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Sleep quality, affect, pain and disability in children with chronic pain: Is affect a mediator or moderator?

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Abstract

Sleep problems have been identified as a potential antecedent of chronic pain and pain-related disability in pediatric populations. In adult studies, affect has been implicated in these relationships. This study sought to better understand the relationships between sleep quality, negative and positive affect and pain and functioning in children with chronic pain. Participants included 213 children and adolescents (aged 7–17) presenting to a tertiary pain clinic with chronic pain. Children completed questionnaires measuring sleep quality, positive and negative affect, pain intensity, and functional disability. Results indicated that 74% of children reported disordered sleeping and that poor sleep quality was significantly associated with increased pain, disability, negative affect, and decreased positive affect. Our hypotheses were partially supported, with negative affect (but not positive affect) mediating the relationship between poor sleep and increased pain; and both positive and negative affect mediating the relationship between poor sleep and increased functional disability. There was no evidence for affect as a moderator. This study adds to the growing literature demonstrating the impact of poor sleep quality on children's pain and functioning, highlighting the need to develop further longitudinal research to confirm the causal roles of these variables.

Keywords

child; chronic pain; sleep; affect

Childhood chronic pain is a serious developmental health concern, affecting up to 30% of children.¹⁹ Associated problems include poor sleep quality, mood disruptions and impaired functioning.^{14, 19, 31} In fact, a recent review concluded that chronic pain subsumes a number

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Disclosures

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of key related issues that should be considered in diagnosis, including mood/affect sleep quality and functional disability.³⁹ However, little is known about the relationships between sleep, pain, and affect in children.

Early models of pain and sleep showed a reciprocal relationship, with increased pain contributing to poor sleep quality and vice versa.^{25, 36} However, emerging research suggests that sleep disruptions (including poor quality, insufficient or too much inefficient sleep, increased sleep latency, and greater incidence of clinical sleep disorders) predict pain and functional disability with greater magnitude than pain predicts sleep problems.^{12, 16} In a recent review of adult and pediatric studies, sleep disruptions were found to increase pain sensitivity and initiate pain episodes.¹² Moreover, an adolescent study using diary and actigraphy measures to assess sleep demonstrated that sleep disturbance significantly amplified pain the following day.²³ Impaired sleep also impacts adolescents' functional disability, defined as restricted home, school, social and leisure activities {Long, 2008 #68;Palermo, 2014 #76}. It thus appears that sleep plays a significant role in children's pain and functioning.

A likely mechanism in the relationship between poor sleep quality and increased pain and functional disability is affect. Both negative affect (NA) and positive affect (PA) have been implicated in the sleep-pain relationship.^{30, 32, 50} Affect contributes to subjective wellbeing,⁸ and encompasses emotion (shorter duration, higher intensity states), and mood (longer duration, lower intensity states), with negative and positive aspects.¹² PA involves the subjective experience of positive states such as interest, joy, and alertness²⁹ while NA is characterized by distress, irritability, and poor concentration.⁴⁵ NA and PA are almost independent of each other, and as such contribute uniquely to wellbeing. Many children with chronic pain meet the criteria for a mood or anxiety disorder²¹ and demonstrate high levels of NA, with a corresponding impact on functioning and wellbeing.^{8, 23} The role of PA in childhood chronic pain is less known.

Ample behavioural and neurobiological evidence links sleep to affective functioning. In healthy adult samples, interrupted sleep impacts the inhibition of pain predominantly through a decrease in PA (rather than an increase in NA).¹³ The roles of positive and negative affect are less clear in the relationship between sleep and pain in children, although good quality sleep is critical to wellbeing in pediatric populations. Sufficient restorative sleep is essential to children's optimal physical, social, emotional and cognitive functioning{Long, 2008 #68}. The main tasks of childhood and adolescence, including academic learning are negatively impacted by sleep disruptions.⁴⁹ In a longitudinal study of children's sleep habits and developmental outcomes, children with ongoing sleep problems in childhood were rated by teachers as more hyperactive, emotionally unsettled and disorganised, and as having poorer social skills 2–3 years later, suggesting that sleep problems influence brain development over time in a manner that interferes with self-regulation skills and broadly impacts wellbeing.^{47, 48} Questions regarding sleep, affect, pain and functional outcomes therefore have developmental considerations, and the sleep-sensitive nature of children's developing regulatory capacities suggests that affect may play an even more profound role in the sleep-pain relationship in children than in adults.

There are two potential pathways involved in the sleep-affect-pain relationship. The first involves a moderating role for affect, whereby the sleep-pain relationship is modified by the individual's affect. For example, in a study of children with pain associated with sickle cell disease, "not sleeping well" resulted in reduced functioning the following day, however greater levels of positive mood weakened the relationship.⁴² The second involves a mediating role for affect, whereby an increase in NA, or decrease in PA may explain why poor sleep quality is related to increased pain and reduced functioning. For example, in a study of pediatric oncology patients, internalising symptoms (including anxiety, depression, and withdrawal) mediated the relationship between sleep-disordered breathing and pain, such that the effect of sleep on pain was reduced after accounting for child internalizing symptoms.³

To date, no study has systemically tested the moderating and/or mediating roles of both positive and negative affect in the relationship between sleep and pain in children with chronic pain. Questions of 'how' are typically approached using mediation to investigate how the relationship between a predictor (in this case, sleep quality) and an outcome (pain and disability) can be explained by a third variable (affect); whereas, questions of 'when' are approached using moderation (i.e., to determine *when* an amount of negative affect-low, average, or high – impacts pain and functioning in the context of poor sleep).¹⁷ It is clinically relevant to understand the particular roles of positive and negative affect as moderators or mediators of the sleep-pain relationship, since future research and interventions can be tailored to understand the utility of: 1) increasing PA and/or reducing NA in children; and 2) addressing both sleep and mood (consistent with partial mediation), or whether primarily addressing mood (moderation model) may be sufficient in reducing pain and improving functioning.

The aim of this study was therefore to examine the relationship between children's sleep quality in relation to their pain intensity and functional disability, and to examine both the mediating and moderating roles of negative and positive affect in these relationships. Consistent with adult studies, it was hypothesized that the relationships between poor sleep and increased pain, and poor sleep and increased functional disability would be mediated by lowered PA such that poor sleep quality would impact increased pain and disability at least partially through a reduction in the child's positive mood. It was similarly hypothesized that NA would mediate the sleep-pain and sleep-disability relationships, such that poor sleep quality would impacts pain and disability, at least partially through a rise in negative mood/emotions. The roles of NA and PA as moderators in the sleep-pain and sleep-disability relationships were explored.

Method

Study Design

Cross-sectional analysis was used to examine the relationships among child self-reports of pain intensity, sleep quality, and negative and positive affect. Children provided assent for the study while their parents provided written consent. Demographic information, including age, race and ethnicity, came from parent completed forms. Parents and children completed questionnaires during the week before their first clinic visit. The University of California

Los Angeles (UCLA) Institutional Review Board (IRB) in the United States, and the Deakin University Human Research Ethics Committee approved the study.

Participants

The clinical sample was part of an ongoing study examining pain, psychological health, and sociodemographic factors in a pediatric tertiary pain clinic. Participants in the present study are representative of the patients typically seen in this clinic, and included 213 children and adolescents (148 girls, 69.5%) with an average age of 14.5 (SD 2.4, range 7–17 years), presenting for treatment at a multidisciplinary tertiary pediatric pain clinic in the United States, between 2009 and 2014). Sample characteristics are presented in Table 1.

Measures

Sociodemographics and Healthcare Utilization—Caregivers completed a questionnaire regarding the child’s age, gender, ethnicity, race and healthcare utilization, as well as their own age and education achievement.

Pain Intensity—The Numeric Rating Scale (NRS)²⁶ assessed overall level of pain during the prior month. Children rated their level of pain on a scale from 0 (*no pain*) to 10 (*worst pain possible*). The 11-point NRS is a well-established, reliable, and valid self-report of pain intensity in children of the ages included in this study.⁶

Functional Disability—The 15-item Functional Disability Inventory (FDI){Walker, 1991 #86} was used to assess children’s self report of physical functioning and limitation in performing daily activities in the domains of home, school, recreation, and social interaction. Activities included, ‘being at school all day’, ‘walking to the bathroom’, ‘doing homework’ and ‘doing something with a friend’. Children rated his/her level of difficulty in performing each activity in the past two weeks on a 5-point Likert scale ranging from 0 – 5 (‘no trouble’ to 5 ‘impossible’). Scores were computed by summing the ratings for each item (range 0 – 60), with higher scores reflecting greater disability related to pain. The scale is reliable and well validated {Kashikar-Zuck, 2011 #107}.

Pain Location—Children completed body maps⁴³ to indicate the body locations where they had experienced pain in the preceding month. This version of the body map has been previously used in pediatric pain populations,³⁵ and its 21 demarcated areas were collapsed to the five regions presented in this paper.

Sleep Quality—Sleep quality during the previous month was assessed using the Pittsburgh Sleep Quality Index (PSQI).⁵ The PSQI was developed to: 1) provide a reliable, valid, standardized measure of sleep quality; 2) discriminate “good” and “poor” sleepers, and 3) provide an easy index for patients to complete and for clinicians and researchers to interpret.⁵ The PSQI consists of 19 items and produces seven sub scores encompassing sleep duration, sleep disturbance, sleep latency, daytime dysfunction, sleep efficiency, subjective sleep quality, and sleeping medication use. Each of the 19 items are weighted on a 0–3 interval scale. The global PSQI score is then calculated by totaling the seven component scores, providing an overall score ranging from 0 to 21, where lower scores denote better

sleep quality. We used the global PSQI score in all analyses. A PSQI global score greater than five is considered to be indicative of poor sleep quality.⁵

In adults, the PSQI has good reliability and validity with high internal consistency (Cronbach's $\alpha = 0.83$) and test-retest reliability with a coefficient of 0.85.^{5, 28} The measure has been used successfully in children with health problems as young as 8-years of age,^{2, 4, 40} and has been validated in children as young as age 14-years, with one small variation to a single question that makes reference to driving.⁹

Positive and Negative Affect—The Positive and Negative Affect Scale for Children (PANAS-C)²² was developed as a child form of the original PANAS,⁴⁶ designed to measure positive affect (PA) and negative affect (NA) in relation to the tripartite model of emotion.⁷ The PANAS-C consists of 27 items that measure the intensity of PA and NA. The 12-item PA subscale consists of mood states including excited, interested, strong, proud, and enthusiastic, while the 15-item NA subscale consists of mood states including anger, disgust, contempt, nervousness, fear, and guilt. Participants were instructed to rate their level of intensity for each affect on a 5-point Likert scale ranging from 1 (*very slightly or not at all*) to 5 (*extremely*) over the past few weeks. Scores were added to yield a NA and PA score. In a study of normative samples of children and adolescents, the average PA score was 34.6, and the average NA score was 19.8.¹ The PANAS-C has good reliability and validity, with high internal consistency (PA Scale Cronbach's $\alpha = 0.86$, NA Scale Cronbach's $\alpha = 0.89$) and test-retest reliability with a coefficient of 0.85.²²

Statistical Analysis

Statistical analyses were conducted using SPSS version 23 and the macro PROCESS.¹⁷ PSQI scoring guidelines do not allow for any subscale to be missing when computing the total score. Therefore, analyses of PSQI total score include the 174 participants with complete PSQI data. Chi squares for categorical data and t-tests for continuous data revealed no significant differences between the group with usable PSQI data and the group without PSQI data on any of the demographic variables, affect, pain, disability or sleep.

Statistical significance was set at $p < .05$ throughout the analyses. Data were screened to identify outliers and assessed for normality distribution. Statistical power analysis for the sample size calculation suggested a sample of 77 would provide 80% power to detect a medium effect size ($d = .5$), given an alpha of .05 for a two-tailed test (G* power 3 software;¹¹).

All analyses included child age and sex as covariates. First, correlations were conducted between the child symptoms of sleep quality, positive affect, negative affect, pain intensity, functional disability and age. Second, regression based PROCESS¹⁷ with bootstrapping (5,000 samples) was used to analyse the extent to which the effect of sleep quality was mediated through perceived negative and positive affect, and were considered significant if the 95% bias-corrected confidence interval of the indirect effect did not include zero.³⁴ Unstandardised indirect effects were computed for each of 5,000 bootstrapped samples, and the 95% confidence interval was computed by determining the indirect effects at the 2.5th and 97.5th percentiles.³⁴ Third, moderating analyses were performed with PROCESS.

Negative affect, positive affect, and sleep were centered and two interaction terms were analyzed in the same model (negative affect $\times$ sleep and positive affect $\times$ sleep).

Results

Descriptive Statistics

Descriptive statistics were used to examine sample characteristics and the variables of interest (sleep quality, negative affect, positive affect, pain intensity) and functional disability. Demographic variables (e.g. age, gender, ethnicity) and pain types are presented in Table 1. Pain types included head ($n = 138$, 65.1%), arm ($n = 99$, 46.7%), mid section ($n = 139$, 65.6%), back ($n = 115$, 54.2%) and leg ($n = 106$, 50.0%). Percentages sum to more than 100% as 75.9% ($n = 161$) of children reported pain in multiple regions. Prior to intake, 59.7% ($n = 117$) of children had consulted five or more doctors for pain ($M = 6.25$, $SD = 4.26$), and the mean number of office visits to medical doctors over the past 12 months was 15 ($SD = 13.31$). Just under half ($n = 98$) had consulted mental health practitioners within the past year ($M = 5.01$ visits, $SD = 9.70$).

On the PSQI, the mean total score was 8.79 ($SD = 4.44$), and 73.6% ($n = 128$) of the sample reported poor sleep quality. PSQI scores of greater than 5 denote poor sleep quality. Severe sleep onset latency, characterized by taking longer than 60 minutes to fall asleep was experienced by 36.1% ($n = 74$) of children, and the average time to get to sleep in this subgroup was 98.58 minutes ($M = 52.20$, $SD = 78.67$, $SD = 64.89$ in the whole sample). Approximately 70% ($n = 148$) of children reported low levels of sadness, 22.7% ($n = 48$) moderate levels of sadness, and 7.1% ($n = 15$) high levels of sadness. For positive affect, 44.5% ($n = 93$) of children experienced low levels of positive emotion, 35.4% ($n = 74$) experienced moderate levels of positive emotion, and 20.1% ($n = 42$) experienced high levels of positive emotion. The average positive affect score was 32.27, which is only slightly lower than normative samples, although the average NA score of 31.06 is somewhat higher than an average of 19.8 found in normative samples.¹ The FDI mean of 21.63 is consistent with previous reports of children with chronic pain {Kashikar-Zuck, 2011 #103}.

Means and standard deviations for each of the child variables are presented in Table 2, including correlations examining the relationships among sleep quality, negative affect, positive affect, pain and disability. As shown in Table 2, results indicated that sleep quality scores were significantly related to pain ratings ($r = 0.31$, $p < 0.001$) and functional disability ($r = .61$, $p < .001$), negative affect ($r = 0.45$, $p < 0.001$), and positive affect ($r = -0.32$, $p < 0.001$), suggesting that worse sleep is related to increased pain and disability, increased negative affect, and reduced positive affect.

Mediation analysis

Regression-based bootstrapping analyses using PROCESS were conducted to examine both negative affect and positive affect as hypothesized mediators of the relationships between sleep quality and pain intensity, and sleep quality and functional disability, controlling for the effects of child age and child sex.

Affect as a mediator of the sleep-pain relationship—Results indicated that sleep quality was a significant predictor of negative affect ($b = 1.17$, $SE = .21$, $p < .001$) and positive affect ($b = -.80$, $SE = .20$, $p < .01$) and that negative affect was a significant predictor of pain ($b = .02$, $SE = .011$, $p < .05$); however, positive affect was not a significant predictor of pain ($b = -.01$, $SE = .01$, $p > .05$). These results support a mediational model for negative affect only.

The indirect effect was tested using a bootstrap estimation approach with 5000 samples.³⁴ Results indicated the indirect coefficient for negative affect was significant ($b = .03$; $SE = .01$; 95% CI .01 to .06). Sleep was still a significant predictor of pain after controlling for the mediators and covariates (age and sex) ($b = .10$, $SE = .03$, $p < .01$), consistent with partial mediation. The ratio of indirect to total effect for negative affect ($b = .22$, $SE = .20$, 95% CI .03 to .57) indicates that negative affect accounts for approximately 22% of the shared variance between sleep and pain. The results are summarized in Figure 1.

Affect as a mediator of the sleep-disability relationship—As above, sleep quality was a significant predictor of positive and negative affect. Negative affect was a significant predictor of functional disability ($b = .21$, $SE = .06$, $p < .001$); as was positive affect ($b = -.18$, $SE = .07$, $p > .001$). These results support a mediational model for negative and positive affect.

The indirect coefficient for negative affect was significant ($b = .25$; $SE = .10$; 95% CI .09 to .48), as was the indirect coefficient for positive affect ($b = .15$; $SE = .06$; 95% CI .05 to .30). Sleep was still a significant predictor of disability after controlling for the mediators and covariates (age and sex) ($b = 1.31$, $SE = .18$, $p < .001$), consistent with partial mediation. The ratio of indirect to total effect for negative affect ($b = .14$, $SE = .06$, 95% CI .05 to .30) and for positive affect ($b = .09$, $SE = .04$, 95% CI .03 to .18) indicates that negative affect and positive affect each account for 14% and 9% of the variance between sleep and disability respectively. The results are summarized in Figure 2.

Moderation analyses

Regression-based bootstrapping analyses using PROCESS were conducted to examine whether the relationship between sleep quality and pain intensity and sleep quality and functional disability (controlling for the effects of child age) is stronger for individuals with high negative affect and for low positive affect.

For pain, the main effects of sleep, negative affect, and positive affect (controlling for child age and sex), as well as the interaction effects accounted for 16% of the variance ($F = 4.35$, $p < .01$). However, the interaction terms for sleep and positive affect ($b = .001$, $SE = .003$, 95% CI $-.004$ to $.007$) and sleep and negative affect ($b = -.002$, $SE = .003$, 95% CI $-.007$ to $.003$) were not significant, suggesting a lack of evidence for moderation.

For functional disability, the main effects of sleep, negative affect, and positive affect (controlling for child age and sex), as well as the interaction effects accounted for 51% of the variance ($F = 30.78$, $p < .001$). However, the interaction terms for sleep and negative affect ($b = -.006$, $SE = .01$, 95% CI $-.03$ to $.02$) and for sleep and positive affect ($b = -.001$,

$SE = .01$, 95% CI $-.03$ to $.02$) were not significant, suggesting a lack of evidence for moderation.

Discussion

The overall aim of this study was to investigate the relationships among sleep, affect pain and functional disability in children with chronic pain. Consistent with previous theory and literature, it was hypothesized that positive affect (PA) and negative affect (NA) would prove to be mediators of the sleep-pain relationships. In our sample, 74% of children experienced significant sleep problems, and, as anticipated, we found an association between poor sleep quality and increased pain and functional disability. Mediation analyses revealed that NA partially explained the relationship between poor sleep quality and increased pain intensity; and that NA and PA partially explained the relationship between poor sleep quality and increased functional disability. There was no support for affect as a moderator of the sleep-pain or sleep-disability relationships.

In accordance with previous literature, our results showed sleep disruptions were associated with increased pain in children. A number of studies have demonstrated a link between poor sleep indices and increased pain and impairment in children with chronic pain.^{23, 32, 33} For example, pediatric pain populations have exhibited significant limitations in their ability to perform in school and engage in daily life activities as a result of sleep disturbances.^{32, 33} Although there is evidence that sleep and pain are implicated in a reciprocal relationship, whereby poor sleep patterns increase pain ratings, and pain impairs sleep,²⁵ more recent research has delineated a temporal relationship whereby poor sleep quality typically precedes increased pain and reduced functioning.¹² Overall, these earlier studies suggest that sleep disruptions significantly impact children's pain experiences, and therefore the assessment and treatment of sleep should be routinely incorporated as part of clinical care and pain management.

A novel aspect of this study was the examination of both PA and NA as potential mediators and/or moderators of the relationships between sleep and pain, and sleep and functioning. Based on previous research, we predicted that PA and NA would operate as mediators, with positive and negative mood explaining the impact of poor sleep quality on pain and functional disability. Our findings partially lend support to this notion. NA (but not PA) mediated the sleep-pain relationship, while both NA and PA mediated the sleep-disability relationship. Although there was a significant association between sleep and positive affect, with poor sleep quality relating to lowered positive mood, there was lack of evidence for this lowered positive mood then leading to increased pain. Conversely both lowered positive mood and heightened negative mood were associated with increased functional disability. Our findings suggest that children with chronic pain who sleep poorly are also likely to experience reduced well-being (positive and negative mood aspects) which lead to impaired functioning, but only negative mood predicts increased pain. However, given the cross-sectional nature of the data, only preliminary statements can be made about these relationships.

Of interest are the similarities between this study and previous child studies, and the simultaneous discrepancies with adult studies. While the present study found only a role for NA (and not PA) in the sleep-pain relationship, previous studies with healthy adults have reported that sleep disruption impacts the inhibition of pain via the PA system, but not the NA system.¹³ Developmental differences may explain the discrepancies, especially given prior pediatric findings which corroborate the importance of NA in understanding sleep and pain. In children with sickle cell disease (SCD), negative mood was found to mediate the relationship between poor sleep and high daily pain the following day {Valrie, 2008 #105}. Together, these studies indicate that while important early in development, NA may play less of a role as self-regulatory capacities develop across maturation. Conversely, PA may gain prominence in the sleep-pain association during the transition from childhood to adulthood, stemming from brain changes during this period. For example, neural systems in PA, particularly reward processing, go through enormous growth during adolescence,¹⁵ and perhaps poor sleep dampens these reward systems in the context of pain intensity only when neural connections are established in adulthood. Further research should examine developing positive and negative affective systems and how these may adapt to poor sleep quality and the experience of pain across the lifespan.

Our findings related to functional disability are similarly mixed in relation to previous literature. For example, in a sample of adults with fibromyalgia, Kothari and colleagues²⁰ reported that PA (but not NA) mediated the relation between poor sleep quality and later activity interference. Although the present findings regarding PA are similar for functional disability, we additionally found NA was a significant mediator of the sleep-disability relationship. As discussed above in relation to pain, it is likely that changes occur across development in affect systems such that the role of NA associated with poor sleep lessens in adulthood. In the case of functional disability, PA systems may be sufficiently developed to impact functioning (but not pain processing systems) early on. An alternative explanation for our findings that PA was only implicated in the sleep-functioning and not the sleep-pain association relates to the nature of the affect questionnaire employed. PANAS positive affect items use activating descriptions, including 'energetic', 'lively' and 'excited', which may be particularly pertinent to a functional outcome that involves activity, compared to pain ratings.

Our moderation results are somewhat distinct from previous literature. While we found no evidence for the moderating role of affect, a previous study of children with SCD reported the impact of poor sleep on reduced next-day functioning weakened at increasing levels of positive mood in children with sickle cell disease.⁴² However, this previous study used a unidimensional measure of affect (positive at one end, negative at the other), which is problematic since positive and negative mood independently influence pain outcomes {Gil, 2003 #106}. In addition, this previous measure specifically examined pain affect. Affect in the context of pain may have a greater role in driving the sleep-pain relationship than general affect. Thus, further research should examine pain affect compared to general affect in the context of sleep and pain to better understand how these specific and general aspects of affect are implicated in the development of sleep and pain problems. Ideally, this research would be conducted longitudinally to establish the temporal ordering of these relationships.

The main limitation of our study is the cross-sectional design, prohibiting causal inferences, especially in determining if disrupted sleep is the primary precursor of increased pain, or if daytime pain is followed by sleepless nights. Additionally, affect may both influence and be influenced by sleep quality.³⁷ Another limitation includes the use of self-report questionnaires. Child informed data is subject to recall bias, due to the considerable cognitive demands placed on children when asked to report pain over extended periods of weeks to months.⁴⁴ Whilst self-report measures are crucial in conveying the self-perceptions of the individual,⁴⁴ future research should incorporate objective instruments (e.g., polysomnography or actigraphy for sleep assessment). The PSQI, although validated to age 14-years may also have been difficult for younger children to understand and future studies that incorporate objective sleep measures may result in more valid measures of sleep quality. The PANAS-C instrument is also limited, since it fails to measure a broad range of emotions to distinguish between symptoms of depression, and symptoms of negative affectivity associated with chronic pain.¹⁸ As mentioned above, alternative measures may be more appropriate for eliciting types of emotional distress specific to the chronic pain experience.¹⁰ Finally, our results do not characterize the distinct developmental differences existing between children and adolescents.¹⁰ For example, during adolescence, unique physiological and social changes occur, involving unique sleep demands,²⁷ and increased pain intensity, depressive symptoms and disability associated with impaired sleep.^{23, 24} Although we controlled for age in analyses, there is evidence for developmental differences in the relationships between affect, sleep and pain (as discussed above), and future studies should include large enough sample sizes to examine potential differences between child and adolescent development.

Despite these limitations, the study has potential clinical implications for future research, which should systematically explore whether incorporating approaches to promote healthy sleep behaviours¹⁰ and addressing internalising symptoms,³ may lead to long-term declines in pain for children and adolescents living with chronic pain. Clinically, and bearing in mind the limitations of our cross-sectional data, the findings suggest that boosting positive affect after a poor night's sleep may be one means of preserving daily function in children with chronic pain. Additionally, targeting negative mood may be beneficial for reducing pain and improving functioning after a poor night's sleep.

Our findings add to the sparse literature in understanding the nature of the relationships among sleep, pain, and affect in pediatric pain populations, and suggest that poor sleep quality contributes to increased pain and disability, at least in part through a reduced sense of wellbeing in children. As such, addressing sleep problems, NA and PA in treatment may reduce pain and improve functioning in children with chronic pain. However, given that affect accounted for less than a quarter and approximately one half of the variance in children's pain and disability scores respectively, it is likely that other biopsychosocial factors beyond this study are also important to target.

In conclusion, this study emphasizes the important role of sleep as a factor in pediatric chronic pain, backed by research showing that children living with chronic pain experience difficulties with attending school, emotional lability, social relationships, and increased pain following insufficient sleep.¹⁰ Negative affectivity may be particularly important when

understanding sleep in relation to pain in children, with mood disruptions and exacerbated pain occurring after poor sleep quality.³¹ Given the paucity of research on sleep in this population, future studies should be directed towards understanding the epidemiology of sleep disorders in children with chronic pain⁴¹ that may lead to clinical innovations focused on problematic sleep. Subsequent analyses should employ rigorous methodologies including longitudinal design and objective physiological markers of sleep, to examine whether improving sleep is an important modifiable risk factor to improve pain and mood, and to verify the efficacy of sleep interventions in improving pediatric chronic pain outcomes long-term.

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References

1. Allan NP, Lonigan CJ, Phillips BM. Examining the factor structure and structural invariance of the PANAS across children, adolescents, and young adults. *J Pers Assess.* 2015; 97:616–625. [PubMed: 25975209]
2. Ayaki M, Torii H, Tsubota K, Negishi K. Decreased sleep quality in high myopia children. *Sci Rep.* 2016; 6:33902. [PubMed: 27650408]
3. Baker AM, Raiker JS, Elkin TD, Palermo TM, Karlson CW. Internalizing symptoms mediate the relationship between sleep disordered breathing and pain symptoms in a pediatric hematology/oncology sample. *Children's Health Care.* 2017; 46:34–48.
4. Benhayon D, Youk A, McCarthy FN, Davis S, Keljo DJ, Bousvaros A, Fairclough D, Kupfer D, Buysse DJ, Szigethy EM. Characterization of relations among sleep, inflammation, and psychiatric dysfunction in depressed youth with Crohn disease. *J Pediatr Gastroenterol Nutr.* 2013; 57:335–342. [PubMed: 23591911]
5. Buysse DJ, Reynolds CF 3rd, Monk TH, Berman SR, Kupfer DJ. The Pittsburgh Sleep Quality Index: A new instrument for psychiatric practice and research. *Psychiatry Res.* 1989; 28:193–213. [PubMed: 2748771]
6. Castarlenas E, Jensen MP, von Baeyer CL, Miro J. Psychometric properties of the numerical rating scale to assess self-reported pain intensity in children and adolescents: A systematic review. *Clin J Pain.* 2016 Aug 11. [Epub ahead of print].
7. Clark LA, Watson D. Tripartite model of anxiety and depression: Psychometric evidence and taxonomic implications. *J Abnorm Psychol.* 1991; 100:316–336. [PubMed: 1918611]
8. Davern M, Cummins R, Stokes M. Subjective wellbeing as an affective-cognitive construct. *J Happiness Stud.* 2007; 8:429–449.
9. de la Vega R, Tome-Pires C, Sole E, Racine M, Castarlenas E, Jensen MP, Miro J. The Pittsburgh Sleep Quality Index: Validity and factor structure in young people. *Psychol Assess.* 2015; 27:e22–27. [PubMed: 26653055]
10. Fales J, Palermo TM, Law EF, Wilson AC. Sleep outcomes in youth with chronic pain participating in a randomized controlled trial of online cognitive-behavioral therapy for pain management. *Behav Sleep Med.* 2015; 13:107–123. [PubMed: 24484373]
11. Faul F, Erdfelder E, Lang AG, Buchner A. G*Power 3: a flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behav Res Methods.* 2007; 39:175–191. [PubMed: 17695343]
12. Finan PH, Goodin BR, Smith MT. The association of sleep and pain: An update and a path forward. *J Pain.* 2013; 14:1539–1552. [PubMed: 24290442]
13. Finan PH, Quartana PJ, Remeniuk B, Garland EL, Rhudy JL, Hand M, Irwin MR, Smith MT. Partial sleep deprivation attenuates the positive affective system: Effects across multiple measurement modalities. *Sleep.* 2016 Sep 9. [Epub ahead of print].

14. Forgeron PA, King S, Stinson JN, McGrath PJ, MacDonald AJ, Chambers CT. Social functioning and peer relationships in children and adolescents with chronic pain: A systematic review. *Pain Res Manag.* 2010; 15:27–41. [PubMed: 20195556]
15. Gruber J, Moskowitz J. Positive emotion: Integrating the light and dark sides. *Oxford Scholarship Online.* Apr.2014
16. Harrison L, Wilson S, Munafo MR. Exploring the associations between sleep problems and chronic musculoskeletal pain in adolescents: A prospective cohort study. *Pain Res Manag.* 2014; 19:e139–145. [PubMed: 25299477]
17. Hayes, AF. *Introduction to Mediation, Moderation, and Conditional Process Analysis: A Regression-Based Approach.* New York, NY: The Guilford Press; 2013.
18. Huelsman TJ, Nemanick RC Jr, Munz DC. Scales to measure four dimensions of dispositional mood: Positive energy, tiredness, negative activation, and relaxation. *Educ Psychol Meas.* 1998; 58:804–819.
19. King S, Chambers CT, Huguet A, MacNevin RC, McGrath PJ, Parker L, MacDonald AJ. The epidemiology of chronic pain in children and adolescents revisited: A systematic review. *Pain.* 2011; 152:2729–2738. [PubMed: 22078064]
20. Kothari DJ, Davis MC, Yeung EW, Tennen HA. Positive affect and pain: Mediators of the within-day relation linking sleep quality to activity interference in fibromyalgia. *Pain.* 2015; 156:540–546. [PubMed: 25679472]
21. Larsson BS. Somatic complaints and their relationship to depressive symptoms in Swedish adolescents. *J Child Psychol Psychiatry.* 1991; 32:821–832. [PubMed: 1918231]
22. Laurent J, Catanzaro SJ, Joiner TE, Rudolph KD, Potter KI, Lambert S, Osborne L, Gathright T. A measure of positive and negative affect for children: Scale development and preliminary validation. *Psychol Assessment.* 1999; 11:326–338.
23. Lewandowski AS, Palermo TM, De la Motte S, Fu R. Temporal daily associations between pain and sleep in adolescents with chronic pain versus healthy adolescents. *Pain.* 2010; 151:220–225. [PubMed: 20719433]
24. Lewandowski AS, Ward TM, Palermo TM. Sleep problems in children and adolescents with common medical conditions. *Pediatr Clin North Am.* 2011; 58:699–713. [PubMed: 21600350]
25. Lewin DS, Dahl RE. Importance of sleep in the management of pediatric pain. *J Dev Behav Pediatr.* 1999; 20:244–252. [PubMed: 10475599]
26. McCaffery, M., Pasero, C. *Pain: Clinical Manual.* 2. St. Louis, MO, Mosby: 1999.
27. Meltzer LJ, Mindell JA. Sleep and sleep disorders in children and adolescents. *Psychiatr Clin North Am.* 2006; 29:1059–1076. abstract x. [PubMed: 17118282]
28. Mollayeva T, Thurairajah P, Burton K, Mollayeva S, Shapiro CM, Colantonio A. The Pittsburgh sleep quality index as a screening tool for sleep dysfunction in clinical and non-clinical samples: A systematic review and meta-analysis. *Sleep Med Rev.* 2016; 25:52–73. [PubMed: 26163057]
29. Naragon, K., Watson, D. Positive affectivity. In: Lopez, S., editor. *The Encyclopedia of Positive Psychology.* Hoboken, NJ: Wiley-Blackwell; 2009. p. 707-711.
30. O'Brien EM, Waxenberg LB, Atchison JW, Gremillion HA, Staud RM, McCrae CS, Robinson ME. Negative mood mediates the effect of poor sleep on pain among chronic pain patients. *Clin J Pain.* 2010; 26:310–319. [PubMed: 20393266]
31. Palermo TM. Impact of recurrent and chronic pain on child and family daily functioning: A critical review of the literature. *J Dev Behav Pediatr.* 2000; 21:58–69. [PubMed: 10706352]
32. Palermo TM, Kiska R. Subjective sleep disturbances in adolescents with chronic pain: Relationship to daily functioning and quality of life. *J Pain.* 2005; 6:201–207. [PubMed: 15772914]
33. Palermo TM, Valrie CR, Karlson CW. Family and parent influences on pediatric chronic pain: A developmental perspective. *Am Psychol.* 2014; 69:142–152. [PubMed: 24547800]
34. Preacher KJ, Hayes AF. SPSS and SAS procedures for estimating indirect effects in simple mediation models. *Behav Res Methods Instrum Comput.* 2004; 36:717–731. [PubMed: 15641418]
35. Schwartz LF, Seidman LC, Zeltzer LK, Tsao JC. Mother-child concordance for pain location in a pediatric chronic pain sample. *J Pain Manag.* 2013; 6:135–145. [PubMed: 26413192]

36. Smith MT, Haythornthwaite JA. How do sleep disturbance and chronic pain inter-relate? Insights from the longitudinal and cognitive-behavioral clinical trials literature. *Sleep Med Rev.* 2004; 8:119–132. [PubMed: 15033151]
37. Steptoe A, O'Donnell K, Marmot M, Wardle J. Positive affect, psychological well-being, and good sleep. *J Psychosom Res.* 2008; 64:409–415. [PubMed: 18374740]
38. Tang NK, Goodchild CE, Sanborn AN, Howard J, Salkovskis PM. Deciphering the temporal link between pain and sleep in a heterogeneous chronic pain patient sample: A multilevel daily process study. *Sleep.* 2012; 35:675–687A. [PubMed: 22547894]
39. Turk DC, Fillingim RB, Ohrbach R, Patel KV. Assessment of psychosocial and functional impact of chronic pain. *J Pain.* 2016; 17(9 Suppl):T21–49. [PubMed: 27586830]
40. Uyan ZS, Turan I, Ay P, Cakir E, Ozturk E, Gedik AH, Gokdemir Y, Erdem E, Sen V, Karadag B, Karakoc F, Ersu R. Sleep disordered breathing and sleep quality in children with bronchiolitis obliterans. *Pediatr Pulmonol.* 2016; 51:308–315. [PubMed: 26129911]
41. Valrie CR, Bromberg MH, Palermo T, Schanberg LE. A systematic review of sleep in pediatric pain populations. *J Dev Behav Pediatr.* 2013; 34:120–128. [PubMed: 23369958]
42. Valrie CR, Gil KM, Redding-Lallinger R, Daeschner C. Daily mood as a mediator or moderator of the pain-sleep relationship in children with sickle cell disease. *J Pediatr Psychol.* 2008; 33:317–322. [PubMed: 17690117]
43. von Baeyer CL, Lin V, Seidman LC, Tsao JC, Zeltzer LK. Pain charts (body maps or manikins) in assessment of the location of pediatric pain. *Pain Manag.* 2011; 1:61–68. [PubMed: 21572558]
44. von Baeyer CL, Marche TA, Rocha EM, Salmon K. Children's memory for pain: Overview and implications for practice. *J Pain.* 2004; 5:241–249. [PubMed: 15219255]
45. Watson D, Clark LA. Negative affectivity: The disposition to experience aversive emotional states. *Psychol Bull.* 1984; 96:465–490. [PubMed: 6393179]
46. Watson D, Clark LA, Tellegen A. Development and validation of brief measures of positive and negative affect: The PANAS scales. *J Pers Soc Psychol.* 1988; 54:1063–1070. [PubMed: 3397865]
47. Williams KE, Nicholson JM, Walker S, Berthelsen D. Early childhood profiles of sleep problems and self-regulation predict later school adjustment. *Br J Educ Psychol.* 2016; 86:331–350. [PubMed: 26918668]
48. Williams KE, Sciberras E. Sleep and self-regulation from birth to 7 years: A retrospective study of children with and without attention-deficit hyperactivity disorder at 8 to 9 years. *J Dev Behav Pediatr.* 2016; 37:385–394. [PubMed: 26982247]
49. Wolfson AR, Carskadon MA. Understanding adolescent's sleep patterns and school performance: A critical appraisal. *Sleep Medicine Reviews.* 2002; 7:491–506.
50. Zempsky WT, Palermo TM, Corsi JM, Lewandowski AS, Zhou C, Casella JF. Daily changes in pain, mood and physical function in children hospitalized for sickle cell disease pain. *Pain Res Manag.* 2013; 18:33–38. [PubMed: 23457684]

Perspective

This article examines the relationship between poor sleep quality, affect (both negative and positive), pain and disability in children with chronic pain. The findings have the potential to better understand the processes involved in how poor sleep may lead to increased pain and pain-related disability.

Highlights

- Sleep, affect, pain and functioning are connected
- Almost three quarters of children with chronic pain reported disordered sleep
- Negative affect, but not positive affect, appears to partially mediate the relationship between poor sleep quality and increased pain ratings in pediatric pain patients.
- Negative and positive affect partially mediate the relationship between poor sleep quality and increased functional disability.

Figure 1.

Mediation model of sleep, negative affect and pain intensity. Estimates of total effect of sleep quality on pain are presented in brackets, with values representing estimates of the total indirect effect of sleep quality on pain through negative affect below the arrow.

Figure 2. Mediation model of sleep, negative and positive affect and functional disability. Estimates of total effect of sleep quality on disability are presented in brackets, with values representing estimates of the total indirect effect of sleep quality on pain through negative affect below the arrow.

Table 1

Demographic information and presenting pain types.

	Children (<i>n</i> = 213)
Child Age (mean (SD))	14.5 (2.43)
Child Gender (<i>n</i> (%))	
Females	148 (69.5%)
Pain Type (<i>n</i> (%))	
Head (Including Face & Neck)	138 (65.1)
Arm (Shoulder, Upper Arm, Elbow, Forearm, Wrist & Hand)	99 (46.7)
Mid (Chest, Abdomen, Hip & Groin)	139 (65.6)
Back (Upper, Mid, Lower)	115 (54.2)
Leg (Thigh, Knee, Calf, Ankle & Foot)	106 (50.0)
Child Ethnicity (<i>n</i> (%))	
Non-Hispanic/Latino	166 (77.9)
Hispanic/Latino	34 (16.0)
Missing/declined to provide	13 (6.1)
Child Race (<i>n</i> (%))	
White	177 (83.1)
African-American	5 (2.3)
Asian	3 (1.4)
American Indian/Alaska Native	2 (0.9)
Other	13 (6.1)
Missing/declined to provide	13 (6.1)
Primary Caregiver Age (mean (SD))	47.6 (5.8)
Primary Caregiver's Education Level (<i>n</i> (%))	
Less than high school	3 (1.4)
Finished high school (or equivalent)	12 (5.6)
Some college or AA degree	55 (25.8)
College degree (BA, BS)	66 (31.0)
Post graduate degree	64 (30.0)
Other	7 (3.3)
Missing/declined to provide	6 (2.8)

Note: percentages sum to more than 100% due to pain in multiple regions. One child did not complete a body map and is therefore not included in Pain Type

Table 2

Correlations, Means and Standard Deviations (SD) of Child Variables.

Measure	Mean	SD	1	2	3	4	5
1. Sleep quality	8.79	(4.44)	-				
2. Negative affect	31.06	(12.61)	0.45**	-			
3. Positive affect	32.27	(11.00)	-0.32**	-0.30**	-		
4. Pain intensity	6.53	(1.96)	0.31**	0.26**	-.16*	-	
5. Functional disability	21.63	(12.48)	0.61**	0.44**	-.34**	0.36**	-

Note.

** $p < .001$;

* $p < .05$