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ORIGINAL ARTICLE

Dysfunctional sleep in persons with spinal cord injuries and disorders

SL LaVela[1,2], SP Burns[3], B Goldstein[3], S Miskevics[1], B Smith[1,4] and FM Weaver[1,4]

Study design: Cross-sectional survey of veterans with spinal cord injuries and disorders (SCI/D).
Objectives: To describe sleep dysfunction (independent of sleep apnea) in persons with traumatic and non-traumatic SCI/D, and to examine characteristics and health outcomes independently associated with sleep dysfunction unrelated to sleep apnea.
Setting: Seven Veterans Affairs SCI care facilities in the United States.
Methods: Mailed cross-sectional survey with follow-up calls completed by end of 2008. Bivariate analyses to compare measures outcomes in persons with SCI/D who were dysfunctional sleepers vs those who were not. Multivariate logistic regression used to identify variables independently associated with dysfunctional sleep in veterans with SCI/D.
Results: Overall, 49% of the sample had sleep dysfunction unrelated to sleep apnea. In this subgroup, bivariate analyses showed that a greater proportion of dysfunctional sleepers than non-dysfunctional sleepers were current smokers, had problems with drinking alcohol, hypertension, asthma, chronic obstructive pulmonary disease (COPD) and problematic weight gain. Variables independently associated with higher odds of dysfunctional sleep included white race, being a current smoker, problems with drinking alcohol, asthma, COPD and problematic weight gain.
Conclusion: Consistent with epidemiological evidence for the general population, we found significant associations of sleep dysfunction with weight gain, smoking, alcohol misuse and select chronic conditions (COPD, asthma). Sustained sleep dysfunction may contribute to health deterioration and mortality, highlighting the need to address the high prevalence of sleep dysfunction (independent of sleep apnea) in persons with SCI/D. In particular, efforts aimed at modifying problematic weight gain, alcohol misuse and smoking are warranted in this cohort to improve sleep.
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Keywords: sleep dysfunction; spinal cord injury; prevalence; health behaviors; comorbidities

INTRODUCTION

An estimated 232 000–316 000 individuals in the United States are living with a spinal cord injury (SCI).[1] About 42 000 veterans with SCI and disorders (SCI/D) are eligible for health care from the Department of Veterans Affairs, making it the single largest network of care for persons with SCI/D in the nation.[2] Individuals with SCI/D are often at increased risk for numerous health concerns, among which is dysfunctional sleep.

Numerous epidemiologic studies have demonstrated that dysfunctional sleep is associated with increased risk of mortality and comorbidities such as diabetes, obesity and hypertension.[3] Dysfunctional sleep is known to adversely affect the quality of life in individuals with a variety of chronic conditions, including lung cancer, Parkinson's disease, renal disease, endocrine diseases, multiple sclerosis, cardiovascular diseases, depression, anxiety disorder and mental health conditions.[4] Individuals with chronic illnesses, including heart disease, diabetes, asthma or depression, who have dysfunctional sleep have been found to have significantly worse quality of life compared with chronically ill persons without dysfunctional sleep.[5]

Literature suggests that the presence of dysfunctional sleep may contribute to poor health outcomes in individuals with SCI/D over and above any effects of the SCI/D itself.[6] However, limited literature exists on dysfunctional sleep in SCI/D, except for the abundant literature on sleep apnea, which is common following SCI/D.[7–9] Biering-Sorensen *et al.*[10] examined self-reported sleep dysfunction in a Denmark cohort of persons with SCI compared with a normal population and reported some similarities (there were no differences in average hours/night of sleep) and some differences (for example, the SCI group snored more often, had more sleep apnea and had greater difficulty falling asleep); this study included sleep apnea-related sleep dysfunction and was limited to traumatic injuries. Jensen *et al.* [6] found that individuals with SCI had significantly worse overall dysfunctional sleep than both the general population and a chronically ill population. Their findings included dysfunctional sleep due to sleep apnea, but did not identify the extent to which sleep apnea contributed to the overall dysfunctional sleep estimates. It has been suggested that the degree of sleep dysfunction, including daytime sleepiness, is directly associated with the frequency of sleep arousals of all types, not just sleep apnea-related arousals alone.[11] As such, this study sought to describe sleep dysfunction independent of sleep apnea in persons with SCI/D with both traumatic and non-traumatic injuries, and to examine characteristics and health outcomes associated with sleep dysfunction unrelated to sleep apnea.

[1]Center for Management of Complex Chronic Care, Hines VA Hospital, Hines, IL, USA; [2]Institute for Healthcare Studies, Feinberg School of Medicine, Northwestern University, Chicago, IL, USA; [3]VA Puget Sound; Spinal Cord Injury Quality Enhancement Improvement Initiative, Seattle, WA, USA and [4]Program in Health Services Research, Stritch School of Medicine Loyola University, Maywood, IL, USA
Correspondence: Dr SL LaVela, Center for Management of Complex Chronic Care, 5000 S. 5th Avenue (151-H); Hines, IL 60141, USA.
E-mail: Sherri.LaVela@va.gov
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MATERIALS AND METHODS

Design

Cross-sectional survey.

Participants/setting

All veterans with SCI/D who received inpatient or outpatient care during a prior 12-month-time period at any of seven Veterans Affairs SCI care facilities in the United States were included in the sample. The sample included individuals diagnosed with traumatic and non-traumatic injuries, including: traumatic lesions of the spinal cord; intraspinal, nonmalignant neoplasms, resulting in neurologic deficit; vascular insults of a thromboembolic, hemorrhagic or ischemic nature; cauda equina syndrome producing neurologic deficit; inflammatory disease of the spine, spinal cord or cauda equina resulting in nonprogressive neurologic deficit; demyelinating disease of the spinal cord; and unstable traumatic lesions of the spinal column. Individuals with multiple sclerosis (MS) were excluded from this study because they may have unique characteristics related to their disease that could impact sleep (for example, sleep problems may be caused by the location of MS lesions in the brain), which is outside the scope of this study.

Data collection

Data were collected using a cross-sectional survey that was sent by mail along with a token incentive and a business reply return envelope. For veterans who did not respond to the mailed survey within 3 weeks, a postage paid/addressed postcard was mailed requesting that they either: (1) complete and send the survey or (2) opt out by checking a box indicating that they were not interested in further contact. If neither the survey nor the postcard was received within 3 weeks of mailing the postcard, a follow-up telephone call was placed to complete the survey over the phone. Survey distribution and follow-up calls were completed by the end of 2008.

Measures

Variables were self-reported and included: veteran demographic and injury characteristics (gender, race, education, age, living arrangement (alone vs not), marital status, injury level (paraplegia vs tetraplegia) and duration of injury; behaviors (drinking and smoking status); and health-care conditions/complications during the prior year (hypertension, high cholesterol, diabetes, asthma, chronic obstructive pulmonary disease (COPD), pressure ulcers and weight gain).

The main outcome measure, dysfunctional sleep, was self-reported as regularly experiencing 'trouble sleeping' or 'regular insomnia' during the prior year; this question matched that used by the Centers for Disease Control and Prevention in the National Health Interview Survey.[12] For analyses, the variable was dichotomized as 'dysfunctional sleep' or 'no dysfunctional sleep.' Individuals with sleep apnea (self-reported and cross-checked using the International Classification of Disease-9 codes in electronic medical records) were excluded from the analyses for this paper to focus on sleep dysfunction unrelated to sleep apnea (hereafter referred to as sleep dysfunction).

Statistical analyses

Descriptive statistics were used to present demographics, injury characteristics, health behaviors and health conditions/complications. A subset analysis was conducted to check for differences in participant demographic or injury characteristics or prevalence of conditions/complications between the sample used ($n=822$) and those that were excluded due to missing data ($n=98$, $<10\%$ of the overall sample). Bivariate analyses were used to compare measures in persons with SCI/D who were dysfunctional sleepers vs those who were not (χ^2 tests for the categorical variables and t-tests for continuous variables). A multivariate logistic regression model was used to generate odds ratios (ORs) and 95% confidence intervals (CIs) to identify variables independently associated with dysfunctional sleep in veterans with SCI/D. Several variables (demographic and injury characteristics, behaviors and complications/conditions) were considered for inclusion in the model based on their association with the dependent variable and impact on other variables in the model. Collinearity was assessed for variables for inclusion in the model to attain the model with the best fit (duration of injury and chronological age were highly collinear; duration of injury was used because it created a better fit model through fit testing using the likelihood ratio test). Covariates in the final model included: race, education, lives alone (vs not), duration of injury, current smoking, problematic alcohol use, and problems during the past year with hypertension, high cholesterol, diabetes, asthma, COPD and weight gain.

An α level of 0.05 was used to determine statistical significance. Statistical analyses were performed with SAS 9.1 (SAS Institute Inc., Cary, NC, USA) and the Stata Version 10 software (Stata Corporation, College Station, TX, USA).

This study was approved by the Institutional Review Boards at each of the participating Veterans Affairs facilities. The authors certify that all applicable institutional and governmental regulations concerning the ethical use of human volunteers were followed during the course of this research.

RESULTS

Surveys were mailed to 5980 veterans across the seven study sites. The denominator was adjusted to 4911, as 62 had multiple sclerosis, 928 surveys were undeliverable and 79 veterans on the initial mailing list had died. Completed surveys were available for 1257 veterans (26% response rate) and 337 with sleep apnea were excluded. Of the remaining 920 individuals in the sample, analyses were conducted on the sample of 822 with complete data for all variables (a cross check of the International Classification of Disease-9 codes showed that only 1 of the 822 subjects had received a diagnosis of unspecified sleep apnea during the study timeframe). In this sample, 64% of participants had paraplegia, the mean age was 60 years (s.d. = 12.17), and the mean duration of injury was 20 years (s.d. = 14.21).

There were no statistically significant differences in the sample included compared with those excluded due to missing data for gender, race, education, age >50 years, living arrangement, marital status, level of injury, duration of injury, drinking behavior or smoking behavior, nor any of the health-care conditions/complications.

Overall, 49% of the sample had sleep dysfunction. With the exception of age (dysfunctional sleepers were younger, on average), the bivariate analyses did not show statistically significant differences in demographic or injury characteristics in veterans with SCI/D who were dysfunctional sleepers vs non-dysfunctional sleepers. A greater proportion of dysfunctional sleepers than non-dysfunctional sleepers were current smokers (30 vs 17%, $P=0.002$) and had problems with drinking alcohol (4 vs 1%, $P<0.0001$). In terms of health-care conditions/complications, a significantly greater proportion of dysfunctional sleepers reported hypertension, asthma, COPD and problematic weight gain than non-dysfunctional sleepers. Bivariate comparisons are shown in Table 1.

Multivariate analyses findings are shown in Table 2. Variables independently associated with dysfunctional sleep in veterans with SCI/D included being white (OR = 1.43, 95% CI 1.01–2.04, $P=0.04$), being a current smoker (OR = 1.91, 95% CI 1.35–2.71, $P=0.0003$) and having problems with drinking alcohol (OR = 4.19, 95% CI 1.17–14.99, $P=0.03$). Odds of being a dysfunctional sleeper were higher in those with asthma (OR = 2.37, 95% CI 1.11–5.10, $P=0.03$), COPD (OR = 1.93, 1.01–3.72, $P=0.05$) and problematic weight gain (OR = 2.06, 95% CI 1.45–2.93, $P<0.0001$).

DISCUSSION

This study indicates a high prevalence of dysfunctional sleep in veterans with SCI/D. In contrast to prior studies of the prevalence of sleep dysfunction, our analysis excluded those with a history of sleep apnea. This is important because in both acute and chronic SCI/D, sleep apnea is known to have a high prevalence, ranging from 40 to 53% of individuals with chronic SCI/D[7,13] and reaching estimations as high as 69–75% in individuals with acute SCI/D;[14] and thus has

Table 1 Participant characteristics and conditions ($n=822$)

	Dysfunctional sleeper (n = 404) (%)	*Non-dysfunctional sleeper (n = 418) (%)*	P-*value*
Demographic characteristics			
Male	94.21	96.70	0.11
White	79.21	75.60	0.22
Some college/college graduate	70.05	67.94	0.51
Mean age (years)	58.64	60.37	0.05
Lives alone	28.47	27.51	0.76
Married	49.31	54.21	0.19
Injury characteristics			
Paraplegic level injury	62.25	66.13	0.28
Mean duration of injury (years)	19.71	20.99	0.20
Behaviors			
Problems with drinking alcohol	3.96	1.00	0.002[a]
Current smoker	29.95	17.46	<0.0001
Health-care conditions/complications			
Hypertension	44.80	37.32	0.03
High cholesterol	27.03	27.72	0.82
Diabetes	16.09	15.79	0.91
Asthma	6.44	2.63	0.009
COPD	8.66	3.59	0.002
Pressure ulcers	18.32	19.14	0.76
Problematic weight gain	30.45	17.22	<0.0001

Abbreviation: COPD, chronic obstructive pulmonary disease.
[a]Fisher's exact test was used due to the small number of observations.

Table 2 Factors associated with dysfunctional sleep in persons with SCI/D ($n=822$)

	OR	*95% CI*	P-*value*
Characteristics			
White (vs non-white)	1.43	1.01–2.04	0.04
Some college/college graduate (vs high school education or less)	1.15	0.84–1.58	0.38
Lives alone (vs does not live alone)	1.06	0.77–1.45	0.74
Duration of SCI/D (continuous)	0.99	0.98–1.006	0.40
Behaviors			
Current smoker (vs past or never)	1.91	1.35–2.71	0.0003
Problems with drinking alcohol in past year (vs no problems)	4.19	1.17–14.99	0.03
Health-care conditions/complications			
Hypertension	1.34	0.98–1.83	0.07
High cholesterol	0.88	0.62–1.23	0.45
Diabetes	0.96	0.64–1.44	0.84
Asthma	2.37	1.11–5.10	0.03
COPD	1.93	1.01–3.72	0.05
Problematic weight gain	2.06	1.45–2.93	<0.0001

Abbreviations: COPD, chronic obstructive pulmonary disease; CI, confidence interval; OR, odds ratio.

been implicated as a primary contributing factor to dysfunctional sleep in this population. After excluding those with a history of sleep apnea, we found a 49% prevalence of dysfunctional sleep, suggesting that dysfunctional sleep is highly problematic in SCI/D independent of sleep apnea. During the same time period as this study, the prevalence of dysfunctional sleep was 19% in the adult general population[12] (both prevalence estimates were based on the question using the wording from the National Health Interview Survey 2007/2008 asking: during the past 12 months have you regularly had insomnia or trouble sleeping).

Characteristics

White race was the only demographic factor independently associated with dysfunctional sleep in our sample. This finding is in contrast to the general population findings of poorer sleep quality in non-white populations.[15] Neurological level (tetraplegia vs paraplegia) was not associated with dysfunctional sleep, similar to findings by Biering-Sorenson.[10] As in the study by Jensen *et al.*[6] injury duration was not associated with poor sleep quality, but younger age was, as is seen in our cohort as well (dysfunctional sleepers in our study were younger).

Participants with SCI/D who were current smokers had an increased risk of dysfunctional sleep. In general, nicotine use has been linked with several facets of sleep dysfunction, including difficulty falling asleep, staying asleep, excessive fatigue during the day[16] and decreased nightly sleep duration.[17] The finding that problematic alcohol use was associated with dysfunctional sleep in persons with SCI/D (4× higher odds) is comparable to findings reported in the general population literature.[17] It is noteworthy, however, that the proportion of the SCI/D participants who self-reported problematic alcohol use was small.

Health conditions/complications

Both COPD and asthma were associated with dysfunctional sleep in our sample of individuals with SCI/D. Similar findings have been noted in studies of the neurologically intact population with COPD and asthma, in particular, less sleep efficiency, a lower total sleep time, difficulty initiating and maintaining sleep,[18] although these findings are often tied to sleep apnea.[19,20] As seen by our bivariate findings (and marginally significant in the multivariate model), hypertension has been found to be associated with dysfunctional sleep, including insomnia and shortened sleep duration.[21] Problematic weight gain was associated with higher odds of dysfunctional sleep in persons with SCI/D in this study, similar to associations in the general population.[22,23] It is noteworthy that sleep apnea has been found to be associated with disrupted and short sleep duration, and is linked to obesity and high rates of morbidity and mortality predominantly due to cardiovascular disease.[24] The exclusion of sleep apnea in our study, may explain why other conditions that are common cardiovascular risk predictors, such as high cholesterol and diabetes, were not significantly related to dysfunctional sleep.

Furthermore, there are a multitude of reasons that may contribute to sleep dysfunction in persons with SCI/D, which should be noted. For example, individuals with SCI/D may experience a reduced number of normal body shifts during sleep that may lead to discomfort and increased awakenings and may be taking a number of medications that disrupt circadian rhythm and the sleep–wake schedule, disturb rapid eye movement sleep and increase nightly arousals. In addition, lack of daytime movement, depression and pain

may contribute to sleep dysfunction in some individuals with SCI/D. Finally, abnormal upper-airway and chest-wall motor activity can affect breathing, which may disturb sleep. In fact, many of the variables associated with sleep dysfunction in this study are directly or indirectly related to respiratory factors. Thus, the exclusion of individuals with sleep apnea actually suggests that virtually any disorder related to breathing may impair sleep.

Limitations

This study relied on self-report of dysfunctional sleep. We were unable to validate responses with objective measures of sleep, such as polysomnogram or actigraphy. The response rate was low and may not be representative of the veteran SCI/D population. Our exclusion of subjects with sleep apnea relied on self-report and may not be accurate. However, we conducted a supplemental analysis of Veterans Affairs administrative data for subjects reporting no history of sleep apnea, and only 1 of the 822 subjects had received a diagnosis of sleep apnea. Individuals who have 'undiagnosed' sleep apnea or are unaware of having sleep apnea may be included in the sample, but it is likely that this was a minority of subjects and it is also likely that the severity would be less in those with undiagnosed sleep apnea.

Conclusion

This work provides valuable information about sleep in veterans with SCI/D. Consistent with epidemiological evidence for the general population, we found significant associations of sleep dysfunction with weight gain, smoking, alcohol misuse and select chronic conditions (COPD and asthma), even after excluding sleep apnea. Evidence suggests that sustained sleep dysfunction may trigger biological mechanisms that contribute to health deterioration and mortality.[25] Our findings indicate that sleep dysfunction occurs at a high prevalence in persons with SCI/D, which warrants efforts and strategies to improve sleep outcomes. We identified several risk factors associated with dysfunctional sleep in SCI/D, suggesting that efforts aimed at modifying problematic weight gain, alcohol misuse and smoking are warranted in this population to improve sleep.

DATA ARCHIVING

There were no data to deposit.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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