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Objective and Subjective Assessment of Sleep in Adolescents with Chronic Pain Compared to Healthy Adolescents

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Abstract

Objectives—The purpose of this study was to compare sleep of adolescents with chronic pain and healthy adolescents using both subjective and objective sleep assessments, and to identify correlates of poor sleep.

Methods—Forty adolescents (n=20 with chronic pain and n=20 healthy adolescents), ages 12 to 17 years (72.5% female) participated. Adolescents completed self-report measures of pain, sleep quality and hygiene, pre-sleep arousal/worry, and depressive symptoms. Sleep patterns were assessed over 7 consecutive days using an actigraph, a motion-monitoring device detecting sleep-wake patterns by measuring activity levels. Total sleep time, sleep efficiency, wake time, and wake bouts were derived from the actigraph and aggregated for analysis.

Results—Compared to healthy peers, adolescents with chronic pain demonstrated similar total sleep time as healthy adolescents, but significantly poorer sleep. In particular, adolescents with chronic pain subjectively reported poorer sleep quality and increased insomnia symptoms, and demonstrated lower actigraphic sleep efficiency and more wake bouts compared to their healthy peers. Depressive symptoms and worry at bedtime were significant predictors of subjectively reported sleep quality but not of actigraphic sleep.

Discussion—Adolescents with chronic pain evidenced poorer sleep quality, increased insomnia symptoms and less efficient sleep with more wake bouts in comparison to healthy adolescents, findings that require replication in a larger sample. Assessment and management of sleep disturbances is an important aspect of care for children and adolescents with chronic pain.

Keywords

adolescent; chronic pain; sleep; insomnia; actigraphy

Introduction

Sleep is a critical developmental need for healthy children and adolescents, and when disturbed, has been associated with problems in school attendance, performance, and mood, and impairment of daily functioning[1]. In a recent study, adolescents with chronic pain and

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disturbed sleep were found to have reduced physical, social and emotional well-being compared to adolescents with chronic pain but fewer sleep disturbances[2].

Epidemiological studies indicate that about 50% of children and adolescents with chronic pain have sleep problems[3]. Sleep disturbances have been documented in children with juvenile rheumatoid arthritis (JRA)[4], sickle cell disease[5; 6] headache[7; 8], and complex regional pain syndrome[9]. Most commonly, these children complain of difficulties falling asleep, frequent night and early morning awakening, and excessive daytime sleepiness[2]. On polysomnography (PSG), children with JRA and children with fibromyalgia have also evidenced sleep fragmentation[10–12].

Previous research has relied primarily on subjective methods to assess children's sleep[13]. With the exception of a few studies in pediatric rheumatology, there has been no other application of PSG to the assessment of sleep in children with chronic pain. Two published studies[14; 15] have utilized another objective methodology for sleep assessment, actigraphy, which uses activity or motion counts as a proxy measure of sleep. It provides unobtrusive measurement of activity over extended periods, demonstrating excellent validity for total sleep duration compared with concomitant PSG, with agreement of up to 95%[16].

Bruni and colleagues[14] compared sleep of 17 healthy controls and 18 children with migraines (ages 8 to 12 years) using 14 days of actigraphy. Although nocturnal motor activity was reduced preceding migraines, sleep was similar between the groups during the interictal period. Haim and colleagues[15] compared sleep patterns in 25 children with recurrent abdominal pain and 15 healthy controls (ages 10 to 17 years) 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.

Although these two small studies are strengthened by the use of an objective sleep assessment, the sample and methods were limited in several ways. First, the samples were heterogeneous in regards to the frequency and intensity of experienced pain and may not accurately reflect the sleep experience of children with more severe chronic pain symptoms. Second, the methods were limited entirely to description of actigraphy findings, and the potential relationship between subjective assessment of sleep using well validated measures and objective assessment of sleep was not possible within the study design. Third, predictors of sleep disturbances were not described and thus, the identification of pain characteristics or psychological factors that may be related to poor sleep could not be appreciated.

In fact, few studies have identified behavioral or psychological correlates of sleep disturbances in children or adolescents with chronic pain. The pain itself has been found to be correlated with reports of sleep disturbances in children with migraine headaches[8] and in children with polyarticular JRA[10]. Pre-sleep arousal, which refers to worry at bedtime, has been studied in adults with chronic pain, with one study reporting the level of cognitive arousal experienced at bedtime, rather than pain severity, to be the primary predictor of sleep quality[17]. Another potential correlate of disturbed sleep is psychiatric comorbidity. In an epidemiological study of the prevalence of insomnia in adolescents, 52.8% of those with insomnia had a comorbid psychiatric disorder, most often a mood disorder[18]. Depressive symptoms have been found to be an important correlate of sleep disturbances in adolescents[2] and adults[19; 20] with chronic pain, predicting severity of sleep disturbances after controlling for demographic and pain-related variables. Anxiety, on the other hand, has not been found to be correlated with sleep quality[19].

To identify potential correlates of sleep, we used a framework described by Lewin and Dahl[21], 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. Transient sleep problems may become chronic, independent of pain severity, due to pre-sleep arousal/worry and negative mood. Smith and colleagues[22] describe a similar hypothesis in adults with chronic pain, that pre-sleep cognitive arousal may lead to insomnia secondary to chronic pain. For example, strong and problematic associations may develop between bedtime fears of separation and worry about physical sensations of pain leading to increased vigilance at bedtime that is incompatible with sleep. Clinical research supports the link between pain sensations and disturbed sleep[4; 7; 23], and experimental research supports the sleep-pain connection demonstrating that sleep deprivation produces hyperalgesia (i.e., enhanced pain sensitivity) in animal models[24] and in otherwise healthy adults[25; 26].

The goal of our study was to extend previous research by conducting a comprehensive assessment of sleep using objective and subjective assessments in a sample of adolescents with chronic pain. We chose to focus on an adolescent sample because adolescents have been described as having a higher risk for sleep disturbances compared to younger children[1]. Moreover, adolescents with similar frequency and intensity of chronic pain were recruited in order to obtain estimates of sleep within a treatment-seeking population that reflects those adolescents with more severe pain complaints. Our assessment plan was comprehensive, allowing description of objective sleep, sleep quality, sleep hygiene, and insomnia symptoms, which have not yet been described in children or adolescents with chronic pain.

Thus although our sample size for this study was small, the measurement plan would allow for estimation of effect sizes and identification of possible predictor variables that may inform future research in this area. We hypothesized that adolescents with chronic pain would demonstrate on actigraphy reduced total sleep time, more time awake after initial sleep onset, more wake bouts, and reduced sleep efficiency; and on subjective measures poorer sleep hygiene and sleep quality, and more insomnia symptoms, compared to an age and sex matched group of healthy peers. Increased depressive symptoms and higher levels of pre-sleep arousal/worry were hypothesized to be associated with poor sleep. Last, we anticipated moderate associations between subjective and objective sleep measures.

Materials and Methods

This study was approved by the Institutional Review Board at the academic medical center where the study was conducted. Written informed consent was obtained from parents and guardians, and written assent was obtained from adolescents for participation in this study.

Procedures

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 on average at a frequency of at least 3 days per week and at least moderate intensity (rated as at least 5 on average on a 0–10 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 healthy comparison group was recruited through postings advertising a study about adolescent sleep 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. There were no exclusion criteria concerning prescribed medications, but participants in both study groups were asked to not make any changes to their current medications during the 7-day actigraphy monitoring period.

The majority (86%) of eligible subjects consented to participate in the study. Subjects who did not enroll into the study were either not interested or too busy to participate. Three participants with chronic pain and two healthy participants who consented to participate were not included in the final analysis due to missing data and/or failure to consistently wear the actigraph.

After the initial screening and enrollment, study participants completed a multimodal assessment of their sleep. Adolescents completed measures of sleep quality, sleep hygiene, pre-sleep arousal, pain, and depressive symptoms, 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 a $10 gift card to local stores.

Measures

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

Sleep patterns—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, with up to 95% agreement[27]. 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[28].

The AW64 has been used in previous studies to monitor sleep patterns in adolescents [29;30]. While actigraphy is not appropriate for the diagnosis of physiological sleep disorders such as sleep disordered breathing or periodic limb movements, it is considered highly appropriate for examining the sleep night-to-night variability in adolescents with poor sleep and is considered to be an effective measure of treatment effectiveness [16; 31]. Acebo, Sadeh, et al., [32] reported that five nights of actigraphy recordings were necessary to obtain reliable estimates of an adolescent's usual or stable sleep pattern and reliability estimates are adequate for sleep start time, wake minutes, and sleep efficiency [32], while measures of sleep

minutes and sleep period may require 7–10 nights for estimates of stable, individual differences. Based on the available reliability and validity data, we aggregated four actigraphy variables across the 7 days of recording. These sleep variables included: minutes of estimated sleep, wake bouts, wake minutes after sleep onset, and sleep efficiency. Minutes of estimated sleep represented the total amount of sleep in minutes each participant received from onset of sleep to onset of awakening. Wake bouts refers to the number of times a teen awoke after sleep onset had occurred, where one wakeful event was counted when at least five consecutive minutes of movement were detected amid thirty minutes of inactivity, i.e. sleep. Wake minutes after sleep onset corresponded to the total number of minutes scored as wake after sleep onset had occurred. 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.

In addition, each participant completed a corresponding daily sleep log that was used to verify and validate 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 wake times.

Sleep quality—Adolescents' self-perceived sleep quality was measured using the Adolescent Sleep Wake Scale (ASWS), developed by LeBourgeois and colleagues[33]. 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)[33].

Insomnia symptoms—From the ASWS, two items were used to describe insomnia symptoms over the previous 4 weeks, (1) sleep latency of 30 or more minutes occurring greater than or equal to 60% of the time, and/or (2) 3 or more nightly awakenings reported occurring at greater than or equal to 60% of the time[33].

Sleep hygiene—The Adolescent Sleep Hygiene Scale (ASHS) was used to assess adolescent sleep hygiene. The ASHS was modified from the Children's Sleep Hygiene Scale[33]. This 24-item scale was developed to measure sleep-facilitating and sleep-inhibiting practices of 12- to 18-year olds along 6 conceptual dimensions: physiological, cognitive, emotional, sleep environment, substances, and sleep stability. For example, items assess eating, drinking, exercising habits, and somatic symptoms prior to sleep, the presence of activities (e.g. watching TV, playing videogames) before or during bedtime that may interfere with sleep, the presence of external stimuli like noise, light, and excessive heat, and use of alcohol or tobacco. Teens reported how often a particular event or behavior occurred within the previous month, utilizing a 6-point scale. Subscale scores range from 1 to 6, with higher scores indicating better sleep hygiene. Internal consistency has been reported to be good (alpha=0.80)[33].

Pain perception—Adolescents completed a retrospective pain questionnaire at study enrollment 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[34]. Pain frequency was determined using a Likert scale with six possible options, "less than once a month," equivalent to a score of 1, 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.

Arousal and worry at bedtime—Adolescents' pre-sleep arousal or worry was assessed using the Pre-Sleep Arousal Scale (PSAS)[35], a 16-item self-report questionnaire measuring cognitive and somatic arousal experienced by individuals prior to sleep onset. For example, cognitive arousal is determined by questions pertaining to having racing thoughts, worry, and anxiety at bedtime, and somatic arousal is assessed with questions pertaining to experiencing unpleasant somatic symptoms, such as tense muscles, cold extremities, or pounding heart prior to falling asleep. Instructions require respondents to report presence and intensity of these thoughts and experiences prior to falling asleep during a typical week. Responses are scored on a 5-point scale, ranging from 1-"not at all" to 5-"extremely". Higher scores indicate greater arousal before falling asleep. Adequate internal consistency has been established and test-retest reliability have been reported in college students, healthy adults, and adults with chronic insomnia[35]. In this study, we adapted the wording of the scale slightly to make the scale more suitable for use with our adolescent sample. In our sample, excellent internal consistency was found both in adolescents with chronic pain (alpha =.90) and in otherwise healthy adolescents (alpha =.86).

Depressive symptoms—Depressive symptoms were assessed using the major depressive disorder (MDD) subscale of the Revised Child Anxiety and Depression Scale (RCADS)[36]. 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[36].

Data Analysis

Statistical analyses were performed using the Statistical Package for the Social Sciences, Version 14.0[37]. Descriptive statistics were summarized using mean and median values, as well as frequency distributions and cross-tabulations. Group differences on categorical variables (annual household income, race, ethnicity, sex) were evaluated using chi-square analyses. T-tests were conducted to compare mean values for primary sleep outcome variables between adolescents with chronic pain using prescription medications and adolescents with chronic pain not using any prescription medications.

Mean group differences on subjective and objective sleep variables were computed using multivariate analysis of variance (MANOVA) to control for Type 1 error due to multiple comparisons among correlated dependent variables. Effect sizes were computed using partial eta-squared. Partial eta squared is interpreted using Cohen's guidelines with >.2 being considered a large effect size, >.1 a medium effect size, and >.05 a small effect size.

To assess associations between pain variables, depressive symptoms, pre-sleep worry, and objective and subjective measures of sleep, Pearson product moment correlations were performed. Further, to identify potential predictors of subjective and objective measures of sleep, linear regression analyses were carried out using adolescent age, group membership (pain vs. healthy), depressive symptoms, and pre-sleep arousal/worry as predictors.

Results

Sample Description and Equivalence of Study Groups

The final sample included 40 adolescents, aged 12–17 years, and their parents. Sample demographics are shown in Table 1. Among adolescents with chronic pain, 70% of the sample reported experiencing pain every day, with mean pain intensity in the moderate to severe range on a 10 cm visual analogue scale (M = 6.60, SD = 1.64). 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, we conducted analyses separately to compare mean values on sleep measures between adolescents taking prescription medications and adolescents not taking any prescription medication.

Analyses indicated no significant differences in age, sex, ethnicity, racial background, or annual income between adolescents with chronic pain and otherwise healthy adolescents. As expected, compared to their healthy peers, adolescents with chronic pain reported significantly more frequent and intense pain.

Medication status and sleep in adolescents with chronic pain

The potential effects of medications on the sleep outcome variables were assessed among adolescents with chronic pain using independent samples t tests. There were no significant group differences on subjective sleep quality ($p = .39$), sleep hygiene ($p = .09$), actigraphic measures of sleep including total sleep time ($p = .78$), sleep efficiency ($p = .98$), wake time ($p = .38$), or wake bouts ($p = .53$) between adolescents using prescription medication (n=12) and adolescents not using any prescription medications (n=8). This finding is consistent with that reported by Meltzer, Logan, and Mindell (2005) who also describe no differences in subjective report of sleep patterns by medication status in a sample of females with chronic musculoskeletal pain. Therefore all subsequent group difference analyses are conducted with the total group of adolescents with chronic pain (i.e., both those taking and not taking prescription medications).

Actigraphic sleep values

Mean values and standard deviations for actigraphic sleep variables by study group are presented in Table 2. A MANOVA was conducted to examine group differences on actigraphic sleep variables. Adolescents with chronic pain had differences on actigraphic sleep variables in comparison to healthy adolescents, Wilks' lambda = .72, $F (6, 33) = 2.19$, $p = .07$, with a large effect size (partial eta squared = .29). Univariate analyses demonstrated that adolescents with chronic pain had significantly lower sleep efficiency compared to otherwise healthy adolescents, $F (1, 40) = 5.44$, $p = .03$, and this was a medium effect with partial eta-squared = .13. Adolescents with chronic pain experienced, on average, significantly more nightly awakenings than their healthy counterparts, $F (1, 40) = 8.39$, $p = .006$, which was also a medium effect with a partial eta-squared of .18. Actigraphy recordings demonstrated that adolescents with chronic pain and healthy adolescents spent similar time in bed (slightly less than 8 hours and 30 minutes) and received a similar amount of sleep of approximately 7 hours of estimated sleep per night. No significant differences

were found between adolescents with chronic pain and their healthy peers on time spent in bed, estimated sleep time, or wake time after sleep onset.

Subjective report of sleep

Mean values and standard deviations on the subjective sleep measures are presented in Table 3 by study group.

Sleep quality—Compared to otherwise healthy peers, participants with chronic pain rated their sleep quality on the subscales of the Adolescent Sleep Wake Scale significantly poorer, Wilks' lambda = .57, Multivariate F (5, 34) = 5.08, p = .001. This effect size was large with a partial eta squared of .43. Specifically, adolescents with chronic pain reported more difficulty falling asleep; F (1, 40) = 19.93, p < .001, maintaining sleep, F (1, 40) = 16.68, p < .001; initiating sleep after an awakening, F (1, 40) = 11.36, p = .002; returning to wakefulness, F (1, 40) = 6.14, p = .02; as well as for their total sleep quality, F (1, 40) = 18.98, p < .0001, than otherwise healthy adolescents. The scores between groups did not significantly differ on the going to bed subscale of the ASWS.

Prevalence of self-reported insomnia symptoms—We compared the prevalence of self-reported insomnia symptoms in the two study groups. Over half (n = 11; 55%) of adolescents with chronic pain reported insomnia symptoms compared to only 10 % (n = 2) of the healthy adolescents, χ^2 (1, 40) = 9.23, p = .002.

Sleep hygiene—The overall MANOVA for the subscales of the Adolescent Sleep Hygiene Scale was not significant, indicating similarity between groups on sleep hygiene, Wilks' lambda = .81, F (6, 33) = 1.27, p = .30. As shown in Table 3, there were significant mean group differences on the total scale and the cognitive subscale, with effect sizes in the medium range.

Relationship between pain, depressive symptoms, pre-sleep arousal/worry, and sleep variables

Table 4 shows the association between pain, depressive symptoms, pre-sleep worry, and sleep variables for the combined sample. There was a moderate association between more intense pain and more actigraphic wake bouts, r = .38, p < .05, and a weaker association with sleep efficiency (r = −.28). Estimated sleep time and wake time were not significantly related to pain. Stronger associations were found between pain and subjective sleep variables. More frequent pain was significantly associated with worse sleep quality (r = −.59, p < .001) and poorer sleep hygiene (r = −.50, p = .001). Having more intense pain was also associated with poorer sleep quality (r = −.50, p = .001) and hygiene (r = −.45, p = .004).

Strong relationships were also found between depression, pre-sleep worry, and subjective sleep. Greater depressive symptoms were related to poorer sleep quality (r = −.73, p < .001) and hygiene (r = −.64, p < .001). Similarly, pre-sleep worry was also significantly related to poorer sleep quality (r = −.72, p < .001) and hygiene (r = −.69, p < .001). Depression and pre-sleep worry had a strong association (r = .76, p < .001). Actigraphic sleep variables, on the other hand, were not significantly related to depressive symptoms or pre-sleep worry.

Association between subjective and objective sleep variables

Associations between subjective sleep variables and objective actigraphic sleep variables were small to moderate. Significant associations were found between self-reported quality of sleep and actigraphic sleep efficiency (r = .37, p < .05) and wake bouts (r = −.34, p < .05), with better subjective sleep quality associated with higher sleep efficiency and fewer wake

bouts. Small and nonsignificant relationships were found between actigraphic sleep variables and sleep hygiene (r's range from −.13 to .13).

Predictors of subjective and objective sleep

Linear regression analyses were performed to identify potential predictors of objective and subjective sleep. We conducted separate regressions for subjective perception of sleep (using the ASWS total score) and objective sleep (using the actigraphic sleep efficiency variable) as shown in Table 5. In the first regression model, adolescent age, study group (pain vs healthy), depressive symptoms, and pre-sleep worry accounted for 22% of the variance in actigraphic sleep efficiency, $F(4, 39) = 2.48$, $p = .06$. Study group was a significant individual predictor ($\beta = -.50$, $p = .01$) with membership in the pain group being associated with lower actigraphic sleep efficiency.

In the second model, adolescent age, study group, depressive symptoms, and pre-sleep worry significantly predicted subjective sleep, $F(4, 39) = 14.64$, $p < .0001$, accounting for 63% of the variance in subjective sleep quality. In this model, both depressive symptoms ($\beta = -.32$, $p = .07$), and pre-sleep worry ($\beta = -.43$, $p = .02$), emerged as individual predictors of self-perceived sleep quality, with greater number of depressive symptoms and more pre-sleep worry relating to poorer subjective sleep quality.

Discussion

The present study examined subjective and objective sleep, along with their determinants, in adolescents with chronic pain and healthy peers. Adolescents with chronic pain were found to have poorer sleep quality and more insomnia symptoms on subjective sleep measures and lower sleep efficiency and more wake bouts on actigraphy compared to healthy controls. Moreover, we found strong associations between pain, depressive symptoms, pre-sleep worry, and subjective perception of sleep quality. In contrast, objective sleep measures were not as strongly related to pain, depression, or worry. Our preliminary findings of reduced sleep quality in adolescents with chronic pain extends previous research using subjective measures of sleep quality, e.g.[2; 9]. Strengths of the current study include use of both subjective and objective sleep measures and an age and sex matched healthy comparison group.

We found that over half of adolescents with chronic pain (55%) in our sample self reported insomnia symptoms while 10% of healthy adolescents reported insomnia. The rate of insomnia in the healthy group is similar to published reports where 12 to 16% of healthy adolescents have been found to report clinically significant insomnia[38]. To our knowledge, this study is the first to specifically report the prevalence of insomnia symptoms in adolescents with chronic pain. Insomnia is well described in adults with chronic pain and, in adults in industrialized societies, insomnia related to chronic pain has been recognized among the most costly forms of illness in terms of prescription medications and lost work productivity[39; 40]. The specific impact of insomnia on adolescents with chronic pain is not yet known. Further studies using polysomnography would be useful to confirm the presence of significant problems with sleep onset and/or maintenance in these youth.

Our findings support the connection between pain and sleep in an adolescent population, although different correlates of objective and subjective sleep were found. Depression and pre-sleep worry emerged as important potential predictors of subjective perception of sleep in adolescents with chronic pain, which is also consistent with previous research[2; 17]. Most children and adolescents with depressive disorders subjectively report sleep problems[41]. However, studies using polysomnography to evaluate sleep in depressed youth are equivocal, with some studies noting alterations in sleep architecture and reduced number of

body movements in depressed adolescents[42; 43] and other studies showing no objective EEG evidence of disturbed sleep[44]. The nature and direction of the relationship between depressive symptoms, worry, pain, and sleep disturbances is unknown. Sleep disturbances might cause depressive symptoms or worry, or pain might cause depressed affect, worry, and sleep disturbances. Alternatively, depressed mood or worry may change perception of sleep in the absence of objective sleep disturbances.

In particular, it is possible that depressed youth may have negative biases or cognitions at bedtime that lead to distorted perceptions of their sleep quality. Depressive symptoms were strongly related to somatic and cognitive arousal at bedtime (pre-sleep worry) in our sample and both were strongly associated with subjective sleep quality. These relationships lend further support for the idea that transient sleep problems may become chronic, independent of pain severity, due to pre-sleep arousal/worry and negative mood. Longitudinal studies are needed to disentangle the temporal relationship among these variables. Future studies may benefit from further assessment of anxiety/worry.

Adolescence is a particularly important time in development to consider sleep patterns and sleep quality because many changes occur, including a decrease in sleep duration[45], a delay in the timing of sleep[46] and an increasingly large discrepancy between weekday and weekend sleep patterns[1]. Sleep quality is generally reduced as well in adolescence[47]. Furthermore, as mentioned, 12 to 16% of adolescents are considered to have clinically significant insomnia[38; 48;49]. In our study, we found that adolescents across both groups were receiving restricted sleep of about 7 hours per night, although optimal developmental sleep requirements for adolescents have been estimated at 9 hours per night[46]. Taken together, adolescence is a vulnerable time for sleep problems to emerge. Perhaps the lack of differences in sleep found in the previous actigraphy studies[14; 15], was in part due to the inclusion of younger school-aged children. Adolescents with chronic pain may be more prone to sleep problems in comparison to younger children with chronic pain.

In this study, actigraphy emerged as a useful tool for examining sleep-wake patterns in adolescents with chronic pain, complimenting the data obtained from subjective sleep measures in this population. We found significant associations between subjective measures of sleep quality and several objective actigraphic variables (i.e., sleep efficiency and wake bouts) demonstrating that these measures may reflect similar content domains. However, as mentioned above, subjective measures of sleep share more overlap with depressive symptoms and pre-sleep worry and may incorporate negative subject biases and fears about sleep. Future research may uncover differing clinical implications of poor sleep quality that is detected by self report versus actigraphy. Our preliminary findings suggest that self reported poor sleep quality is associated with depressive symptoms and pre-sleep arousal, which may serve as targets of behavioral intervention.

Although our data on medications was too limited to comprehensively analyze the effects on adolescent sleep, further research in this area is needed. Surprisingly little empirical data are available on the effects of different classes of medications and dosages on children's sleep[50]. It is unknown whether polysomnography may be more sensitive for evaluating the effects of medications on children's sleep in comparison to actigraphy and self report. This is clearly an area in need of further investigation.

There are several limitations to our study that should be considered in interpreting our findings. Our sample size is small, and the resultant loss in power allowed us to identify only medium and large effects, while smaller effects may have been missed. Our sample included adolescents with chronic pain who were all receiving treatment. It is possible that untreated youth and youth in the community would have demonstrated different sleep

patterns and sleep quality. In addition, adolescents had a range of different chronic pain problems and there were not sufficient numbers of subjects to allow any subgroup comparisons. It is possible that certain types of pain problems are related to increased sleep disruption. Last, because our objective sleep measure included only motion or activity counts, we are unable to make inferences about sleep architecture including possible sleep fragmentation and delayed sleep onset that may occur in youth with chronic pain. Polysomnography will need to be used in future studies to address these questions.

Our findings have clinical implications for the assessment and management of sleep problems in youth with chronic pain. The rate of insomnia and self perceived poor sleep appears to be quite high in treatment-seeking adolescents with chronic pain. Sleep problems should be assessed in all adolescent patients with chronic pain, and specific sleep interventions will likely be needed by a subgroup of these patients. Only one published study has evaluated a sleep intervention in a pediatric pain population. In this study, the benefits of sleep hygiene education were assessed in a group of children and adolescents with migraine headaches and sleep problems[51]. These investigators found that children who received sleep hygiene education obtained an improvement in migraine attacks (lower frequency and shorter duration) compared to children in a control group who did not receive sleep hygiene education. The development of treatments for comorbid sleep disturbances in adolescents with chronic pain is an important area of future research. Treatments may target inadequate sleep hygiene and insomnia using a range of effective behavioral sleep interventions developed for children and adolescents[52].

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Table 1

Sociodemographic and clinical characteristics of sample by study group

Demographics		Healthy Group N = 20	Pain Group N = 20	Sig. (p value)
Age	**Mean (SD)**	14.60 (1.98)	15.05 (1.40)	.41
Gender	**N (%)**			.72
Male		6 (30.0)	5 (25.0)	
Female		14 (70.0)	15 (75.0)	
Race	**N (%)**			.15
Caucasian		17 (85.0)	19 (95.0)	
Asian		1 (5.0)	0 (0.0)	
Other		2 (10.0)	1 (5.0)	
Parental marital status	**N (%)**			.55
Married		18 (90.0)	16 (80.0)	
Divorced		1 (5.0)	1 (5.0)	
Separated		1 (5.0)	1 (5.0)	
Never married		0 (0.0)	2 (10.0)	
Annual family income	**Median**	$70,000 or more	$60,000–70,000	.17
Pain frequency in previous 3 mo	**N (%)**			.001
Not at all		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)	.001
	Median	2.0	6.0	

Table 2

Mean scores (SD) on actigraphic sleep variables between adolescents with chronic pain and healthy adolescents

	Pain group Mean (SD)	Healthy group Mean (SD)	p value	Partial eta squared
Time spent in bed	8 hrs 26 min (44)	8 hrs 25 min (47)	.94	.00
Total estimated sleep time	7 hrs 03 min (42)	7 hrs 17 min (44)	.31	.03
Sleep efficiency	76.1 (9.5)	81.8 (5.5)	.03	.13
Sleep latency (min)	32.4 (42.9)	18.4 (13.9)	.17	.05
Wake bouts	3.8 (3.0)	1.6 (1.3)	.006	.18
Wake time (min)	82.6 (38.4)	67.5 (31.6)	.18	.05

Table 3

Mean scores (SD) on subjective sleep variables between adolescents with chronic pain and healthy adolescents

	Pain group Mean (SD)	Healthy group Mean (SD)	p value	Partial eta squared
ASWS total score	3.5 (0.7)	4.4 (0.6)	.000	.32
Subscale scores				
Going to bed	3.4 (0.9)	3.9 (1.2)	.15	.05
Falling asleep	3.3 (1.0)	4.5 (0.7)	.000	.34
Maintaining sleep	3.5 (1.0)	4.7 (0.8)	.000	.31
Reinitiating sleep	4.5 (0.7)	5.2 (0.5)	.002	.23
Returning to wakefulness	2.5 (1.0)	3.4 (1.2)	.02	.14
ASHS total score	4.6 (0.6)	5.0 (0.4)	.03	.12
Subscale scores				
Physiological	4.6 (0.8)	4.9 (0.8)	.33	.03
Cognitive	3.9 (0.9)	4.4 (0.6)	.02	.13
Emotional	4.4 (1.1)	4.8 (1.1)	.26	.03
Sleep environment	5.1 (0.7)	5.5 (0.6)	.06	.09
Substances	6.0 (0.0)	6.0 (0.1)	.32	.03
Sleep stability	3.8 (1.2)	4.3 (0.7)	.09	.07

Table 4

Pearson correlations between pain, depressive symptoms, pre-sleep arousal, and objective and subjective sleep variables (n = 40 healthy and pain groups combined)

	Pain Intensity	Pain Frequency	Depression	Pre-Sleep Arousal
ASWS total score	−.50***	−.59***	−.73***	−.72***
ASHS total score	−.45**	−.50***	−.64***	−.69***
Estimated sleep time	.00	−.12	−.04	−.08
Sleep efficiency	−.28	−.23	−.06	−.04
Wake bouts	.38*	.25	.14	.21
Wake time	.15	.04	−.11	.00

* p< .05,

** p< .01,

*** p< .001

Table 5

Multiple regression analysis: Prediction of objective and subjective sleep

	R^2	F	Sig F	Beta	P
Actigraphic sleep efficiency	.22	2.48	.06		
Age				.26	.12
Study group				−.50	.01
Depression				.24	.33
Pre-sleep arousal				−.06	.81
Subjective ASWS score	.63	14.64	.000		
Age				.10	.37
Study group				−.18	.18
Depression				−.32	.07
Pre-sleep arousal				−.43	.02

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