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Sleep Quality and Efficiency in Adolescents with Chronic Pain: Relationship with Activity Limitations and Health Related Quality of Life

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Abstract

The primary purpose of this report was to test hypothesized relationships among poorer sleep quality, increased activity limitations, and reduced health-related quality of life (HRQOL) in adolescents with and without chronic pain. Forty adolescents (20 with chronic pain, 20 healthy) completed measures of HRQOL, activity limitations, pain, depression, and sleep quality. Actigraphy was completed over 7 days. Correlational analyses demonstrated significant relationships where poorer subjective sleep quality was associated with greater activity limitations and reduced HRQOL. Lower actigraphic sleep efficiency was associated with greater activity limitations. In multiple regression analyses, frequency of pain predicted activity limitations and HRQOL. Controlling for pain and depression, lower sleep efficiency was a significant predictor of greater activity limitations but not of HRQOL. Adolescents with chronic pain would benefit from thorough assessment and treatment of sleep disturbances as alleviation of sleep complaints might enhance HRQOL and physical functioning in this population.

Sleep difficulties are commonly reported by children and adolescents with chronic pain (Roth-Isigkeit, Thyen, Stoven, Schwarzenberger, & Schmucker, 2005; Palermo & Fonareva, 2006). For example, in a large epidemiological study of children with chronic pain in the community (Roth-Isigkeit, et al., 2005), over half reported some sleep problems. Self-reported sleep problems have also been documented in clinical populations of children and adolescents with juvenile rheumatoid arthritis (JRA) (Bloom *et al.*, 2002), headache (Bruni *et al.*, 1997; Miller, Palermo, Powers, Scher, & Hershey, 2003), sickle cell disease (Valrie, Gil, Redding-Lallinger, & Daeschner, 2007) and complex regional pain syndrome (Meltzer, Logan, & Mindell, 2005). Most commonly, children and adolescents with chronic pain describe difficulties falling asleep, frequent night and early morning awakening, and excessive daytime sleepiness (Gilman, et al., 2007; Palermo & Fonareva, 2006).

Previous studies of sleep in children with chronic pain have primarily relied on subjective measures of sleep. Two small published studies have used actigraphy to assess sleep in children with chronic pain (Bruni, Russo, Violani, & Guidetti, 2004; Haim *et al.*, 2004). Bruni and colleagues (2004), using actigraphy and self-report diaries for 2 weeks, compared sleep of 17 healthy controls and 18 children with migraines, finding that although nocturnal motor activity was reduced preceding migraine attacks, sleep was similar between the groups during the interictal period. Haim and colleagues (2004) compared sleep patterns in 25 children with recurrent abdominal pain and 15 healthy controls using actigraphy over 7 days. Although children with recurrent abdominal pain complained about disturbed sleep on self-report, actigraphy measures of sleep were similar between the groups. These findings highlight the importance of combining subjective and objective measures of sleep, which may provide different information about sleep in children and adolescents with chronic pain.

Our research group has recently described actigraphic and subjective assessment of sleep in adolescents with chronic pain compared to healthy adolescents (Palermo, Toliver-Sokol, Fonareva, & Koh, in press). This paper involves the same sample of adolescents included in the present report. Results showed that adolescents with chronic pain had similar total sleep time as healthy adolescents but significantly poorer sleep, in particular, lower actigraphic sleep efficiency and more wake bouts, and worse subjective sleep quality (Palermo, et al., in press). An important question that was not addressed by this report concerns the impact of sleep problems on adolescent daily functioning and health-related quality of life, in other words, what is the functional impact of having sleep problems on youth with chronic pain and healthy youth?

This is an important question to address because previous research has demonstrated that sleep disruptions are linked to functional consequences in both healthy adolescents (Fallone, Owens, & Deane, 2002; Wolfson & Carskadon, 1998) and adolescents with chronic pain (Palermo & Kiska, 2005). In adolescents with chronic pain, self reported sleep problems have been associated with significant reductions in functioning in a broad range of physical and social activities as well as on overall health-related quality of life (Palermo & Kiska, 2005). It is unclear whether objective assessment of sleep would be similarly linked to reductions in daily functioning and HRQOL.

We chose to focus on sleep in adolescents instead of younger children because of the higher prevalence of sleep problems in this age group (Wolfson & Carskadon, 1998). In particular, adolescents are at risk for increased sleep problems owing to the changes that occur in sleep/wake patterns during adolescence, including a decrease in sleep duration (Iglowstein, Jenni, Molinari, & Largo, 2003), a delay in the timing of sleep (Carskadon, Wolfson, Acebo, Tzischinsky, & Seifer, 1998), and an increasingly large discrepancy between weekday and weekend sleep patterns (Wolfson & Carskadon, 1998). Furthermore, 12 to 16% of adolescents are considered to have clinically significant insomnia (Morrison, McGee, & Stanton, 1992; Ohayon, Caulet, & Lemoine, 1998; Roberts, Lee, Hernandez, & Solari, 2004). Because the problems of sleep deprivation and difficulties falling asleep are pronounced in adolescence, there may be particular detrimental effects on adolescent's ability to cope with and manage chronic pain.

Because pain intensity and depressive symptoms have been identified as important correlates of sleep disturbances in adolescents with chronic pain, we wanted to also account for these in examining the association between sleep and functional consequences. Specifically, pain intensity has been found to be correlated with reports of sleep disturbances in children (Miller et al., 2003) and adolescents (Gilman, et al., 2007) with headaches, and in children with polyarticular JRA (Passarelli et al., 2006), where higher levels of pain were associated with increased sleep disruption. Depressive symptoms have also been found to be an important correlate of sleep disturbances in adolescents with chronic pain (Palermo & Kiska, 2005; Palermo, et al., in press), predicting severity of sleep disturbances after controlling for demographic and pain-related variables.

The framework that was used in this study was a model described by Lewin and Dahl (1999), examining the links between the regulation of sleep and pediatric pain. The primary tenet of the framework is that there are bi-directional effects between pain and sleep. Pain can directly affect sleep by prolonging sleep onset and interfering with the depth and continuity of sleep states, and the psychological and physiological sequelae of insufficient sleep (e.g., worry, negative thoughts, decrements in behavioral control) may have deleterious effects on pain management, including functional consequences. Clinical research supports the link between pain sensations and disturbed sleep (Bloom et al., 2002; Bruni et al., 1997; Fuggle, Shand, Gill, & Davies, 1996), and experimental research supports

the sleep-pain connection demonstrating that sleep deprivation produces hyperalgesia (i.e., enhanced pain sensitivity) in animals (Kundermann, Krieg, Schreiber, & Lautenbacher, 2004) and in otherwise healthy adults (Kundermann, Sernal, Huber, Krieg, & Lautenbacher, 2004; Onen, Alloui, Gross, Eschallier, & Dubray, 2001).

Specifically, we sought to extend previous findings of the relationship between subjective reports of sleep problems and health-related quality of life (HRQOL) in adolescents with chronic pain (Palermo & Kiska, 2005) by examining this relationship using objective actigraphy data and in comparison to a healthy control group. While our initial report in this sample summarizes the objective and subjective sleep findings (Palermo, et al., in press), the purpose of the present report is to specifically focus on the relationship between sleep disruption and adolescent's daily functioning and HRQOL. We hypothesized similar relationships as those found previously using self report instruments (Palermo & Kiska, 2005) where poorer sleep quality on both actigraphic measures and subjective measures would be associated with more limited physical activities and decrements in health related quality of life. Last, we hypothesized that in a multivariate model, increased activity limitations and worse HRQOL would be predicted by poorer sleep efficiency and sleep quality after controlling for the influence of pain and depression.

Methods

Procedures

This study was approved by the Institutional Review Board at Oregon Health and Science University (OHSU). Written informed consent was obtained from parents and guardians, and written assent was obtained from adolescents for participation in this study.

Telephone screening was completed with parents to identify potential eligible participants. Screening questions asked about the presence of pain symptoms, frequency of current pain, duration of pain complaints, whether the adolescent was currently receiving treatment for chronic pain, and whether the adolescent had a diagnosed sleep disorder. Upon study enrollment, participants completed a multimodal assessment of their sleep. Adolescents completed measures of pain, depressive symptoms, daily functioning, and quality of life, and sustained actigraphy monitoring and a daily sleep log for 7 consecutive days. After completion of the study, the participants were compensated for their time with gift cards to local stores.

The majority (86%) of eligible participants consented to participate in the study. Participants who did not enroll into the study were either not interested or too busy to participate and did not differ from participants on demographics or pain diagnoses. Five participants were not retained in these analyses due to missing data and/or actiwatch malfunction.

Sample

Forty adolescents, aged 12–17 years, and their parents were enrolled into the study. The sample consisted of two study groups: a group of adolescents with chronic pain and a group of otherwise healthy adolescents.

Adolescents with chronic pain (n = 20)—Participants with chronic pain were recruited from a multidisciplinary pediatric chronic pain clinic via a letter or in person during a clinic visit. Inclusion criteria for the pain group required that (a) the participants were between 12 and 18 years and were currently receiving care from the chronic pain clinic; (b) pain had been present for at least 3 months; (c) pain was occurring at a frequency of at least 3 days per week and at least moderate intensity (rated average pain as 5 or greater

on a 0 to 10 scale); (d) pain was not related to chronic disease; (e) there was no diagnosis of developmental disabilities; and (f) the participants were literate in English.

The pain group was predominantly female (75%) and Caucasian (95%) with a mean age of 15.05 (SD = 1.40). All adolescents enrolled had experienced pain for at least 6 months and had moderate to severe usual pain intensity (M = 6.60, SD = 1.64 on a 10 cm visual analogue scale). Primary pain locations included: head and neck (n=7), shoulder (n = 2), abdomen (n = 2), lower back (n = 2), and extremities (n = 7). Primary pain diagnoses included: 40% chronic headaches (migraines, tension), 10% functional abdominal pain, 40% myofascial pain (of any part of the body excluding headaches), 10% complex regional pain syndrome, type 1. All adolescents reported using either over the counter or prescription medications to manage their pain. Sixty percent of adolescents were using prescription medications, including anticonvulsant (e.g. gabapentin) (n = 5), opioid (e.g. oxycodone) (n = 4), or antidepressant (e.g. amitriptyline) (n = 4) medications. Because these types of medications are believed to have sleep-promoting effects, in our initial report (Palermo, et al., in press), we conducted analyses separately to compare mean values on sleep measures between adolescents taking prescription medications and adolescents not taking any prescription medication and found no differences on any of the sleep measures.

Otherwise healthy adolescents (n = 20)—The healthy comparison group was recruited through postings advertising a study about sleep in adolescents in the local metropolitan area. Interested participants were screened by a qualified member of the research team. Inclusion criteria included, (a) age between 12 and 18 years; (b) absence of chronic pain; (c) age (within 6 months) and sex match to an adolescent in the chronic pain group; (d) absence of any serious chronic medical conditions or developmental disabilities; and (e) able to speak and understand English.

Healthy adolescents did not have any history of chronic pain, and were similar in age and sex distribution to the adolescents with chronic pain. Adolescents were predominantly female (70 %) and Caucasian (85%), with a mean age of 14.60 (SD = 1.98).

Measures

Sociodemographics—Parents completed a background questionnaire assessing participants' age, sex, race, parental marital status, occupation, and family income.

Medical history—Medical history was obtained from parent and adolescent self-report and medical chart review. Pain diagnoses were obtained from adolescent's medical records. Parents and adolescents indicated which medications the adolescent was using at the time of the study.

Actigraphy—Sleep patterns were assessed using the Actiwatch-AW64 system (MiniMitter, Bend, OR), which detects sleep-wake patterns by recording ambulatory activity, or the lack thereof. Movement is sensed by an "omni directional" mercury flow switch that is open when there is no movement and closed when movement is detected. Actigraphy allows for unobtrusive measurement over extended periods in the home environment and demonstrates good validity compared with traditional polysomnography recordings (Gruber & Sadeh, 2004). This lightweight watch-like device was worn by our participants on their non-dominant wrist for seven consecutive days. Upon going to bed and awaking, a button (i.e., event marker) on the Actiwatch was depressed closing the switch and registering as an individual marker at that moment in time. Sleep-wake patterns were extracted from the activity data using the Actiware Sleep version 3.4, which bases its algorithm on the amplitude and frequency of detected movements, which we scored in one-

minute epochs. This software was developed and previously validated by Webster and colleagues (1982). MiniMitter Actiwatches have been used in multiple studies investigating sleep in children and adolescents, with healthy (Gaina, Sekine, Chen, Hamanishi, & Kagamimori, 2004) and clinical populations (Armitage et al., 2004). Most recently, the AW64 has been used in studies to assess sleep in children and adolescents with ADHD (Crabtree, Ivanenko, & Gozal, 2003; Sangal et al., 2006).

Actigraphic variables were aggregated across the 7 days of recording. For the purpose of this paper, we focus on sleep efficiency. Sleep efficiency was calculated as the ratio of estimated total sleep time and total time spent in bed as a percentage, with values closer to 100 meaning the most efficient sleep.

Each participant completed a corresponding daily sleep log that was used to verify the actigraphy data. The log was used to report bedtimes, night awakenings, sleep latency or the estimated time in minutes it took to fall asleep, and times when the actiwatch was removed.

Pain perception—Adolescents completed a pain questionnaire to quantify their pain during the previous three months. Pain was evaluated on several dimensions including the 1) location of pain, 2) frequency, and 3) intensity. Pain location was determined by markings on a validated body outline displaying an anterior and posterior view of the body (Savendra, Tesler, Holzemer, Wilkie, & Ward, 1989). Pain frequency was determined using a Likert scale with seven possible options, “not at all,” equivalent to a score of 0, to “daily,” which is equivalent to a score of 6. Usual pain intensity was measured using a 10 cm Visual Analog Scale (VAS) with anchors of “no pain,” representing a score of 0, to “worst pain imaginable,” representing a score of 10.

Sleep quality—Adolescents’ self-perceived sleep quality was measured using the Adolescent Sleep Wake Scale (ASWS) developed by LeBourgeois and colleagues (LeBourgeois, Giannotti, Cortesi, Wolfson, & Harsh, 2005). The ASWS is a 28-item self-report scale that assesses sleep quality using a 6-point scale, ranging from 1-“always” to 6-“never,” to describe occurrence and frequency of which various sleep problems have occurred during the previous month. Five behavioral dimensions of teens’ sleep are measured by the ASWS, including going to bed, falling asleep, maintaining sleep, reinitiating sleep, and returning to wakefulness. Mean subscale scores are obtained and totaled over 5 subscales. Subscale scores range from 1 to 6, with higher scores indicating better sleep quality. Adequate internal consistency for the full ASWS has been demonstrated ($\alpha=.86$) (LeBourgeois et al., 2005).

Activity limitations—The Child Activity Limitations Interview (CALI) (Palermo, Witherspoon, Valenzuela, & Drotar, 2004) was used to assess the degree of activity limitation, or functional impairment, experienced by adolescents. A self-report version was used in this study. This 21-item measure was completed by each adolescent and their parent who reported perceived difficulty on a scale of 0 (*not very difficult*) to 4 (*extremely difficult*) in completing typical daily activities (such as after school practices and eating regular meals) due to pain. Difficulty ratings are summed across items to obtain a total score that represents level of activity limitations experienced by an adolescent. Higher CALI scores indicate greater levels of pain-related disability. The CALI has demonstrated good internal consistency, one-month test-retest reliability, and cross-informant reliability with parents’ responses (Palermo et al., 2004). Construct validity of the CALI has been established in children and adolescents with recurrent and chronic pain (Palermo et al., 2004).

Health-related quality of life—Health related quality of life was assessed by self report and parent-proxy report using the Pediatric Quality of Life Inventory Short Form (Peds QL

SF-15). The PedsQL has been widely used to assess HRQOL in healthy children and children with chronic health conditions (e.g., Connelly & Rapoff, 2006; Varni, Burwinkle, Seid, & Skarr, 2003). The short version contains 15 items that measure physical functioning (5 items), emotional functioning (4 items), social functioning (3 items), and school functioning (3 items). Scores are derived on a scale from 0 to 100 with higher scores indicating better functioning.

Depressive symptoms—Depressive symptoms were assessed using the major depressive disorder (MDD) subscale of the Revised Child Anxiety and Depression Scale (RCADS), (Chorpita, Yim, Moffitt, Umemoto, & Francis, 2000). Each item of the subscale was rated on a 4-point scale from “never” to “always,” in reference to how often each of the items occurred. Higher scores indicated greater frequency of depressive symptoms. T-scores are calculated on the basis of the teen’s gender and grade in school. This subscale has demonstrated good internal consistency ($\alpha = .76$). Previous research has established its validity through relationships with other depression measures (Chorpita et al., 2000).

Data Analysis

Statistical analyses were performed using the Statistical Package for the Social Sciences, Version 14.0 (SPSS Inc., 2003). Descriptive statistics were summarized using mean values, as well as frequency distributions. Several group comparisons between adolescents with chronic pain and healthy adolescents were conducted on demographic variables using chi-square and t-tests. Group differences on sleep quality, health-related quality of life, and activity limitations were computed using analysis of variance procedures. Effect sizes were computed using partial eta-squared. Relationships among sleep quality, activity limitations, and HRQOL were examined using Pearson product moment correlations. Two sets of multivariate models were computed to test for the independent contribution of sleep efficiency and sleep quality to the prediction of activity limitations and HRQOL after controlling for pain and depressive symptoms. Adolescents were used as the primary informant for hypothesis testing; however, all analyses were repeated using parent report and any differences from teen report are described.

Results

Descriptive statistics group comparisons

Demographic and clinical characteristics of both groups are shown in Table 1. Healthy adolescents and adolescents with chronic pain were found to be equivalent on demographic variables including age, sex, ethnicity, and family income. Among adolescents with chronic pain, 70% of the sample reported experiencing pain every day, with mean pain intensity in the moderate to severe range ($M = 6.6$, $SD = 1.6$). In contrast, as expected, healthy adolescents experienced infrequent pain (median value = less than once a month) and significantly lower pain intensity ($M = 2.2$, $SD = 2.1$) than adolescents with chronic pain. Depressive symptoms were also significantly higher in adolescents with chronic pain compared to healthy adolescents ($M = 57.0$, $SD = 12.8$ pain group, $M = 40.5$, $SD = 10.1$ healthy group, $p < .001$).

Table 2 shows the mean scores on primary variables of interest by group. As reported in Palermo, et al., (in press), adolescents with chronic pain ($M = 3.4$, $SD = 0.7$) reported significantly poorer subjective sleep quality than their healthy peers ($M = 4.3$, $SD = 0.7$), $p < .001$ and lower actigraphic sleep efficiency ($M = 76.1$, $SD = 9.5$ pain group, $M = 81.8$, $SD = 5.5$ healthy group, $p = .025$).

Health-related quality of life scores differed between groups, with healthy adolescents having higher (better) QOL scores compared to adolescents with chronic pain across all domains. Specifically, on the Physical, Emotional, School, and Total HRQOL scales, significant differences were found with adolescents with chronic pain reporting reduced physical, emotional and school functioning, and reduced overall QOL compared to healthy peers. As expected, mean scores on the CALI indicated moderate functional impairment (activity limitations) among youth with chronic pain ($M = 30.8$, $SD = 19.1$), and this was significantly higher than activity limitations reported by healthy peers ($M = 2.5$, $SD = 4.3$, $p < .001$).

Relationships among sleep and daily functioning

Bivariate correlations of the relationships among sleep quality and teen daily functioning are shown in Table 3. Activity limitations were strongly related to subjective sleep quality including difficulties falling asleep ($r = .62$, $p < .001$), maintaining sleep ($r = -.50$, $p < .001$), reinitiating sleep ($r = -.48$, $p < .01$), returning to wakefulness ($r = -.43$, $p < .01$), total sleep quality ($r = -.60$, $p < .001$) and actigraphic sleep efficiency ($r = -.37$, $p < .05$), where worse subjective sleep quality and actigraphic sleep efficiency were associated with increased activity limitations.

Similarly, there were also strong relationships between HRQOL subscales and subjective sleep quality. The pattern of relationships across the physical, emotional, social, school, and total QOL scales was such that worse subjective reports of sleep quality were associated with worse HRQOL. Smaller and non-significant relationships were found between actigraphic sleep efficiency and the HRQOL subscales.

The pattern of bivariate correlations when using parent report of activity limitations and HRQOL was very similar to the pattern observed with the teen self-report. The only difference was the strength of the relationship between sleep efficiency and activity limitations reported by the parent that fell short of meeting the conventional criteria for significance ($r = -.30$, $p = .06$).

Relationship between objective and subjective sleep quality

Objective and subjective sleep quality measures were significantly related. Actigraphic sleep efficiency was moderately associated with subjectively reported total sleep quality on the ASWS ($r = .37$, $p < .05$).

Prediction of activity limitations and HRQOL

Four separate hierarchical multiple regression analyses were conducted to test a predictive model that after controlling for pain frequency and depressive symptoms, sleep would predict activity limitations and HRQOL. In one set of models, the variable actigraphic sleep efficiency was tested, while in the second set of models, the total ASWS score (sleep quality) was used (see Table 4 and 5).

As hypothesized, the first model using actigraphic sleep efficiency was significant, explaining 64% of the variance in activity limitations, $F(3, 36) = 21.1$, $p < .0001$. Pain frequency was a significant predictor of activity limitations, where more frequent pain predicted increased activity limitations ($\beta = .53$, $p < .001$). After controlling for pain and depression, actigraphic sleep efficiency contributed unique variance (R^2 change = .05, $p < .03$) to the prediction of activity limitations. Lower sleep efficiency was related to increased activity limitations ($\beta = -.24$, $p < .03$). Depression was not a significant predictor.

The second model using subjective sleep quality was also significant, explaining 61% of the variance in activity limitations, $F(3, 36) = 18.9, p < .0001$. Pain frequency was the only significant predictor, where more frequent pain was associated with increased activity limitations ($\beta = .61, p < .001$). Depression and sleep quality were not significant individual predictors.

The same regression models were conducted using total HRQOL scores as the dependent variable (see Table 5). In the first model, 76% of the variance in total HRQOL scores was explained, $F(3, 36) = 37.3, p < .001$. Depression was the only significant predictor ($\beta = -.66, p < .001$). In the second model, 75% of the variance in total HRQOL scores was explained, $F(3, 36) = 36.63, p < .001$. Depressive symptoms ($\beta = -.52, p < .001$) and pain frequency ($\beta = -.28, p < .03$) were significant predictors. Thus, in contrast to activity limitations, after controlling for pain and depression, total HRQOL scores were not predicted by sleep quality or sleep efficiency.

Discussion

Our main findings extend previous research demonstrating relationships among sleep quality and daily functioning in adolescents with chronic pain. Specifically, using actigraphy and subjective survey measures, we demonstrated that lower subjective sleep quality and lower actigraphic sleep efficiency are related to increased activity limitations and reduced HRQOL. Although there were several differences in the relationships found between subjective sleep measures and actigraphy, in general, there was a consistent pattern whereby more sleep disruption was associated with reduced functioning across a variety of domains of adolescent daily life. Because none of the previous studies using actigraphy (Bruni et al., 2004; Haim et al., 2004) evaluated the relationship between actigraphic measures of sleep and children's functioning, the present report contributes to this gap in knowledge. The current study is among the first to use both actigraphy and self-report to evaluate sleep in adolescents with chronic pain and assess the relationship between sleep and daily functioning.

We found that among the sleep behaviors assessed by the Adolescent Sleep Wake Scale that subjective report of difficulties falling asleep were most strongly associated with adolescent daily functioning. Because difficulties falling asleep may have several different sources and etiologies, future work is needed to better understand the diagnostic and conceptual basis for the sleep disruption. Studies in adults with chronic pain have identified insomnia as a clinically significant problem (Ohayon, 2005). It remains unclear whether youth with chronic pain similarly struggle with insomnia, but data concerning difficulties falling asleep point to the need to explicitly assess for insomnia symptoms in these youth.

Similar to previous studies (Palermo & Kiska, 2005; Palermo, et al., in press), we also found strong relationships among depressive symptoms, sleep, and adolescent functioning. Palermo and Kiska (2005) found that depressive symptoms functioned as a generalized risk factor independently predicting the severity of sleep disturbances in adolescents with chronic pain, highlighting the important role that depression may play for these youth. Our findings also demonstrate a significant relationship between depressive symptoms and adolescent's subjective sleep quality, as well as with their daily functioning and quality of life. There are likely bidirectional relationships among depressive symptoms, pain, sleep disturbances, and functional impairment. Because sleep disturbances, depressive symptoms, and persistent pain can all contribute to functional impairment, studies that track changes among these variables over time would help in refining theoretical frameworks for understanding the development or progression of problems with impaired functioning in youth with chronic pain.

Several limitations of this study should be considered in interpreting the findings. Our sample size was small and our power was limited to detecting only medium and large effects. In addition, adolescents had a range of different chronic pain problems and there were not sufficient numbers of participants to allow any subgroup comparisons. It is possible that certain types of pain problems are related to increased sleep disruption. However, we did limit our sample to adolescents who experienced frequent and moderate to high levels of pain in an attempt to capture a group at risk for functional impairment. We did not assess for sleep disorders in this study but rather focused on sleep quality; however, participants may have been experiencing sleep disorders (e.g., sleep disordered breathing) that reduced sleep quality. More thorough sleep assessments would extend this area of inquiry. Our sample was also limited by lack of ethnic diversity. Last, adolescents who do not seek treatment for chronic pain may have different levels of impairment in daily functioning and likewise in sleep problems. Adolescents who seek treatment have typically been reported to experience more disabling pain with widespread impairment (Kashikar-Zuck, Goldschneider, Powers, Vaught, & Hershey, 2001) compared to adolescents who are sampled in community based studies.

Despite recent interest in the description of sleep in children and adolescents with chronic pain, to date, the literature is quite limited. This is in contrast to the literature on sleep in adults with chronic pain where prevalence and impact data are available (Smith & McGhan, 1997; Stoller, 1994). Moreover, treatments for secondary sleep disturbances have been developed and tested in adult chronic pain populations (Morin, Kowatch, & Wade, 1989) but have not yet emerged in treating the child or adolescent pain population.

However, evidence is mounting that HRQOL and physical functioning in adolescents with chronic pain might be enhanced with interventions that target sleep, and specifically problems related to sleep quality. Future studies are needed to identify mechanisms that mediate the relationship between pain and sleep. Our findings suggest that depressive symptoms are an important potential correlate to explore further in future research.

Given that sleep complaints are not only common but also adversely affect daily functioning for adolescents with chronic pain, there exist a variety of opportunities for sleep clinicians to contribute their expertise to this population. First, sleep clinicians can increase awareness and educate health care providers about the role of sleep in health problems such as chronic pain, potentially providing referral options for sleep evaluation and treatment for these patients. Second, because sleep interventions have not yet been developed and tested in pediatric patients with chronic pain, sleep clinicians are in a position to help design such trials and investigate whether treatments developed for otherwise healthy adolescents with sleep disturbances may be applicable to pain populations.

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Table 1

Sociodemographic and Clinical Characteristics of Sample by Study Group

Demographics	Healthy Group N = 20	Pain Group N = 20
Age [Mean (SD)]	14.60 (1.98)	15.05 (1.40)
Sex [N (%)]		
Female	14 (70.0)	15 (75.0)
Race [N (%)]		
White, Caucasian	16 (85.0)	19 (95.0)
Asian American	3 (15.0)	0 (0.0)
Black	1 (5.0)	1 (5.0)
Parental marital status [N (%)]		
Married	18 (90.0)	16 (80.0)
Divorced	1 (5.0)	1 (5.0)
Separated	1 (5.0)	1 (5.0)
Single/Never married	0 (0.0)	2 (10.0)
Annual family income, Median	\$70,000 or more	\$60,000 –70,000
Pain frequency in previous 3 months [N (%)]		
None	3 (15.0)	0 (0.0)
Less than 1 a month	9 (45.0)	0 (0.0)
1–3 times a month	6 (30.0)	0 (0.0)
Once a week	2 (10.0)	0 (0.0)
2–3 times a week	0 (0.0)	4 (20.0)
4–6 times a week	0 (0.0)	2 (10.0)
Daily	0 (0.0)	14 (70.0)
Pain intensity, Mean (SD)	2.15 (2.08)	6.60 (1.64) **
Depressive symptoms, T score, Mean (SD)	40.5 (10.1)	57.0 (12.8) **

**
p < .001

Table 2

Sleep quality, activity limitations, and HRQOL subscale scores among adolescents with chronic pain and healthy adolescents

Variable	Pain Group M (SD)	Healthy Group M (SD)	P value	Partial eta-squared
Actigraphic sleep efficiency, (%)	76.1 (9.5)	81.8 (5.5)	.025	.13
ASWS Total score (1–6, 6 = better sleep quality)	3.4 (0.7)	4.3 (0.7)	.001	.33
Physical Scale (0–100, 100 = best HRQOL)	48.8 (28.6)	95.3 (7.9)	.001	.56
Emotional Scale (0–100, 100 = best HRQOL)	62.8 (22.8)	83.1 (18.5)	.004	.20
Social Scale (0–100, 100 = best HRQOL)	75.8 (27.0)	86.7 (15.9)	.13	.06
School Scale (0–100, 100 = best HRQOL)	41.7 (24.2)	75.0 (24.8)	.001	.33
Total HRQOL, (0–100, 100 = best HRQOL)	56.5 (22.0)	86.3 (13.8)	.001	.41
Activity limitations, (0–84, 0 = no limitations)	30.8 (19.1)	2.5 (4.3)	.001	.53

Table 3
Relationship between sleep quality and teen daily functioning (activity limitations and HRQOL)

	ASWS Going to Bed	ASWS Falling Asleep	ASWS Maintaining Sleep	ASWS Reinitiating Sleep	ASWS Returning Wakeful	ASWS Total Score	Actigraphic Sleep Efficiency
Activity Limitations	-.30	-.62***	-.50***	-.48**	-.43**	-.60***	-.37*
Physical Scale	.36*	.69***	.53***	.51***	.49***	.67***	.28
Emotional Scale	.40**	.58***	.45**	.44**	.36*	.57***	.15
Social Scale	.29	.36*	.36*	.37*	.22	.41**	-.06
School Scale	.52***	.67***	.49***	.49***	.61***	.72***	.21
Total QOL	.45**	.69***	.54***	.54***	.51***	.70***	.20

* p < .05

** p < .01

*** p < .001

Table 4

Hierarchical regression analyses predicting teen activity limitations

Model 1: Pain frequency, depressive symptoms and actigraphic sleep efficiency as predictors of activity limitations

	ΔR^2	<i>F</i> value	β at final step
Step 1:	.59***	26.2***	
Pain frequency			.53***
Depressive symptoms			.24
Step 2:	.05*	21.1***	
Actigraphic sleep efficiency			-.24*

Model 2: Pain frequency, depressive symptoms and sleep quality as predictors of activity limitations

	ΔR^2	<i>F</i> value	β at final step
Step 1:	.58***	26.2***	
Pain frequency			.61***
Depressive symptoms			.01
Step 2:	.03	18.9***	
Sleep quality (ASWS)			-.24

*
 $p < .05$ **
 $p < .01$ ***
 $p < .001$

Table 5

Hierarchical regression analyses predicting total quality of life scores, teen report

Model 1: Pain frequency, depressive symptoms and actigraphic sleep efficiency as predictors of total QOL

	ΔR^2	<i>F</i> value	β at final step
Step 1:	.74***	53.2***	
Pain frequency			-.24
Depressive symptoms			-.66***
Step 2:	.02	37.3***	
Sleep efficiency			.13

Model 2: Pain frequency, depressive symptoms and subjective sleep quality as predictors of total QOL

	ΔR^2	<i>F</i> value	β at final step
Step 1:	.74***	53.2***	
Pain frequency			-.28*
Depressive symptoms			-.52***
Step 2:	.01	36.6***	
Sleep quality (ASWS)			.16

*
 $p < .05$ **
 $p < .01$ ***
 $p < .001$