25.4)	142 (15.2)	4.85	0.008
6–9	331 (69.2)	745 (79.8)		
>9	28 (5.4)	63 (5.0)		
Frequent insomnia (12 months)				
Yes	282 (61.1)	389 (40.9)	37.54	<0.001
No	196 (38.9)	581 (59.1)		
Excessive daytime sleepiness				
Yes	169 (38.8)	213 (21.7)	25.24	<0.001
No	308 (61.2)	756 (78.3)		

sleep (Foo & Mason, 2003). It is also possible that certain medication used to treat pain conditions, such as opioids, steroids, and nonsteroidal anti-inflammatory drugs may influence sleep architecture (Lamberg, 1999).

One of the goals of this study was to examine the relationship between the presence of a chronic rheumatic condition and smoking on sleep quality. We found that those with a chronic rheumatic condition were significantly more likely to endorse shorter amounts of sleep, frequent insomnia, and excessive daytime sleepiness. However, we

Table 5 Comparisons between heavy smokers and light/moderate smokers with chronic rheumatic conditions on sleep characteristics

Variable	Smoking status		X ²	P
	Heavy smoker (n %)	Light/moderate smoker (n %)		
Average hours of sleep per night				
<6	53 (25.2)	50 (25.6)	0.04	0.960
6–9	146 (69.7)	182 (68.6)		
>9	14 (5.1)	14 (5.8)		
Frequent insomnia (12 months)				
Yes	145 (68.7)	132 (54.2)	3.88	0.050
No	72 (31.3)	120 (45.8)		
Excessive daytime sleepiness				
Yes	89 (45.1)	78 (33.4)	2.51	0.114
No	127 (54.9)	174 (66.6)		

did not find an interaction between the presence of a diagnosis of a chronic rheumatic condition and smoking status on sleep outcomes. This suggests that the increased rates of smoking and sleeping difficulties in individuals with a chronic rheumatic condition are unique and additive.

One of the novel components of this study was examination of the relationship between smoking and sleep in individuals with a chronic rheumatic condition.

Specifically, of those individuals with a chronic rheumatic condition, we found that those who were current smokers were significantly more likely to be short sleepers and experience frequent insomnia and daytime sleepiness compared to both nonsmokers with a chronic rheumatic condition and smokers without a chronic rheumatic condition. These findings are consistent with another study that found that smokers with fibromyalgia were more likely to report feeling fatigued and awaking unrefreshed on the Fibromyalgia Impact Questionnaire (FIQ) compared to nonsmokers (Weingarten et al., 2009). Conversely, Fishbain et al. (2007) did not find a difference on a measure of fatigue between smokers and nonsmokers with lower back pain. However, it is important to note that this study did not examine sleeping characteristics specifically.

In order to assess for a dose response relationship, we further categorized current smokers with a chronic rheumatic condition into heavy (i.e., ≥ 20 cpd) and moderate/light (< 20 cpd) smokers. While we found no between group differences on the average hours of sleep per night, heavy smokers were significantly more likely to report insomnia and showed slightly elevated reports of excessive daytime sleepiness compared to the light/moderate smokers. While this dose response relationship has been documented with respect to heavy smokers and number of pain locations and intensity (Ulrich et al., 2006), to the best of our knowledge this is the first study to demonstrate that the number of cigarettes consumed is significantly associated with insomnia and sleep quality in individuals with a chronic rheumatic condition typically associated with pain.

Finally, we found a relationship between mood and the presence of a chronic rheumatic condition such that those with a diagnosis were significantly more likely to endorse current feelings of depression (32.7 vs. 8.6 %) and/or anxiety (29.4 vs. 9 %). A number of studies have demonstrated individual associations between mood disorders, smoking (Breslau et al., 1993; Weingarten et al., 2009) and sleep (Blair et al., 2003; Castro & Daltro, 2009; Goodrich et al., 1998) in individuals with a chronic pain condition. However, in this study the relationship between smoking and sleep in individuals with a chronic rheumatic condition persisted even after controlling for current feelings of depression and anxiety, suggesting that these behaviors contribute their own unique variance and cannot be accounted for solely by comorbid affective symptoms.

The use of cross sectional survey data has a number of inherent limitations which should be noted. First, our sample consisted of individuals who were defined as having a chronic rheumatic condition as evidenced by the presence of a diagnosis of a rheumatological disorder and accompanying functional impairment. While we believe that this sample likely represents a patient population that typically experiences chronic pain, we had no way of

assessing whether or not these individuals indeed experience chronic pain, and if so, at what level of severity. Therefore, future studies using clinical samples and more precise measures of chronic pain are warranted. On a related note, the controls in this study were all respondents who did not meet criteria for the chronic rheumatic condition group. It is likely that a number of these individuals also have illnesses or conditions which could cause pain and related impairments. As such, future inquiries should include a clearly defined pain free comparison group.

Second, due to methodological limitations of the survey instrument, this study focused specifically on individuals with a chronic rheumatic condition as opposed to using a more broad definition of chronic pain. While epidemiological surveys have found arthritis and rheumatism to be among the most common sources of chronic pain (Clark, 2002; Elliott et al., 1999), it is possible that there are factors unique to these conditions that may limit generalizability to other types of chronic pain conditions.

Smoking and sleep related variables were assessed via single-item self-report which is subject to a number of biases and may not accurately capture the true prevalence of these behaviors. With respect to smoking, there is some evidence to suggest that self-reports may offer an underestimation of true smoking behavior when compared to cotinine levels (Gorber et al., 2009). Moreover, discrepancies have also been found in self-report measures of sleep when compared to more objective diagnostic tools (Espit et al., 1989; Landis et al., 2003; Palermo et al., 2007). However, it must be noted that these differences tend to be small and are more likely to be a factor when collecting more detailed sleep information (e.g., sleep latency) as opposed to the general questions asked in this study. While the nature of this study precluded the use of more objective measures of smoking (e.g., cotinine, Time-Line Follow-Back (TLFB) calendar) and sleep (e.g., actigraphy, polysomnography) additional studies using smaller samples may be able to employ such methods to obtain more precise estimates and gain a better understanding of the specific relationships between these variables.

Finally, the use of a cross sectional design did not allow for examination of temporal order, and as such it was impossible to determine the directionality of the relationship between the presence of a chronic rheumatic condition, smoking, and sleep. Future studies employing prospective and longitudinal designs will be useful to help tease apart issues of causality.

Despite these limitations, the current study offers an important first step in understanding the additive relationship between cigarette smoking and sleep in individuals with a chronic rheumatic condition typically associated with pain. These findings remained significant even after controlling for a number of potential covariates suggesting a unique relationship between smoking and sleep in

individuals with a chronic rheumatic condition that does not appear to be accounted for by other commonly identified factors. Moreover, while this study focused specifically on rheumatic conditions, it is plausible that these findings would generalize to other types of chronic pain conditions. These findings point towards the importance of better understanding the relationship between smoking and sleep in chronic pain populations.

References

- Anch, A. M., Lue, F. A., MacLean, A. W., & Moldofsky, H. (1991). Sleep physiology and psychological aspects of the fibrositis (fibromyalgia) syndrome. *Canadian Journal of Psychology*, *45*, 179–184.
- Andersson, H., Ejlertsson, G., & Leden, I. (1998). Widespread musculoskeletal chronic pain associated with smoking. An epidemiological study in a general rural population. *Scandinavian Journal of Rehabilitative Medicine*, *30*, 185–191.
- Battie, M. C., Videman, T., Gill, K., Moneta, G. B., Nyman, R., Kaprio, J., et al. (1991). Smoking and lumbar intervertebral disc degeneration: an MRI study of identical twins. *Spine*, *16*, 1015–1021.
- Belt, N. K., Kronholm, E., & Kauppi, M. J. (2009). Sleep problems in fibromyalgia and rheumatoid arthritis compared with the general population. *Clinical and Experimental Rheumatology*, *27*, 35–41.
- Biering-Sorensen, F., & Thomsen, C. (1986). Medical, social and occupational history as risk indicators for low-back trouble in a general population. *Spine*, *11*, 720–725.
- Blair, M. J., Robinson, R. L., Katon, W., & Kroenke, K. (2003). Depression and pain comorbidity: A literature review. *Archives of Internal Medicine*, *163*, 2433–2445.
- Brage, S., & Bjerkedal, T. (1996). Musculoskeletal pain and smoking in Norway. *Journal of Epidemiology and Community Health*, *50*, 166–169.
- Branco, J., Atalaia, A., & Paivat, T. (1994). Sleep cycles and alpha-delta sleep in fibromyalgia syndrome. *Journal of Rheumatology*, *21*, 1113–1117.
- Breslau, N., Kilbey, M. M., & Andreski, P. (1993). Nicotine dependence and major depression: New evidence from a prospective evaluation. *Archives of General Psychiatry*, *50*, 31–35.
- Busse, D. J., Reynolds, C. F., Monk, T. H., Berman, S. R., & Kupfer, D. J. (1989). The Pittsburgh Sleep Quality Index: A new instrument for psychiatric practice and research. *Psychiatry Research*, *28*, 193–213.
- Castro, M. M., & Daltro, C. (2009). Sleep patterns and symptoms of anxiety and depression in patients with chronic pain. *Arquivos de Neuro-Psiquiatria*, *67*, 25–28.
- Clark, D. J. (2002). Chronic pain prevalence and analgesic prescribing in a general medical population. *Journal of Pain Symptom Management*, *23*, 131–137.
- Conway, S. G., Roizenblatt, S. S., Palombini, L., Castro, L. S., Bittencourt, L. R., Silva, R. S., et al. (2008). Effect of smoking habits on sleep. *Brazilian Journal of Medical and Biological Research*, *41*, 722–727.
- Ditre, J. W., & Brandon, T. H. (2008). Pain as a motivator of smoking: Effects of pain induction on smoking urge and behavior. *Journal of Abnormal Psychology*, *117*, 467–472.
- Edwards, R. R., Almeida, D. M., Klick, B., Haythornthwaite, J. A., & Smith, M. T. (2008). Duration of sleep contributes to next-day pain report in the general population. *Pain*, *137*, 202–207.
- Elliott, A. M., Smith, B. H., Penny, K. I., Smith, W. C., & Chambers, W. A. (1999). The epidemiology of chronic pain in the community. *Lancet*, *354*, 1248–1252.
- Eriksen, W. B., Brage, S., & Bruusgaard, D. (1997). Does smoking aggravate musculoskeletal pain? *Scandinavian Journal of Rheumatology*, *26*, 49–54.
- Espit, C. A., Lindsay, W. R., & Espie, L. C. (1989). Use of the Sleep Assessment Device to validate insomniacs' self-report of sleep pattern. *Journal of Psychopathology and Behavioral Assessment*, *11*, 71–79.
- Feldman, D. E., Rossignol, M., Shrier, I., & Abenham, L. (1999). Smoking: A risk factor for development of low back pain in adolescents. *Spine*, *24*, 2492–2496.
- Fertig, J. B., Pomerleau, O. F., & Sanders, B. (1986). Nicotine-produced antinociception in minimally deprived smokers and ex-smokers. *Addictive Behaviors*, *11*, 239–248.
- Fishbain, D. A., Lewis, J. E., Cole, B., Cutler, R. B., Rosomoff, H. L., & Rosomoff, R. S. (2007). Variables associated with current smoking status in chronic pain patients. *Pain Medicine*, *8*, 301–311.
- Foo, H., & Mason, P. (2003). Brainstem modulation of pain during sleep and waking. *Sleep Medicine Review*, *7*, 145–154.
- Goldberg, M. S., Scott, S. C., & Mayo, N. E. (2000). A review of the association between cigarette smoking and the development of non-specific back pain and related outcomes. *Spine*, *25*, 995–1014.
- Goodrich, S. M., Cogan, D. P., Randolph, P. P., & Racz, G. (1998). The prediction of pain using measures of sleep quality. *Pain Digest*, *8*, 23–25.
- Gorber, S. C., Schofield-Hurwitz, S., Hardt, J., Levasseur, G., & Tremblay, M. (2009). The accuracy of self-reported smoking: A systematic review of the relationship between self-reported and cotinine-assessed smoking status. *Nicotine & Tobacco Research*, *11*, 12–24.
- Han, K. J., Choi, S. S., Lee, J. Y., Lee, H. K., Shim, E. J., Kwon, M. S., et al. (2005). Antinociceptive effect of nicotine in various pain models in the mouse. *Archives of Pharmacology Research*, *28*, 209–215.
- Hirsch, M., Carlander, B., Verge, M., Tafti, M., Anaya, J. M., Billiard, M., et al. (1994). Objective and subjective sleep disturbances in patients with rheumatoid arthritis. A reappraisal. *Arthritis and Rheumatism*, *37*, 41–49.
- Jakobsson, U. (2008). Tobacco use in relation to chronic pain: Results from a Swedish population survey. *Pain Medicine*, *9*, 1091–1097.
- Jamison, R. N., Stetson, B. A., & Parris, W. C. V. (1991). The relationship between cigarette smoking and chronic low back pain. *Addictive Behaviors*, *16*, 103–110.
- Janner, L. D., Girdler, S. S., Shapiro, D., & Jarvik, M. E. (1998). Pain inhibition, nicotine, and gender. *Experimental Clinical Psychopharmacology*, *6*, 96–106.
- Knott, V. J. (1990). Effects of cigarette smoking on subjective and brain evoked responses to electrical pain stimulation. *Pharmacology Biochemistry and Behavior*, *35*, 341–346.
- Lamberg, L. (1999). Chronic pain linked with poor sleep; exploration of causes and treatment. *Journal of the American Medical Association*, *281*, 691–692.
- Landis, C. A., Frey, C. A., Lentz, M. J., Rothermel, J., Buchwald, D., & Shaver, J. L. F. (2003). Self-reported sleep quality and fatigue correlates with actigraphy in midlife women with fibromyalgia. *Nursing Research*, *52*, 140–147.
- Leino-Arjas, P. (1998). Smoking and musculoskeletal disorders in the metal industry: A prospective study. *Occupational and Environmental Medicine*, *55*, 828–833.
- Lexcen, F. J., & Hicks, R. A. (1993). Does cigarette smoking increase sleep problems? *Perception & Motor Skills*, *77*, 16–18.

- Marty, M., Rozenberg, S., Duplan, B., Thomas, P., Duquesnoy, B., & Allaert, F. (2008). Quality of sleep in patients with chronic low back pain: A case-control study. *European Spine Journal*, *17*, 839–844.
- McCracken, L. M., & Iverson, G. L. (2002). Disrupted sleep patterns and daily functioning in patients with chronic pain. *Pain Research & Management*, *7*, 75–79.
- Mitchell, M. D., Mannino, D. M., Steinke, D. T., Kryscio, R. J., Bush, H. M., & Crofford, L. J. (2011). Association of smoking and chronic pain syndromes in Kentucky women. *The Journal of Pain*, *12*, 892–899.
- National Center for Health Statistics. (2008). *National Health Interview Survey, 2007 description (machine readable data file and documentation)*. Hyattsville: Public Health Services, Centers for Disease Control and Prevention, US Department of Health and Human Services.
- Naughton, F., Ashworth, P., & Skevington, S. M. (2007). Does sleep quality predict pain-related disability in chronic pain patients? The mediating roles of depression and pain severity. *Pain*, *127*, 243–252.
- Okura, K., Lavigne, G. J., Huynh, N., Manzini, C., Fillipini, D., & Montplaisir, J. Y. (2008). Comparison of sleep variables between chronic widespread musculoskeletal pain, insomnia, periodic leg movements syndrome and control subjects in a clinical sleep medicine practice. *Sleep Medicine*, *9*, 352–361.
- Palermo, T. M., Fonareva, I., & Janosy, N. R. (2008). Sleep quality and efficiency in adolescents with chronic pain: Relationship with activity limitations and health-related quality of life. *Behavioral Sleep Medicine*, *6*, 234–250.
- Palermo, T. M., Toliver-Sokol, M., Fonareva, I., Koh, I., & Titolo, J. L. (2007). Objective and subjective assessment of sleep in adolescents with chronic pain compared to healthy adolescents. *Clinical Journal of Pain*, *23*, 812–820.
- Palmer, K. T., Syddall, H., & Cooper, C. D. C. (2003). Smoking and musculoskeletal disorders: Findings from a British national survey. *Annals of Rheumatic Diseases*, *62*, 33–36.
- Pamuk, O. N., Dönmez, S., & Cakir, N. (2009). The frequency of smoking in fibromyalgia patients and its association with symptoms. *Rheumatology International*, *29*, 1311–1314.
- Phillips, B. A., & Danner, F. J. (1995). Cigarette smoking and sleep disturbance. *Archives of Internal Medicine*, *155*, 734–737.
- Pilowsky, I., Crettenden, I., & Townley, M. (1985). Sleep disturbance in pain clinic patients. *Pain*, *23*, 27–33.
- Scott, S. C., Goldberg, M. S., Mayo, N. E., Stock, S. R., & Poitras, B. (1999). The association between cigarette smoking and back pain in adults. *Spine*, *24*, 1090–1098.
- Soldatos, C. R., Kales, J. D., Scharf, M. B., Bixler, E. O., & Kales, A. (1980). Cigarette smoking associated with sleep difficulty. *Science*, *207*, 551–553.
- Strine, T. W., Okoro, C. A., Chapman, D. P., Balluz, L. S., Ford, E. S., Ajani, U. A., et al. (2005). Health-related quality of life and health risk behaviors among smokers. *American Journal of Preventive Medicine*, *28*, 182–187.
- Sult, S. C., & Moss, R. A. (1986). The effects of cigarette smoking on the perception of electrical stimulation and cold pressor pain. *Addictive Behaviors*, *11*, 447–451.
- Tang, N. K., Wright, K. J., & Salkovskis, P. M. (2007). Prevalence and correlates of clinical insomnia co-occurring with chronic back pain. *Journal of Sleep Research*, *16*, 85–95.
- Theadom, A., Cropley, M., & Humphrey, K. L. (2007). Exploring the role of sleep and coping in quality of life in fibromyalgia. *Journal of Psychosomatic Research*, *62*, 145–151.
- Ulrich, J., Hanke, M., Meyer, C., Völzke, H., Baumeister, S. E., & Alte, D. (2006). Tobacco smoking in relation to pain in a national general population survey. *Preventive Medicine*, *43*, 477–481.
- US Centers for Disease Control and Prevention. (2005). Cigarette smoking among adults—United States, 2004. *Morbidity and Mortality Weekly Report*, *54*, 1121–1124.
- Vogt, M. T., Hanscom, B., Lauerma, W. C., & Kang, J. D. (2002). Influence of smoking on the health status of spinal patients: The National Spine Network Database. *Spine*, *27*, 313–319.
- Waller, D., Schalling, D., Levander, S., & Edman, G. (1983). Smoking, pain tolerance, and physiological activation. *Psychopharmacology (Berlin)*, *79*, 193–198.
- Weingarten, T. N., Podduturu, V. R., Hooten, W. M., Thompson, J. M., Luedtke, C. A., & Oh, T. H. (2009). Impact of tobacco use in patients presenting to a multidisciplinary outpatient treatment program for fibromyalgia. *Clinical Journal of Pain*, *25*, 39–43.
- Wetter, D. W., & Young, T. B. (1994). The relation between cigarette smoking and sleep disturbance. *Preventive Medicine*, *23*, 328–334.
- Wetter, D. W., Young, T. B., & Bidwell, T. R. (1994). Smoking as a risk factor for sleep-disordered breathing. *Archives of Internal Medicine*, *154*, 2219–2224.
- Yunus, M. B., Arslan, S., & Aldag, J. C. (2002). Relationship between fibromyalgia features and smoking. *Scandinavian Journal of Rehabilitative Medicine*, *31*, 301–305.
- Zhang, L., Samet, J., Caffo, B., et al. (2006). Cigarette smoking and nocturnal sleep architecture. *American Journal of Epidemiology*, *164*, 529–537.
- Zhang, L., Samet, J., Caffo, B., et al. (2008). Power spectral analysis of EEG activity during sleep in cigarette smokers. *Chest*, *133*, 427–432.