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Sleep Moderating the Relationship between Pain and Health Care Use in Youth with Sickle Cell Disease.

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Abstract

Objective: The purpose of the current study was to investigate the influence of sleep on the relationship between pain and health care use (HCU) in youth with sickle cell disease (SCD). It was hypothesized that poor sleep would be related to higher HCU and would strengthen the relationship between high pain frequency and more HCU among youth with SCD.

Methods: Ninety-six youth with SCD (aged 8–17 years), and their guardians, were recruited from three regional pediatric SCD clinics. Guardians reported on the youth's pain frequency and HCU using the Structured Pain Interview for Parents, and youth wore a sleep actigraph for up to two weeks to assess sleep duration and sleep efficiency. A series of regression models were calculated with the following outcomes: emergency department visits, hospitalizations, and health care provider contacts.

Results: Inconsistent with hypotheses, poor sleep was not directly related to HCU. Also, higher sleep duration appeared to strengthen the relationship between high pain frequency and more ED visits.

Conclusions: Findings suggest that good sleep may serve as protective factor for better matching pain to HCU. Results should be interpreted in the context of study limitations. Future research is needed to investigate possible mechanisms linking sleep duration to HCU in response to pain and to ascertain if sleep patterns influence the relationship between pain and other functional outcomes in youth with SCD. Clinically, these findings support the need to acknowledge and address the role that sleep plays in responding to SCD pain in pediatric populations.

Keywords

sickle cell; sleep; pain; health care use

INTRODUCTION

Sickle cell disease (SCD) is a family of genetic blood disorders that affects over 20 million people across the world and approximately 100,000 individuals of primarily African descent living in the United States.[1] Individuals with SCD are at increased risk of mortality,[2] poor health related quality of life,[3] functional disability,[4] and high health care utilization (HCU). Results from a study of total medical costs (including hospitalizations and emergency department [ED] visits) associated with SCD care estimated that the average cost per patient per month was \$1,946 and that annual medical costs for SCD per year likely exceeds \$1.1 billion.[5] Pain is the most prevalent complication associated with SCD and is also the chief complaint associated with the majority of ED visits and hospitalizations for the population; making it the primary driver increasing HCU and health care costs.[6] Individuals with SCD often suffer from intermittent severe, acute pain episodes, characterized as unanticipated pain periods ranging from hours to weeks throughout childhood and adolescence, which may develop into chronic pain during late adolescence and adulthood. A major goal of health care providers (HCPs) working with patients with SCD is to promote proper pain management, which includes promoting appropriate HCU in response to pain. Unfortunately, little is known about what factors may affect the relationship between SCD pain and HCU. These factors are important targets for interventions to encourage appropriate HCU. The current study focused on investigating the influence of sleep on the relationship between pain and HCU in youth with SCD.

Youth with SCD are at high risk of sleep disturbances.[7] Results from polysomnography (PSG) studies indicate that approximately 36% of youth with SCD suffer from sleep disordered breathing (SDB),[8] a family of disorders characterized by inadequate oxygenation during sleep. Also, approximately 21–41% of youth with SCD[9] report some form of insomnia, a behavioral sleep disorder characterized by trouble falling asleep, staying asleep, or both.[10] Youth with SCD evidence poorer sleep quality than demographically matched controls.[11] SCD pain and poor sleep are commonly comorbid,[12] which is consistent with research in other pain populations.[13] There is also evidence that poor sleep in individuals with SCD is related to higher HCU. Findings from a study of adults with SCD found that patients who evidenced sleep disturbance had more frequent ER visits and hospitalizations for pain during the previous 12 months.[7] As for youth, a study of 132 children with SCD undergoing tonsillectomies and adenoidectomies to treat obstructive sleep apnea evidenced a post-operative decrease in their mean number of ER visits per year. [14] Also, a study of 1772 children with SCD reported that more fatigue, including fatigue due to disrupted sleep, was related to more hospitalizations for acute pain.[15]

The Model of the Pain-Sleep Relationship in Pediatric Pain Populations,[13] proposes that both high pain and poor sleep are related to worse functional outcomes, such as HCU, and that pain and sleep interact to influence functional outcomes. However, the influence of

sleep on HCU and the interaction between pain and sleep on HCU have not been investigated in a pediatric SCD population. Sleep may influence whether youth and their families seek health care in response to pain by worsening the pain experience. Research in individuals with SCD and other pain conditions indicates that poor sleep patterns may worsen the pain experience,[16] possibly via the link between poor sleep and increased inflammation. Sleep may also influence decision making in response to pain by reducing pain coping resources or compromising pain coping skills of youth with SCD. Poor sleep in healthy youth has been related to poor neurocognitive functioning, and is seen as essential for memory consolidation and emotion regulation.[17] In addition, poor sleep in youth with SCD has been linked to high negative mood the following day,[18] which is consistent with research in other pediatric pain populations linking poor sleep to high negative mood and emotional dysregulation.[13] Overall, sleep may lead to poor neurocognitive functioning and emotional dysregulation, which would make it hard for youth to cope with their pain and increase the chances that they and their families would seek health care in response to it.

As sleep quality influences pain perception and decision-making, it is important to understand if and how sleep influences responses to SCD pain, such as seeking healthcare. The current study aimed to investigate whether poor sleep is related to high HCU in response to SCD pain and whether sleep moderates the relationship between SCD pain and HCU. We hypothesized that poor sleep, as evidenced by short sleep duration and low sleep efficiency, will be related to higher HCU (i.e., emergency department visits, hospitalizations, and HCP contacts due to pain) and will strengthen the relationship between high pain frequency and more HCU among youth with SCD.

MATERIALS AND METHODS

Participants

The current participants were a subset of a sample of youth with SCD and their guardians recruited from three regional pediatric SCD clinics in the southeast US as part of a larger investigation of SCD pain, sleep, and related factors.[19] Data was collected between 2011 and 2015. Inclusion criteria included having a diagnosis of SCD, being aged 8 to 17 years, English speaking, and having had at least one SCD pain episode in the past year. A pain episode was defined as at least 20 minutes of SCD-related pain,[20] and the screening criteria has been used in previous SCD pain studies.[21] Exclusion criteria included a comorbid pain condition, inability to complete surveys, history of extreme noncompliance as reported by the HCP, on chronic blood transfusions, or receiving a sleep intervention (e.g., on a sleep medication or receiving continuous positive airway pressure therapy, $n = 4$). Additional inclusion criteria for the current study was having at least 5 nights of sleep actigraphy data and having complete HCU and pain frequency data, which reduced the sample to 96 youth-guardian pairs out of the total 123 youth who participated in the larger study (78% of the total sample).

The current study sample of 96 youth with SCD were aged 8–17 years ($M = 11.47$ years, $SD = 3.03$ years). The final sample of youth did not significantly differ in relation to age, sex, guardian level of education attained, SCD genotype severity, or whether they were currently prescribed hydroxyurea when compared to the youth in the larger study. The majority of the

youth in the sample had sickle cell genotype HbSS (n = 44, 46%), 35 had HbSC (36%), 10 had HbS β + (10%), 4 had HbS β 0 (4%), and 3 had another SCD genotype (3%). Also, the majority of the sample were female (55.21%, N = 53), and were not taking hydroxyurea (55.79%, N = 53). The mean of education level of the guardians was 13.21 years (SD = 1.92 years, Range = 8 to 18 years).

Procedure

The Institutional Review Boards associated with all three of the regional pediatric SCD clinics approved all study-related procedures. Potential participants were approached during the youth's regularly scheduled pediatric SCD clinic visits, and informed of the study and its procedures. If the youth and their guardians were interested, guardians completed informed consent forms, which included HIPAA authorization to review the youth's medical records, and youth completed assent forms. The guardians reported on the youth's demographic and disease information, pain frequency, and HCU due to pain (i.e., number of ER visits, hospitalizations, and doctor visits/calls) in the past year. Then, youth wore sleep actigraphs for up to two weeks to assess sleep duration and efficiency.

Measures

Demographic and Disease Information.—Youth's age in years, sex, and SCD genotype were collected via guardian interview, and confirmed using the participants' electronic health records. Sex was coded as 0 for males and 1 for females, and SCD genotype was coded as 1 for severe genotypes (i.e., HbSS and HbS β 0) and 0 for all other genotypes. Medical charts were also reviewed to determine if they were currently prescribed hydroxyurea. Also, guardians' reported on their level of education attained as an indicator of socioeconomic status, which was quantified as number of years of education.

Pain Frequency and HCU.—Guardians reported on the youth's pain and HCU using the Structured Pain Interview for Parents (SPI-P).[22] To assess for pain frequency, the guardians reported on the number of SCD pain episodes (defined as at least 20 minutes of pain attributed to SCD) experienced by youth in the past year. To assess HCU in response to SCD pain, the guardians report on the number of ED visits, hospitalizations, and HCP visits and calls (contacts) the youth had in the past year due to SCD pain. Previous studies[20] have found acceptable interrater and test-retest reliability over a 9- to 12-month period for this measure.

Sleep Duration and Sleep Efficiency.—Youth wore Motionlogger Micro Actigraphs (Ambulatory Monitoring, Inc., NY), which are the size of wrist-watches, on their non-dominant wrists for up to two weeks. Actigraphs are designed to electronically monitor movement, which is then recorded in 1 minute epochs by their internal memory. Raw actigraphic data was downloaded, cleaned, and scored using the Analysis Software Program (ActionW2), which features reliable and well validated sleep and wake algorithms developed by Sadeh and associates,[23] and daily reports of sleep onset and offset times obtained via daily survey assessment. Each participant's average scores for all nights throughout the study were then used to calculate the sleep variables: sleep duration and sleep efficiency. Sleep duration is scored as the total time between sleep onset and sleep offset, and sleep

efficiency is the percent of time asleep versus in bed. A five-night minimum of actigraph data has been established to ensure reliability.[24] The above procedures are consistent with current guidelines related to the use and scoring of sleep actigraphy.[25] The nights did not need to be consecutive, and weekday and weekend nights were included, with only 1 participant not having at least one weekend day included. This takes into account variability in sleep during the week that may be important for understanding the general level of sleep deprivation and disruption experienced by youth with SCD, and is consistent with previous pediatric research studies.[26–29] Sleep actigraphy has been validated in comparison to polysomnography, with agreement rates for sleep and wake identification higher than 90%. [30]

Data Analyses

All data was analyzed using SAS 9.4 for Windows. Descriptive statistics for all of the variables of interest were calculated: means, SDs, and ranges for continuous variables and percentages for categorical variables. Correlations and t-tests were calculated to assess the relationships between possible covariates (i.e., age, sex, guardian education level, SCD genotype severity, and hydroxyurea use), pain frequency, sleep variables (i.e., sleep duration and sleep efficiency), and HCU (i.e., number of ED visits, hospitalizations, and HCP visits or calls). Possible covariates that were significantly related to pain, sleep, or HCU ($p < .05$) were retained for the subsequent analyses.

To assess the relationship between sleep and HCU and examine whether sleep moderates the relationship between pain frequency and HCU, a series of regression models were calculated with the three HCU variables as the dependent variables and the following independent variables: pain frequency, the sleep variables, and the interaction between pain frequency and each of the sleep variables, while controlling for significant covariates. To decrease collinearity between the variables and interaction terms, pain frequency and the sleep variables were centered prior to calculating the interaction terms. We probed significant interactions ($p < .05$) using moderation models run using Hayes' PROCESS macro in SAS by calculating the simple slopes of pain frequency and the HCU variable at low, medium, and high levels of the sleep variables (i.e., the mean and $\pm$ the one standard deviation of the mean).

The HCU variables were found to be skewed (all > 3) and to have high kurtosis (all > 13), which may have impacted residuals associated with each of the regression models. As an assumption of linear regressions is that their residuals are normally distributed, we examined the skew and kurtosis for the residuals as well as the QQ plots for each of the regression models calculated. We found that the residuals tended to be skewed and have high kurtosis for all three model. In examining the model related to the ED data, once outliers were removed, the skew and kurtosis of the residuals were found to be acceptable (skew = 1.33, kurtosis = 1.50) and the QQ plot was found to be acceptable. Removing possible outliers from the hospitalization and health care contacts data did not significantly impact the normality of the residuals; thus, it was decided to log transform the variables, which resulted in the skew and kurtosis of the residuals to be in the acceptable range (skew between 1- and +1 and kurtosis between -2 and +2), and the QQ plots were found to be acceptable.

RESULTS

Means, standard deviations and ranges for the primary study variables are in Table 1. Investigating the relationships between the possible covariates, youth taking hydroxyurea were more likely to be older ($t = -3.28, p < .01$) and to have a more severe SCD genotype ($\chi^2 = 32.42, p < .01$). Analyses investigating the relationships between the possible covariates and the dependent and independent variables indicated that older age was related to more frequent pain ($r = .33, p < .01$), lower sleep durations ($r = -.33, p < .01$), and fewer HCP contacts ($r = -.30, p < .01$). Higher guardian education was related to fewer HCP contacts ($r = -.21, p = .04$). Also, youth with a more severe SCD genotype and those taking hydroxyurea had more hospitalizations in the past year ($t = -2.49, p = .01$ and $t = -3.18, p < .01$, respectively). Thus, SCD genotype and hydroxyurea use were used as covariates in the models with hospitalization as the dependent variable, while age and guardian education level were used as covariates in the models with HCP contacts as the dependent variables. Youth sex was not significantly related to pain frequency, the sleep variables, or the HCU variables, and was not used in any of the subsequent analyses.

As for the relationships between the dependent and independent variables, pain frequency and the sleep variables were not related to any of the HCU variables. More frequent pain was related to low sleep durations ($r = -.27, p < .01$). Also, more ED visits was related to more hospitalizations ($r = .54, p < .01$) and HCP contacts ($r = .26, p = .01$). Hospitalizations was not significantly related to HCP contacts.

Regression Models

To test the primary hypotheses, simultaneous regression models were calculated with the following dependent variables: number of ED visits, hospitalizations, and HCP contacts. Independent variables entered were pain frequency, sleep duration, sleep efficiency, and the interactions between pain frequency and the sleep variables, while controlling for covariates identified above. The model with the number of ED visits as the dependent variable was significant and accounted for 11% of the variance ($F(5,88) = 3.35, p < .01$; See Table 2). Pain frequency and the interaction between pain frequency and sleep duration were uniquely related to ED visits. Simple slopes analyses revealed that high pain frequency was related to more ER visits at low ($p = .01$), medium ($p < .01$) and high sleep durations ($p < .01$), and the pattern of findings indicated that as sleep duration increases, the relationship between high pain frequency and more ED visits strengthened (see Figure 1).

The model with number of hospitalizations as the dependent variable was significant and accounted for 10% of the variance ($F(7,87) = 2.47, p = .02$). Whether the youth took hydroxyurea was the only significant association ($t = 2.25, p = .03$), accounting for 5% of the variance. Youth who took hydroxyurea had more hospitalizations than youth who did not. The model with number of HCP contacts as the dependent variable was significant and accounted for 10% of the variance ($F(7,88) = 2.51, p = .02$). Age and guardian education level were the only unique associations ($t = -2.66, p < .01$, $\text{Partial } R^2 = .07$, and $t = -2.10, p = .04$, $\text{Partial } R^2 = .04$, respectively), such that older age and higher guardian education were related to fewer HCP contacts.

DISCUSSION

SCD pain is the primary driver leading to high health care costs associated with caring for individuals with SCD,[6] leading to an emphasis on promoting appropriate HCU in response to a pain as key part of pain management training for this population. However, there has been little research examining what factors might influence whether youth with SCD and their families seek health care in response to youth's pain. Guided by the Model of the Pain-Sleep Relationship in Pediatric Populations,[13] which posits that pain and sleep interact to influence functional outcomes, the current study focused on investigating if sleep quality influences whether youth with SCD seek health-care in response to their pain.

Inconsistent with our hypotheses, poor sleep quality was not related to more HCU, and poor sleep quality did not strengthen the relationship between high pain frequency and more HCU among youth with SCD. In contrast, our findings indicated that higher sleep durations strengthen the relationship between high pain frequency and more HCU, specifically more ED visits. It could be that when youth with SCD get more sleep, they and their families are better able to match their pain to their HCU. In contrast, when youth get less sleep, the link between pain frequency and HCU is disrupted, and other factors may become strongly associated with HCU behaviors, which would be problematic. For example, poor sleep quality has been linked to high negative affect,[31] and a systematic review of individuals with SCD found that more symptoms of depression were related to higher HCU.[32] Relatedly, youth with SCD who report higher optimism appear to be better able to match their pain severity to their pain medication use.[33] Thus, youth with SCD who sleep less may have elevated negative affect, which influences their decision making when experiencing pain, regardless of the frequency of the pain.

An alternative explanation for our findings is that high SCD severity explains the influence of sleep duration on the relationship between pain frequency and HCU. Youth who experience more severe SCD symptoms may sleep more as a method of coping with their symptoms, particularly their pain, as well as seeking more HCU by going to the ED to address their symptoms. However, this explanation is not consistent with our findings indicating that high pain frequency was related to low sleep durations, and with the lack of relationship between SCD genotype severity and sleep duration. Another explanation for our findings could be that sleep duration is acting as a proxy for pain medication use, as more pain medication use may lead to youth sleeping more. It could be that youth who tend to take pain medication to address their pain have more contact with EDs to access those pain medications. Thus, strengthening the relationship between pain frequency and ED visits. This reinforces the need to disentangle the temporal relationships between sleep, pain medication use, and other indicators of HCU.

Beyond our primary findings, the results also indicated unique associations of different types of HCU, and the need to explore what prompts youth and their families to use different services in response to pain. For example, we found that hydroxurea use was uniquely associated with more hospitalizations. One explanation is that youth with severe SCD symptoms are likely to be prescribed hydroxyurea and to experience more acute SCD symptoms, leading to more ED visits. This is consistent with the correlational findings

indicating that having a more severe SCD genotype is related to more hospitalizations, and that hydroxurea use is related to having a more severe SCD genotype and being older, which are both factors related to having more severe SCD symptoms. In addition, guardians of younger youth and with lower levels of education reported more HCP contacts. These findings may indicate that guardians with less knowledge and experience with SCD are more likely to reach out to HCPs, making these guardians a primary target for SCD focused education and support. High pain frequency was related to low sleep durations, which is consistent with previous research indicating a link between pain and disrupted sleep in youth with SCD[12] and other pediatric populations.[13] Older age was also related to high pain frequency and low sleep durations, which is consistent with research indicating that SCD pain increases across the pediatric years,[34] and that sleep duration generally decreases during childhood.[35]

Notably, having a more severe SCD genotype, as indicated by having HbSS or HbS/β0, was related to more hospitalizations, but was not uniquely associated with any of the HCU indicators over and above other factors. This may be because having HbSS or HbS/β0, which is related to worse SCD symptoms (Platt et al., 1991), is a gross indicator of SCD disease severity as it does not explain the full variability in SCD symptoms. Previous studies have also found a lack of a relationship between having HbSS or HbS/β0 and HCU in youth with SCD when taking into account other factors.[36] More recent research on individuals with SCD has found a link between genetic modifiers associated with low fetal hemoglobin levels, pain, vaso-occlusive crises, and high HCU.[37] In addition, the current sample was restricted to youth who had experienced at least one SCD pain episode in the past year. This may have biased the sample, such that participants were more likely to have experienced severe symptoms than in the general pediatric SCD population, and this could have reduced the association of SCD genotype to HCU.

Clinically, these findings support the need to acknowledge and address the role that sleep plays in responding to SCD pain in pediatric populations. Based on these findings and findings of other studies indicating that pain responses are influenced by the context of sleep, it is essential to promote proper sleep hygiene and address sleep problems, with a focus on achieving an appropriate amount of sleep, as a part of pediatric SCD pain interventions. Also, systematic evaluations of sleep patterns in youth with SCD may be useful for planning targeted pain prevention and management activities. Given that low sleep durations appear to disrupt the pain-ED use link for this population, youth with SCD who also evidence low sleep durations can be targeted for interventions focused on promoting proper use of health care in response to pain. In addition, promoting proper sleep patterns as part of pain management efforts targeting young children with SCD may lead to better pain management as youth age.

As for future research directions, studies are needed to investigate possible mechanisms linking sleep durations to ED visits in response to pain in youth with SCD, and to investigate if sleep patterns influence the relationship between pain frequency and other functional outcomes. Research is also needed to identify and investigate other factors that may influence responses to pain in youth with SCD. Based on the Pain-Sleep Relationship Model, positive and negative affect may influence both the relationship between pain and

sleep and the influence of pain and sleep on function. Lastly, our findings stress the importance of sleep duration in understanding how youth with SCD and their families respond to youth's pain; however, very little research has been focused on understanding what factors may impact sleep patterns in youth with SCD. Research indicating that youth with SCD are at increased risk of poor sleep in comparison healthy demographically similar youth[11] suggests that there may be disease specific factors affecting sleep in youth with SCD. This may include a higher risk of clinical sleep disorders, such as sleep disordered breathing[8] and periodic limb movement disorder,[38] or increased inflammation leading to disrupted sleep patterns.[39] Conversely, given that the majority of youth with SCD are of African descent, there may also be racial or cultural factors that influence sleep durations in youth with SCD. For example, time-diary and actigraphy research indicates that Black adolescents tend to sleep less than adolescents of other races.[40] Some proposed mechanisms include the influence of discrimination and culturally specific beliefs about sleep.[41] Overall, research is needed identify and understand the unique impact of different biopsychosocial factors on sleep in youth with SCD.

Notably, the current study has a number of limitations that limits its generalizability. The study exclusively focused on two aspects of sleep (i.e., sleep duration and sleep efficiency), and only used actigraphy to assess sleep. Research is needed to examine if other aspects of sleep assessed using other methods may impact responses to pain, such as subjective sleep quality (which is assessed via self-report) or the presence of a clinical sleep disorder, such as sleep disordered breathing or periodic limb movement (which are assessed via polysomnography). Weekday and weekend nights were included in our actigraph calculations, which may have altered the findings given that youth tend to differ in their weekday and weekend sleep patterns.[42] However, it is consistent with previous pediatric research [26–29] and does allow for a more comprehensive estimate of the amount of sleep deprivation and disruption experienced throughout the week. Also, the current study assessed HCU using retrospective guardian report, which may be influenced by response bias. Parents may have under or overestimated their youth's HCU due to deficits in their memory, caregiver stress, or social desirability. Notably, although medical chart data would have been more objective, it may also have been biased as the medical chart is limited to health care use provided by the hospital connected with each pediatric SCD clinic. Whereas, caregivers have access to information on HCU across multiple hospitals and health care systems. Sleep and HCU were assessed during different periods (e.g., HCU over the past year and sleep prospectively over 5–14 days). This could have influenced the strength of the relationships examined, and did not allow for clear examinations of directionality. Thus, it is important for future research to utilize objective indicators of HCU, such as hospital or health care records, and to coordinate data collection methods to match assessment periods and allow for examination of temporal relationships. This could be done via use of coordinated mHealth technology methods, such as concurrent sleep actigraphy and ecological momentary assessment paired with electronic medical record review during the period of assessment.

Another limitation is that the current study focused on youth with SCD and their guardians accessing structural health care, such as hospitals or HCPs, in response to the youth's pain. However, a primary way of managing pain is by using opioids. Given the increasing

emphasis on the dangers of consistently using opioids and national efforts to reduce their use, it is important to understand if sleep influences when youth with SCD take opioids and other pain medications in response to pain. Also, as mentioned previously, research is needed to elucidate what roles pain medication use plays in connecting sleep to other indicators of HCU. Lastly, the current study focused on youth and youth's health care seeking behaviors are largely influenced and often guided by their guardians. The influence of sleep on the pain-HCU relationship should be examined in adult populations as well, where the impact of sleep on responding to SCD pain may be stronger given the direct effects of sleep on the decision makers in regards to seeking health care.

In conclusion, the current study focused on addressing gaps in the previous literature by investigating the role of sleep in the relationship between pain and HCU in youth with SCD. Sleep did appear to influence the pain-HCU relationship such that higher sleep duration strengthened the relationships between high pain frequency and ED visits. Future research is needed to further explore the possible mechanisms by which sleep may be influencing HCU in response to pain and to explore if sleep may be an influencing factor in the relationship between pain and other functional outcomes in youth with SCD. Additionally, as this study has shown that sleep is an important factor in understanding how youth with SCD and their families respond to pain, these findings support the need for more research to better understand sleep in youth with SCD. This can include research to identify and examine the impact of different biopsychosocial factors on sleep patterns in this population.

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FIGURE 1.
Simple slopes equations of the regressions of pain frequency on number of emergency department visits at conditional levels of sleep duration.

Table 1:

Demographics for Primary Predictors and Outcomes

	Mean	SD	Range
Pain Frequency (episodes)	27.66	59.75	1–365
Sleep Duration (hr:min)	7:57	0:58	5:16 – 10:55
Sleep Efficiency	90.89%	7.17%	54.10%–99.43%
Number of ED visits	2.11	2.56	0–12
Number of Hospitalizations	1.40	4.60	0–40
Number of Health Care Contacts	3.15	6.93	0–52

Note: Information on number of ED visits was after two outliers were removed, and information on hospitalizations and health care contacts was prior to log transformations of those variables.

Table 2:

Regression Model for ED Visits (N = 94)

	ED Visits		
	<i>F</i>	Adjusted <i>R</i> ²	
	3.35**	.11	
	β	<i>t</i>	Partial <i>R</i> ²
Pain Frequency	1.73	3.85**	.14
Sleep Duration	0.34	1.26	.02
Sleep Efficiency	−0.08	−0.24	.00
Pain Frequency * Sleep Duration	1.00	3.25**	.10
Pain Frequency * Sleep Efficiency	0.04	0.05	.01

**
p < .01,

*
p < .05;

Note: ED = Emergency Department