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Sleep Problems in Individuals With Spinal Cord Injury: Frequency and Age Effects

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Abstract

Objectives—The two objectives of this study were (a) to replicate the previous finding of more severe sleep difficulties in a sample of individuals with spinal cord injury (SCI) compared with normative samples, and (b) to examine the associations between aging variables (specifically, chronological age, duration of SCI, age at SCI onset) and the severity of sleep difficulties.

Design—Cross-sectional survey.

Research Method—A survey was administered to 620 individuals with SCI that included measures of demographic characteristics and sleep difficulties.

Results—The findings indicated that sleep problems are more common in individuals with SCI than in normative samples. In addition, younger participants in our sample reported more sleep problems than did older participants. Duration of SCI and age at onset, however, were not significantly associated with sleep difficulties.

Conclusion—The analyses used in this study provide a model for examining age effects using concurrent survey data that may be useful for other investigators interested in studying the associations between age-related variables and important health-related domains.

Keywords

spinal cord injury; sleep problems; aging; multiple regression

Sleep problems occur frequently in the general population (Hays & Stewart, 1992), and are even more common in individuals with spinal cord injury (SCI; Biering-Sorensen & Biering-Sorensen, 2001). Although some of the sleep difficulties reported by individuals with SCI are likely related to the high incidence of central sleep apnea that is very common in this population (Biering-Sorensen, Norup, Jacobsen, & Biering-Sorensen, 1995; Burns, Kapur, Yin, & Buhrer, 2001; Burns, Little, Hussey, Lyman, & Lakshminarayanan, 2000), aging is also independently associated with decreases in sleep quality and efficiency and may exacerbate sleep problems associated with SCI. For example, Mellinger and colleagues reported that the rate of serious insomnia in people aged 65 to 79 years was 25%, as compared with only 14% in individuals aged 18 to 34 years (Mellinger, Balter, & Uhlenhuth, 1985). Moreover, a number of physiological measures of sleep quality, such as total sleep time, sleep efficiency, percentage of slow-wave sleep, percentage of rapid eye movement (REM) sleep, and REM latency, have all been shown to decrease with age (Ohayon, Carskadon, Guilleminault, & Vitiello, 2004). Similarly, measures of sleep dysfunction, such as sleep latency, percentage of lighter stages of

sleep (stage 1 and stage 2 sleep), and wake after sleep onset all increase with age (Ohayon et al., 2004; Unruh et al., 2008). As a group, these findings suggest a linear (negative) relationship between age and sleep quality – that is, sleep quality tends to decrease as people get older.

Research in individuals with SCI suggests that the joints and organ systems of these individuals “age” faster than those of individuals without SCI. As a result, individuals with SCI tend to report more health problems, and at a younger age, than do nondisabled individuals (Bauman & Waters, 2004; Capoor & Stein, 2005). Another age-related variable, time since original SCI (i.e., duration of SCI), has shown important relationships to health in individuals with SCI. Specifically, even after controlling for chronological age, by the time an individual has lived with an SCI for 20 or more years, significant declines in functional capacity are known to occur (Capoor & Stein, 2005). Additionally, the *rate* of decline increases with increasing age (Capoor & Stein, 2005). These findings suggest a curvilinear (quadratic) relationship between age and health problems in individuals with SCI. To the extent that these health problems include sleep difficulties, the findings would predict that increases in sleep problems may not begin to occur until a person reaches a certain age, but that once sleep problems begin, they may become more serious at an accelerated rate.

The evidence that (1) sleep problems increase with age, (2) sleep problems are more frequent in individuals with SCI than in otherwise healthy individuals, and (3) persons with SCI show evidence of earlier physical decline (“aging”) than nondisabled individuals, suggests the possibility that middle-age and elderly individuals with SCI may be particularly vulnerable to experiencing sleep difficulties. However, to our knowledge, no study has yet examined the associations between multiple aging-related variables and sleep problems in individuals with SCI, and if such associations exist, whether they are linear (increased sleep dysfunction with increased age) or quadratic (an increased *rate* of sleep dysfunction with age among older individuals than younger individuals). Lack of research in this area may be due, in part, to the many complexities involved in teasing out the effects of different aging-related variables.

One of those complexities is the statistical overlap between age-related variables (Krause & Adkins, 2004). Three key age-related variables are chronological age, age at injury, and duration of injury. In a cross-sectional survey study, and relative to individuals who are younger, individuals with SCI who are older are both (a) more likely to have had the SCI for a longer duration, and (b) more likely to have been older when they were injured. This means that if a significant “chronological age” effect is found in an analysis, unless age at injury or duration of SCI are controlled, it is not possible to know if the significant age effect was due to the patient being older, the patient having a longer duration of SCI, the patient having been injured later in life, or some combination of these. Yet, because of their linear relationship, it is not possible to study the individual effects of these three variables in the same analysis, making it difficult to separate the effects of one variable from the others. However, it is possible to tease out the effects of at least some of these factors if one performs and then interprets a *series* of analyses, rather than attempting to examine these variables in a single analysis. One of the primary goals of this paper is to illustrate this statistical approach using actual data, to provide future researchers with a strategy for addressing this problem of linear dependence.

Given the complexities involved in interpreting the findings from research examining aging variables, especially those that use data collected at one point in time, firm conclusions regarding the reasons and causes of any significant results cannot be made. However, this does not mean that analyses concerning age effects and age-related variables using concurrent survey data should not be performed. Such analyses can, in fact, be used to identify those aging-related variables in need of further study, and to determine if age or age-related variables *might* play an important predictive role in patient functioning. However, investigators need to

be very careful when performing and interpreting analyses to examine the association between age-related variables and key measures of patient functioning.

Given these considerations, this study sought to better understand the associations between age-related predictors and sleep problems in individuals with SCI, while taking into account some of the complexities associated with understanding the relationships between age-related variables and sleep quality. Specifically, the current study was designed to (a) replicate the previous finding of more severe sleep difficulties in a sample of individuals with SCI compared with normative samples; and (b) examine the associations between aging variables (specifically, chronological age, duration of SCI, age at SCI onset) and the severity of sleep difficulties.

We tested two specific hypotheses in this study. First, we hypothesized, based on previous research (Biering-Sorensen & Biering-Sorensen, 2001; Biering-Sorensen et al., 1995), that the individuals with SCI in our sample would report a higher level of sleep dysfunction than normative samples of individuals who are not disabled. Second, based on the findings from non-SCI (otherwise healthy) samples (Ohayon et al., 2004; Unruh et al., 2008), we hypothesized a significant association between chronological age and sleep dysfunction, with increased dysfunction associated with increased age. In these analyses, we examined both linear (i.e., increased sleep dysfunction with increased age) and quadratic (i.e., faster rates of sleep dysfunction with increased age among older individuals compared with younger individuals) associations, given that quadratic relationships are hypothesized for most areas of decline with age in SCI models (Capoor & Stein, 2005). Analyses concerning the association between age at SCI onset and duration of SCI were considered exploratory, as there is not yet empirical evidence (one way or the other) to indicate that these variables play an important role in sleep dysfunction. As with chronological age, both linear and quadratic associations between sleep dysfunction and these aging variables were examined.

Method

Participant Recruitment and Consent Procedures

The participants for this study came from a sample of individuals who completed a survey designed to provide data that could be used to improve the measurement of pain, fatigue, and other health symptoms in persons with disabilities. This is the first paper using data from the SCI participants in this survey. The participants were recruited through the University of Washington (UW) in Seattle, Washington, the Shepherd Center at the Virginia Crawford Research Institute in Atlanta, Georgia, and by means of World Wide Web and print advertisements. Those participants who were recruited from the UW had previously participated in another survey study (Jensen, Hoffman, & Cardenas, 2005), and had been recruited from the Northwest Regional Spinal Cord Injury Model System (<http://sci.washington.edu/>) for that study. Eligibility requirements for participation in the current survey study included self report of SCI and age of at least 18 years.

Invitation letters were mailed to 2,433 potential study participants, and non-responders were sent a follow-up letter after 1 month. Paper-and-pencil surveys were then mailed to all interested participants. A reminder letter and another copy of the survey were sent to those who had not returned the survey after 1 month. If the survey had not been received by the study office within 2 weeks of sending the reminder letter, a telephone call was made to the participant. During this telephone call, participants recruited from the Shepherd Center were then given the option to complete the survey online. This option was also available to advertisement respondents but was not made available to those recruited from the UW. In total, 8 participants completed the survey via the Web. All study procedures, including the consent process, were approved by the UW Institutional Review Board.

Each completed survey was checked for missing data upon return, and participants were called by telephone up to a total of four times to collect missing data. If contact was not made, a brief letter was sent asking the participant to call the study office. A total of 620 participants (Shepherd: 404; UW: 210; advertisements: 6) completed and returned the survey (74.1% response rate; see flow chart in Figure 1). Twenty-five dollars was paid to all participants except those recruited via Web and print advertisements.

Measures

The survey included questions about basic demographic information (age, education level, employment status, race/ethnicity, marital status), descriptive information about the SCI (time since SCI, age at injury, SCI level[s], completeness of injury), sleep problems, and three criterion domains (psychological functioning, physical functioning, and pain).

Sleep quality was assessed using the Medical Outcomes Study Sleep (MOSS) scale (Hays & Stewart, 1992). The MOSS scale includes 12 items that assess 12 domains of sleep quality (during the past 4 weeks) including: (1) time to fall asleep (rated on a 5-point scale from *0-15 min* to *more than 60 min*); (2) average numbers of hours slept per night during the past 4 weeks; and (3) frequency of (a) restless sleep, (b) feeling rested upon awakening, (c) awakening short of breath or with a headache, (d) feeling sleepy during the day, (e) difficulty falling asleep, (f) awakening during the night with difficulty falling asleep, (g) difficulty remaining awake during the day, (h) snoring during sleep, (i) taking naps during the day, and (j) getting the amount of sleep that is needed. The latter 10 domains are all rated using a six-level frequency scale, ranging from *none of the time* to *all of the time*. The MOSS items are weighted and scored to yield six subscales and a total sleep problems index (Sleep Problems Index II), with scores on five scales (all but the average number of hours slept per night) standardized on a 0–100 scale, and higher scores on the Sleep Problem Index II indicating more sleep problems. The MOSS has been validated in large samples, and normative scores are available for comparison (Hays & Stewart, 1992; Spritzer et al., 2003). Moreover, research supports the validity of self-report sleep quality measures, in that such measures show significant associations with objective sleep laboratory measures of sleep quality (Rosenthal, Roehrs, & Roth, 1993), and ability to discriminate between subjects with and without sleep apnea (Yi et al., 2009). Research also supports the validity of the MOSS in samples across a wide spectrum of ages, including samples that include older individuals (e.g., Rejas, Ribera, Ruiz, & Masramón, 2007; Vernon, Brandenburg, Alvira, Griesing, & Revicki, 2008).

Analyses

The response rate to the survey and basic demographic and descriptive information about the respondents were examined first to describe the sample. We then compared our sample to participants in the USA Model Spinal Cord Injury Systems database on available demographic and SCI history variables, using *t* tests for continuous and chi-square analyses for categorical variables, to determine how representative our sample was of Model System participants. Next, average scores on the MOSS scales and total MOSS sleep index were computed, and then tested for differences with normative values using *t* tests. Cohen's *d* (*d*) values were calculated as effect size indices to help interpret any significant findings from the preceding analyses, given that the large sample size could result in statistically significant results that are not clinically meaningful. In interpreting these values, we used the standard definitions to determine if an effect was small (*d* = .20), medium (*d* = .5), or large (*d* = .8) (Cohen, 1988).

Finally, we performed three multiple regression analyses to examine the unique contributions of chronological age, duration of injury, and age at injury to the prediction of sleep problems (see *Regression Considerations* section, below). The MOSS index score was used as the criterion variable for these analyses. Chronological age, duration of injury, and age at injury

onset were the primary predictors in these analyses and were entered in the regression models as continuous variables. Linear and quadratic terms were included in the models in order to test for the hypothesized quadratic relationship between chronological age and sleep dysfunction, and explore both linear and quadratic associations between age at injury and duration of injury, and sleep quality. Because including linear and quadratic terms increases the chances of problematic multicollinearity in regression analyses, the predictors were centered prior to inclusion in the models. Specifically, we transformed the predictors by first computing the mean, and subtracting the mean score from the raw score (Cohen & Cohen, 1983).

Control Variables

Prior to performing the regression analyses, the univariate associations between the demographic and four SCI-related variables (listed above) and the criterion (total MOSS score) were examined to determine if any could be a potential confounder, with a plan to enter the variables that showed significant univariate associations into the regression analyses as control variables. Sex, $t(618) = 2.27, p < .05$ and marital status, coded as “currently married or cohabitating” and “not currently married or cohabitating,” $t(615) = 2.55, p < .05$, were the only demographic or SCI-related variables that demonstrated significant univariate associations with MOSS, and so were both entered in step 1 of the regressions (described below).

Regression Considerations

Due to the linear association between the three primary age variables, and as mentioned above, it is not possible to examine all three in the same equation (Krause & Adkins, 2004). This is because in any single analysis, an aging variable entered after another in the regression analysis will always contain information about *two* aging variables. For example, a regression model might be constructed in which the injury duration variable is entered first and the age at injury variable entered second. In this model, when injury duration is controlled in the first step, age at injury when entered in the second step would contain information about both age at injury *and* chronological age (Cohen, 1988). This is due to the fact that chronological age can directly be defined as age at injury plus injury duration (chronological age = age injury + injury duration). Thus, because of this statistical artifact, after controlling for injury duration, entering *either* age at injury or chronological age in step 2 would result in the same increase in the R^2 value. This makes it very difficult to interpret a significant effect for the second variable entered—such an effect could emerge if age at injury and/or chronological age are related to the criterion variable.

To address this problem, and in order to determine the significant unique variance that each variable contributes to the prediction of the criterion, we performed a series of three regression analyses. In these analyses, each predictor has an opportunity to be entered either first or second (e.g., chronological age followed by injury duration, injury duration followed by onset age, and onset age followed by chronological age). By examining the pattern of significant findings in this series of three regression analyses, it becomes possible to determine if the three aging variables that are otherwise linearly dependent account for independent variance in the criterion. For example, if injury duration plays a significant and unique (i.e., when controlling for the other aging variables) predictive role, then the duration variable should be significant when entered before the other aging variables and also significant (a) when the variable itself is entered following either of the other two variables, and (b) when a variable containing duration information is entered following one of the other aging variables.

Testing for Nonlinear Relationships

The nonlinear (quadratic) relationships between the predictor variables and sleep problems can be examined in a similar way. A quadratic relationship exists between two variables when a

unit change in one variable is associated with an exponential (quadratic) change in another. This results in a curved shape when plotting the relationship. Such relationships emerge, for example, when there are “ceiling effects.” The presence of a quadratic association can be tested by computing a quadratic term (by squaring the variable of interest), and entering this term as a predictor following the linear term (Cohen & Cohen, 1983). For example, in the first regression analysis for this study, after entering the demographic control variables, we entered chronological age (linear term) in the second step, followed by injury duration (linear term) in the third step. Both of these variables test for the linear relationships between these predictors and sleep problems. We then tested for nonlinear relationships in subsequent steps, such that the quadratic term for chronological age (chronological age squared) was entered in step 4, followed by the quadratic term for injury duration (injury duration squared) in step 5.

In the event of a significant quadratic term in the regression models, we planned to categorize the participants into discrete age variables, and then compute the means and standard deviations of sleep scores for each group. The same categorical method was planned for each variable, with seven groups delineated in decade (10-year) increments: <25, 25–34, 35–44, 45–54, 55–64, 65–74, 75+. These categories were chosen because they provide sufficient detail to examine nonlinear relationships, and also because they are large enough to include adequate numbers of participants to yield reliable means. They were also chosen because they are a subset of the standard cutoffs used in research on aging and disability (e.g., <25, 25–34, and 35–44 all fall into the standard “young adult” range).

Summary of Regression Approach

The regression approach selected here was intended to (a) include relevant control variables, (b) allow for evaluation of the unique individual contributions of chronological age, injury duration, and age at injury onset, and (c) test for nonlinear relationships among these variables and the outcome (sleep quality). Thus, in the first regression, the two demographic control variables (sex and marital status) were entered in step 1, followed by chronological age (linear) in step 2, injury duration (linear) in step 3, chronological age (quadratic) in step 4, and finally injury duration (quadratic) in step 5. The second regression equation consisted of the demographic variables in step 1, injury duration in steps 2 and 4, and age at injury in steps 3 and 5. The third regression analysis included the demographic variables in step 1, age at injury in steps 2 and 4, and chronological age in steps 3 and 5.

Results

Response Rate and Participant Characteristics

In total, 837 individuals indicated interest in participation and were mailed surveys or invited to participate via the Web. Of these, 620 participants completed the survey (paper: $n = 612$; Web: $n = 8$) representing 74% of those who expressed initial interest.¹ The average age of participants in the final sample was 44.9 years ($SD = 14.3$; range: 18 – 84). There was large variability in the number of years since SCI onset (range: 1–56; $M = 11.6$; $SD = 10.2$). The vast majority of participants (86%) reported that their injury occurred less than 25 years ago. The average age of SCI onset was 34.0 years ($SD = 14.3$; range: 9 – 79). A motor vehicle accident (48%) was the most frequent single cause of SCI reported by study participants. Other causes included a fall (18%), a sports injury (7%), a gunshot wound (6%), diving (4%), or one of several other individual causes (18%). The percentages of participants reporting their highest level of injury were as follows (1% of participants had missing data): C1–4, 21%; C5–8, 27%;

¹All analyses were performed using data that included all respondents ($N = 620$) and data that excluded the Web respondents ($N = 612$), to determine if including the Web respondents influenced the findings. No substantive differences emerged from the two analytic approaches. The results using the larger sample are reported as they are likely more representative of the population.

T1-5, 11%; T6-12, 33%; and L1-S4/5, 7%. Over half of respondents (52%) described their injury as incomplete, whereas 41% reported that they had a complete injury, and 8% reported that they did not know if their injury was complete or incomplete.

Consistent with the higher frequency of males in the general SCI population, the majority of participants in the current study (67%) were male. Almost 80% of respondents indicated their racial or ethnic background as White, with the remainder self-reporting as Black (11%), Hispanic (4%), Asian or Pacific Islander (2%), Native American (1%), or mixed heritage (3%). Participants reported the following levels of educational attainment: vocational or technical school (8%), some college (28%), college graduate (25%), and graduate school (14%). Nineteen percent reported no education following high school graduation or GED attainment, and 6% indicated that they did not graduate from high school.

Comparison to SCI Model Systems Participants

Data concerning a number of demographic and SCI history variables from participants in the USA Spinal Cord Injury Model Systems are available in the SCI Model Systems Annual report (National Spinal Cord Injury Statistical Center, 2007). The results of the comparisons of our sample to Model Systems participants as a group indicated significant differences on every variable examined except for age at injury. Regarding cause of injury, the percentages of individuals whose injury was caused by violence, a fall, an motor vehicle accident, and a sports-related event in the Model Systems database were 18%, 20%, 43%, and 11%, respectively. These percentages in our sample were 6%, 18%, 48%, and 7%, and the differences in rates were statistically significant, χ^2 ($df = 3$, $N = 485$) = 60.34, $p < .001$. There were also more males (81%) in the Model Systems sample than in our sample, 67%, χ^2 ($df = 1$, $N = 620$) = 83.76, $p < .001$, fewer White participants in the Model Systems sample (67%) than our sample, 79%, χ^2 ($df = 1$, $N = 620$) = 40.94, $p < .001$, and more African American participants in the Model Systems sample (22%) than in our sample, 11%, χ^2 ($df = 1$, $N = 620$) = 49.29, $p < .001$. In short, even though our sample was recruited from two SCI Model System programs, they cannot be deemed to be representative of the population of participants in the model systems as a whole. However, data from individual model systems are not available, and it is possible that the differences found may be due to differences between the pools of potential subjects for this study (which was limited to two of the 12 Model Systems), rather than due to recruitment or selection bias.

Sleep Problem Scores and Comparison With Normative Values

Mean scores on the MOSS scales for the current SCI sample and two normative referent groups [chronically ill populations (CIP) and the general population (GP)] are presented in Table 1. Comparison analyses indicated that participants with SCI in the current study reported significantly greater overall sleep problems, as measured by the MOSS index II score, than both CIP and GP ($p < .001$ for both). The magnitude of these group differences was medium to large ($d = .50$ and $.63$, respectively; Cohen, 1988). In terms of the specific MOSS subscales, the current SCI sample reported significantly greater sleep disturbance, more snoring, fewer hours of sleep per night, poorer sleep adequacy, and greater daytime somnolence than both CIP and GP ($p < .001$ for all comparisons except sleep quantity where $p < .01$ for GP comparison). Participants with SCI also reported significantly more nighttime respiratory difficulties than GP ($p < .001$), but not CIP ($p > .05$).

Relative Contributions of Chronological Age, Duration of Injury, and Age at Injury to the Prediction of Sleep Problems

As described above, three regression analyses were conducted with sleep problems (MOSS index) as the criterion in each. Results from the first regression indicated that after controlling for sex and marital status, chronological age (linear) was a significant addition to the model

($\Delta R^2 = .01, p < .05$). Injury duration (linear) did not account for significant, unique variance in the next step. In contrast, chronological age (quadratic) was a significant contributor in step 4 ($\Delta R^2 = .02, p < .001$); however, injury duration (quadratic) was not significant in the final step.

In the second regression equation, duration of injury (linear) was entered second, followed by age at SCI onset (linear) in step 3. The quadratic terms for these variables were entered in steps 4 and 5, respectively. The results of this analysis indicated that duration of injury was not significant when entered in steps 2 (linear) or 4 (quadratic). In contrast, age at SCI onset was a significant addition in steps 3 (linear: $\Delta R^2 = .01, p < .05$) and 5 (quadratic: $\Delta R^2 = .02, p < .001$).

In the third regression analysis, age at injury (linear) accounted for significant variance in MOSS ($\Delta R^2 = .006, p < .05$). After controlling for demographic variables and age at injury (linear), chronological age (linear) was a marginally significant addition to the model in the third step ($\Delta R^2 = .004, p < .10$). The quadratic term for age at injury onset accounted for additional, unique variance in sleep problems in step 4 ($\Delta R^2 = .019, p < .01$). Finally, chronological age (quadratic) again was a marginally significant contributor in the final step of the regression model ($\Delta R^2 = .005, p < .10$).

As noted previously, the predictors in the above regression analyses were centered to reduce multicollinearity. Variance inflation factors were also examined as indices of multicollinearity. All values fell well below 10, the commonly accepted standard above which harmful multicollinearity is generally indicated, and none exceeded 2.60.

Follow-up Analyses for Significant Variables in the Regression Models

As a group, the results indicated that only one of the predictors in the regression analyses—chronological age—consistently contributed to the prediction of sleep problems. Although age at onset made a significant contribution to the criterion when it was entered prior to the other age-related variables, and remained significant when entered after duration, “injury duration” (which contains information about *both* injury duration and age at onset when entered after chronological age) was not a significant predictor of sleep problems when chronological age was controlled. This indicates that the significant effects found for age at onset when entered prior to the other age-related variables, and when entered after duration, were due to its association with chronological age.²

We next conducted analyses to further explore the relationship between sleep problems and the primary predictor—chronological age—that emerged as a significant contributor to the prediction of the criterion variable in the regression models presented above. The regression coefficients for the significant linear term yield a straightforward interpretation; older chronological age is associated with fewer sleep problems (Table 2). Moreover, the significant quadratic terms indicated that a nonlinear relationship better characterizes the relationship of sleep problems to chronological age.

The negative regression coefficient for chronological age (quadratic) indicated that this relationship has an inverted U-shape (see Figure 2). The results of between-group statistical analyses indicated that the 65–74 age group had significantly fewer sleep problems than each of the younger age groups ($p < .01$ for all), but did not significantly differ from the 75+ age group. The 75+ age group had significantly fewer sleep problems than three younger age groups (25–34, 35–44, and 45–54; $p < .05$ for all), but did not significantly differ from the other groups

²To confirm this, we ran a fourth regression analysis, entering age at onset after chronological age. In this analysis, the age at onset variable (which included information about both age at onset and duration) did not make a significant contribution to the criterion.

(<25, 55–64, and 65–74). Table 3 contains mean MOSS index scores and range across each of these age groups.

Discussion

The primary findings from this study may be listed as follows: (a) as predicted, the participants with SCI in our sample report higher sleep dysfunction scores than individuals in normative samples; (b) although chronological age showed both linear and quadratic relationships to sleep difficulties, the direction of these relationships were not in the hypothesized direction—in our sample, older participants reported fewer sleep difficulties; (c) duration of SCI and age at onset were not associated significantly with sleep difficulties in our sample. Moreover, the analyses in this study provide a model for examining age effects using concurrent survey data that may be useful for other investigators interested in studying the associations between age-related variables and important health-related domains.

The replication of previous studies demonstrating a higher incidence of sleep difficulties in individuals with SCI compared to other individuals, including other chronically ill individuals and otherwise healthy individuals, underscores the importance of assessing and addressing these problems in individuals with SCI. Poor sleep or decreased sleep, including sleep associated with apnea, can itself contribute to negative outcomes, such as coronary artery calcification, hypertension, coronary artery disease, arrhythmias, heart failure, diabetes, and stroke (Al Lawati, Patel, & Ayas, 2009; Bradley & Floras, 2009; King et al., 2008). Thus, the presence of sleep difficulties could contribute to dysfunction and poor health outcomes in individuals with SCI over and above any effects of the SCI itself.

The findings from this study support the need to assess the presence of sleep problems in individuals with SCI, and to provide effective treatments when indicated. To the extent that obstructive sleep apnea is contributing to these sleep problems, then continuous positive airway pressure (CPAP) treatment should be considered, given its proven efficacy (Giles et al., 2006). There is also evidence that cognitive-behavioral therapy and other psychological and behavioral interventions can improve sleep (Guilleminault, Davis, & Huynh, 2008; Morin et al., 2006). These interventions should also be offered to individuals with SCI reporting sleep difficulties.

Both linear and quadratic effects for chronological age emerged as significant predictors of sleep difficulties. However, the direction of these effects was not consistent with our hypotheses, or with previous research showing more sleep problems with age in cross sectional studies of other patient populations (Unruh et al., 2008). Specifically, the linear effects were the result of a decrease in sleep problems in the older participants (in particular, those aged 65 years or older) relative to the younger and middle-aged participants, and the quadratic effect was associated with a slightly lower (but non-significant) level of sleep problems in the very young (less than 25 years old) participants compared to the young adults (25–44 years old), and the subsequent decline in sleep problems in the lower middle-aged (45–54 years old) and then higher middle-aged (55–64 years old) sample compared to the older sample (65 years and older).

In the absence of longitudinal data supporting these as age effects and not cohort effects, any speculations regarding the reasons for these inconsistent findings must be considered very tentative. It is possible, for example (although we think unlikely, given the preponderance of evidence supporting decreases in sleep efficiency with age), that there is something about having an SCI that makes a person's sleep improve dramatically as he or she grows older. One possible explanation could be (a) a slight increase in sleep problems (due to aging) as people with SCI age from being very young to becoming a young adult, but that this aging effect then

becomes overshadowed by (b) a cohort effect resulting from the selection of healthier participants in the older group (i.e., the possibility that health factors associated with poor sleep might be related to mortality). Another possibility is that a third variable related to both aging and sleep may be influencing both, but that neither is causally related to the other. Finally, it is possible that the age effects found could be related to greater *acceptance* of sleep problems as a part of aging by persons with SCI; thus, increased age may simply be associated with a decreased tendency to report poor sleep with increased age, even if little or no change in actual sleep quality occurs. Unfortunately, the findings from a concurrent survey cannot be used to help explain the effects found; that will require longitudinal studies. In the meantime, however, the findings support the need for future research to examine the effects and health correlates of sleep problems in individuals with SCI, and determine if early and effective treatments of these sleep problems produce improvement in the quality of life of all individuals with SCI, regardless of age.

The analytic strategy used in this study provides the researcher interested in examining aging variables with a specific statistical approach for examining the independent contributions of aging variables, even when those predictors have a linear relationship with one another. Specifically, by examining and interpreting the results of the series of analyses (and keeping in mind that one second aging-related variable entered after another can contain information about two aging variables), investigators can tease out the unique effects of predictors which are otherwise linearly dependent, and which therefore cannot be entered simultaneous in a single analysis. The use of multiple regression in this study may be compared and contrasted with the uses of multiple regression described in a recent article published in *Rehabilitation Psychology* (Hoyt, Imel, & Chan, 2008). As pointed out by Hoyt et al. (2008), multiple regression may be used to describe relationships among variables, improve the prediction of a critical variable, or develop and test theory. The focus of the regression strategy described here was on the first of these uses, allowing researchers interested in aging and age-related predictors to determine which of these may play the most important role in key health-related outcomes.

However, it is important to keep in mind that the age effects found in this study, while statistically significant, accounted for less than 5% of the variance in reported sleep problems. This reflects a “weak” to “moderate” effect size (Cohen, 1988). Clearly, variables in addition to age play an important role in the amount and quality of sleep in individuals with SCI. Such variables could include pain (which is commonly seen in individuals with SCI; Jensen et al., 2005), distress, or even complex interactions between these variables and sleep difficulties.

Another critical limitation to this study is the correlational nature of the data and analyses. Causal conclusions cannot be drawn from correlational data, so one cannot conclude, for example, that being older (> 65 years old) or very young (<25 years old) “causes” improvements in sleep. Related to this, the complex interactions between age-related variables, such as chronological age, cohort effects, age at SCI onset, and SCI duration, requires complex (or at least more systematic and detailed) analyses just to determine which of these variables may contribute unique variance to the prediction of sleep or any other criterion measure to be examined. Moreover, the sample is predominantly White and relatively well educated, and the sample was found to differ in some respects from a larger sample of participants representing individuals with SCI from 14 different model systems (the reader will recall that most of the participants in this study were recruited from two of the model systems). This limits the generalizability of the findings. Because of the study's limitations, it is important to not draw firm conclusions from this single study. Rather, studies such as this, at best, provide only tentative support for some hypotheses that then require confirmation in other research that can replicate the patterns of associations found in other samples.

Despite the limitations of the current study, the findings advance our understanding of the relative importance of age-related variables for predicting sleep difficulties. First, the data suggest that duration of SCI (time since SCI onset) and the age at which the SCI occurred are not related to sleep difficulties. Second, we can conclude that, although it might be possible that chronological age results in some slight increase in sleep difficulties, all else being equal, any effects of age appear to be overshadowed by the effects of having an SCI; merely having an SCI increases one's risk for sleep difficulties, especially perhaps among young adult cohorts of individuals with SCI. Finally, the findings yielded an unexpected but strong association between chronological age and sleep difficulties, such that being older with an SCI is associated with a substantial decrease in sleep problems. Because this finding is consistent with the possibility that sleep problems may be linked to higher rates of mortality in individuals with SCI, it highlights the need to examine this possibility more closely, and for studies to examine the effects of sleep treatments on health, longevity, and quality of life in individuals with SCI.

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Figure 1.
Flow chart for survey participation. UW = University of Washington.

Figure 2. Graph of the relationships between sleep problems and current age. *Note.* Higher Medical Outcome Study Sleep (MOSS) index scores indicate worse sleep problems.

Table 1

Medical Outcome Study Sleep (MOSS) Scale Scores in Individuals From the Current Sample (Individuals With Spinal Cord Injury), Individuals With Chronic illness, and the General Population

MOSS scale	Current sample ($n = 620$), M (SD)	Individuals with chronic illness ($n = 3,445$) ^a			U. S. general population ($n = 1,011$) ^b		
		M (SD)	t	d	M	t	d
Sleep disturbance	39.12 (27.50)	29.20 (23.37)	8.98**	.39	24.47	13.27**	.53
Snoring ^c	36.24 (34.27)	30.89 (30.25)	3.80**	.17	28.33	5.61**	.23
Respiratory/shortness of breath	14.74 (24.70)	13.29 (21.82)	1.46	.06	9.45	5.34**	.21
Sleep quantity (hours/night) ^c	6.57 (1.76)	6.93 (1.40)	-5.01**	.23	6.79	-3.04*	.12
Sleep adequacy	50.71 (26.32)	60.67 (25.38)	-9.42**	.39	60.47	-9.23**	.37
Daytime somnolence	38.22 (23.92)	26.41 (19.82)	12.29**	.54	21.89	17.00**	.68
Sleep problems index II	38.76 (20.62)	29.15 (18.04)	11.61**	.50	25.79	15.66**	.63

Note. t , one-sample t test statistic; d , Cohen's d measure of effect size.

^aFrom Spritzer and Hays (2003).

^bFrom Hays et al. (2005).

^cDue to missing data, $n = 591$ and $n = 611$ for snoring and sleep quantity, respectively

* $p < .01$.

** $p < .001$.

Table 2

Multiple Regression Analyses Predicting Sleep Problems From Current Age, Injury Duration, and Age at Spinal Cord Injury (SCI) Onset

Step and variables	Total R^2	R^2 change	F change	β
Step 1: Sex	.013	.013	4.06*	.08*
Marital status				.08 [†]
Step 2: Chronological age (linear)	.023	.010	6.45*	-.11*
Step 3: Injury duration (linear)	.023	.000	.08	.01
Step 4: Chronological age (quadratic)	.044	.021	13.21***	-.15***
Step 5: Injury duration (quadratic)	.048	.004	2.33	.09
Step 1: Sex	.013	.013	4.06*	.08*
Marital status				.08 [†]
Step 2: Injury duration (linear)	.014	.001	.49	-.03
Step 3: Age at SCI onset (linear)	.024	.010	6.37*	-.12*
Step 4: Injury duration (quadratic)	.024	.000	.28	.03
Step 5: Age at SCI onset (quadratic)	.044	.020	12.49***	-.16***
Step 1: Sex	.013	.013	4.06*	.08*
Marital status				.08 [†]
Step 2: Age at SCI onset (linear)	.019	.006	3.93*	-.09*
Step 3: Chronological age (linear)	.024	.004	2.64 [†]	-.10 [†]
Step 4: Age at SCI onset (quadratic)	.043	.019	12.09**	-.16**
Step 5: Chronological age (quadratic)	.048	.005	3.29 [†]	-.10 [†]

[†] $p < .10$.

* $p < .05$.

** $p < .01$.

*** $p < .001$.

Table 3

Descriptive Data for Sleep Problem Scores (Medical Outcome Study Sleep Index) Across Chronological Age Groups

Chronological age (years)	<i>N</i>	<i>M</i> (<i>SD</i>)	Observed range
Less than 25	60	38.99 (18.67)	11.11–84.44
25–34	103	41.47 (20.77)	2.22–91.11
35–44	130	41.71 (21.15)	.00–95.56
45–54	162	40.36 (21.00)	.00–100.00
55–64	105	36.40 (20.14)	.00–93.33
65–74	48	27.34 (16.66)	4.44–77.22
75 and greater	12	27.27 (19.05)	4.44–68.33

Note. Higher scores indicate worse sleep problems.