Published in final edited form as:

Health Psychol. 2012 November ; 31(6): 830–833. doi:10.1037/a0026485.

Daytime and nighttime sleep patterns in adolescents with and without chronic pain

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Abstract

Objective—The aims of the current study were to characterize daytime and nighttime sleep patterns of adolescents with chronic pain, and to compare their sleep patterns to a healthy age and sex-matched cohort.

Methods—Sixty-one adolescents from a pain clinic and 60 age and sex-matched youth from the community (mean age = 15.07; 69% female) participated. Participants underwent 10 days of actigraphic sleep monitoring to assess total sleep time (minutes of estimated sleep at night), wake minutes after initial sleep onset, sleep efficiency, and occurrence of sleep during the day.

Results—Adolescents with chronic pain and healthy youth had similar nighttime sleep patterns (total sleep time, wake minutes after initial sleep onset, and sleep efficiency). However, adolescents with chronic pain spent more time sleeping during the day than their healthy peers. Longer daytime sleep was associated with more activity limitations in youth with chronic pain.

Conclusion—Although previous research using self-report methodology has indicated that adolescents with chronic pain commonly endorse poor sleep, findings from the current study suggest that these complaints may not be explained by differences in nighttime sleep patterns as measured by actigraphy. Use of multidimensional sleep assessment may help to understand the potential impact of sleep on chronic pain in adolescents.

Keywords

Chronic pain; sleep patterns; daytime sleep; actigraphy; adolescents

Sleep is intricately connected to adolescent health and well-being (Wolfson & Carskadon, 1998). However, research indicates that adolescents commonly report numerous daytime and nighttime sleep disturbances, including obtaining less than the recommended 9 hours of sleep per night, longer sleep onset latencies (i.e., > 30 minutes), an increasing discrepancy between weekday and weekend sleep patterns, and spending more time sleeping during the day (Millman, 2005; National Sleep Foundation, 2006; Shinkoda, Matsumoto, Park, & Nagashima, 2000). Adolescence represents a period of increased risk for sleep disturbances, and for adolescents with a medical condition, sleep disorders and disturbances are common (Lewandowski, Ward, & Palermo, 2011).

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Chronic pain is a widespread medical condition in childhood, affecting 20 to 35% of children (Perquin et al., 2000), and is associated with a range of sleep difficulties including difficulties falling asleep, night wakings, sleep fragmentation, poor sleep habits, and poor perceived sleep quality (e.g., Meltzer, Logan, & Mindell 2005; Palermo, Wilson, Lewandowski, Toliver-Sokol, & Murray, 2011; Valrie, Gil, Redding-Lallinger & Daeschner, 2007). Adolescents with chronic pain have also reported problems with daytime fatigue (Gold, Mahrer, Yee, & Palermo, 2009) and frequent napping (Tsai et al., 2008; Zamir, Press, Tal, & Tarasiuk, 1998). Research on sleep patterns in youth with chronic pain has been limited to date by small sample sizes, lack of comparison/control groups, and reliance primarily on self-report methodology.

Therefore, the aim of this study was to characterize daytime and nighttime sleep patterns of adolescents with chronic pain, and to compare their sleep patterns to a healthy age and sex-matched cohort. Actigraphy (which measures motion) was used to provide an objective estimate of sleep patterns, and is a methodological strength because it allows for unobtrusive sleep assessment in the adolescent's natural environment. We hypothesized that adolescents with chronic pain would demonstrate on actigraphy reduced nighttime sleep duration, more time awake after initial sleep onset, reduced sleep efficiency, and longer and more frequent daytime sleep compared to their healthy peers.

Methods

Participants—Participants were part of a larger ongoing longitudinal study of sleep disturbances in adolescents. Our prior work in this sample has examined daily associations between sleep and pain intensity (Lewandowski, Palermo, De la Motte, & Fu, 2010), and psychosocial correlates of insomnia (Palermo et al., 2011). We have not reported comparisons of actigraphic data in this sample. All procedures were approved by the hospital Institutional Review Board. Participants included 61 adolescents with chronic pain and 60 age- and sex-matched healthy adolescents (see Palermo et al., 2011 for details on recruitment and study flow).

Procedure—Parents reported demographic information and their adolescent's prescription pain medications. Adolescents reported on usual pain intensity and activity limitations, and completed 10 days of actigraphy monitoring and a daily electronic sleep diary. A-priori power analysis indicated that a sample of 50 adolescents in each study group was necessary for detection of medium to large effects with a power of .80.

Measures

Sleep patterns—Sleep patterns were assessed using the Actiwatch-AW64 system (MiniMitter, Bend, OR), worn on the nondominant wrist, which records sleep-wake patterns based on movement detected by an omnidirectional sensor. Data were scored in 1-minute epochs using the Actiware Sleep version 5 software (Webster, Kripke, Messin, Mullaney, & Wyborne, 1982). Actigraphy has demonstrated up to 95% agreement with polysomnography recordings, indicating good validity (Sadeh, Hauri, Kripke, & Lavie, 1995), and 5 to 7 nights of recordings are considered reliable estimates of total sleep time (Acebo et al., 1999). Participants pushed an event marker on the Actiwatch at bedtime and when they woke in the morning and also completed a corresponding daily electronic sleep diary to assist with scoring the actigraphy records.

Actigraphy was used to calculate all sleep variables, including: total sleep time (in minutes), wake minutes after initial sleep onset, sleep efficiency, nap duration (in minutes), and number of naps. Actigraphy data were available for all subjects ($M = 9$ days, $SD = 1.6$, range

= 3–15 days); averaged sleep variables were used in analyses. *Total sleep time* refers to the total amount of time scored as sleep in minutes from sleep onset to sleep offset. Sleep onset was defined as the first 10 min segment with no more than one epoch of any recorded activity and sleep offset was defined as the last 10 min segment with no more than one epoch of any recorded activity. *Wake minutes after initial sleep onset* represented the number of minutes scored as wake after nighttime sleep onset. *Sleep efficiency* was calculated as the ratio of total sleep time and total time spent in bed at night as a percentage, with values closer to 100 indicating more efficient sleep. Mean *nap duration* was calculated by averaging all naps in minutes, and *number of naps* was coded as the raw number of naps (minimum of 15 minutes duration) during the assessment period. Nap data were coded only if present in daytime actigraphy records and confirmed in the electronic diary.

Pain—Adolescents rated their usual pain intensity over the past month using an 11 point Numerical Rating Scale (NRS) anchored at 0 = no pain and 10 = worst pain possible.

Activity limitations—Adolescent subjective report of activity limitations due to pain was assessed using the Child Activity Limitations Interview-21 (CALI-21; Palermo, Lewandowski, Long, & Burant, 2008). Adolescents reported pain-related difficulty in completing 21 daily activities over the past four weeks. Items were summed to compute the total score.

Prescription pain medications—Parents reported their teen's current prescription pain medication use in three medication classes: antidepressants, anticonvulsants, and opioids.

Results

Description of study groups

See Table 1 for sample demographics. Chi-square and *t*-test analyses indicated no significant differences between groups in age, sex, ethnicity, and SES, indicating that our matching procedure was successful. As expected, adolescents with chronic pain reported greater pain intensity, pain frequency, and activity limitations compared to their healthy peers, $F(3, 115) = 106.98, p < 0.001$.

Greater activity limitations were related to more daytime sleep in adolescents with chronic pain but not in healthy adolescents. In youth with chronic pain, a higher number of naps and longer nap duration were correlated with greater activity limitations (r 's = .25–.28, $p < .05$). Activity limitations were not related to nighttime sleep in either group. Pain intensity was not related to daytime or nighttime sleep in either group.

As shown in Table 1, none of the adolescents in the healthy group were prescribed antidepressants, anticonvulsants, or opioids. Among adolescents with chronic pain, 46 (75%) received one or more of these medications to address their pain problem. Therefore, prescription pain medications were examined as correlates of activity limitations, pain intensity, and sleep variables for the chronic pain group. Use of prescription pain medications was significantly correlated with greater activity limitations (Spearman's $\rho = .45-.48, p < .001$) and higher pain intensity (Spearman's $\rho = .33-.39, p < .001$). Use of antidepressants, anticonvulsants, and opioids were also significantly related to longer nap duration and greater number of naps (Spearman's $\rho = .18-.39, p < .05$), but were not related to nighttime sleep variables ($p > .05$).

Group differences in daytime and nighttime sleep patterns

Table 2 shows sleep variables for youth in the chronic pain and healthy groups. Multivariate analysis of variance (MANOVA) was used to compare the groups on nighttime total sleep time, wake minutes after sleep onset, sleep efficiency, and nap duration. There were significant group differences on sleep patterns, Wilks' $\lambda = 0.88$, $F(4, 116) = 3.65$, $p = 0.008$, with a medium effect size (partial $\eta^2 = 0.12$). Univariate analyses indicated that, contrary to our hypothesis, adolescents with chronic pain and healthy adolescents had similar total sleep time, $F(1, 119) = 2.70$, $p = 0.10$, minutes awake after initial sleep onset, $F(1, 119) = 0.16$, $p = 0.70$, and sleep efficiency, $F(1, 119) = 0.15$, $p = 0.70$; these were small effect sizes ($\eta^2 = .001-.02$). Thus, nighttime sleep patterns were nearly identical between groups. However, as hypothesized, adolescents with chronic pain had longer nap duration than their healthy peers, $M = 56$ min vs 27 min, $F(1, 119) = 8.24$, $p = 0.005$; this was a medium effect with partial $\eta^2 = .07$. Also as hypothesized, adolescents with chronic pain were more likely to take one or more naps during the study period than their healthy peers, 87% vs 44%, $\chi^2(1, N = 121) = 4.40$, $p = .03$.

Discussion

This study evaluated differences in daytime and nighttime sleep patterns in adolescents with chronic pain compared to a healthy age and sex-matched cohort. The groups had nearly identical nighttime sleep patterns reflecting about 7 hours of nightly sleep with some awakenings during the night, indicating that adolescents in the current study were likely to have insufficient nighttime sleep irrespective of chronic pain status. However, adolescents with chronic pain had more daytime sleep including more total naps and naps that were longer in duration. Greater daytime sleep was correlated with higher activity limitations in youth with chronic pain but not healthy youth. These findings add to the limited data on sleep patterns in youth with chronic pain (Tsai, et al., 2008; Zamir, et al., 1998).

Research using self-report methodology has demonstrated that youth with chronic pain have poorer perceived sleep quality relative to their healthy peers (e.g., Palermo, Toliver-Sokol, Fonareva, & Koh, 2007). Findings from the current study suggest that complaints of poor sleep by adolescents with chronic pain documented in previous research may not be clearly explained by differences in nighttime sleep patterns as measured by actigraphy. It is possible that these youth have more worries about sleep loss or greater difficulty coping with insufficient nighttime sleep, thereby leading to greater compensatory sleep during the day. Daytime sleep may also facilitate avoidance of feared situations such as increased pain associated with movement or anxiety-provoking events such as school-reentry. Studies using polysomnography have documented sleep abnormalities such as periodic limb movements and alpha-delta intrusions in youth with chronic pain, which may also contribute to increased daytime sleep (e.g., Passarelli et al., 2006). Multidimensional sleep assessment may help to more fully understand sleep quality in youth with chronic pain and the potential impact of poor sleep on pain intensity and functional outcomes.

Parent-report of antidepressant, anticonvulsant, and/or opioid use for pain management was associated with more daytime sleep, and higher pain intensity and activity limitations among adolescents with chronic pain. Seventy-five percent of adolescents with chronic pain were prescribed one or more medications that may impact sleep and alertness. Although these medications are widely used in pediatric chronic pain treatment, research on their effectiveness is extremely limited (Finley & Gregoire, in press), particularly on side effects as they may relate to daytime sleep and function.

There are several limitations of the study that should be considered. While the use of actigraphy is a methodological strength, it is a proxy measure of sleep providing information

on motion only. Self-report and polysomnography may extend evaluation of other aspects of sleep difficult to assess with actigraphy, such as time spent awake but motionless at night. Second, we were unable to account for differences between groups that may be related to seeking treatment. Finally, these results may not generalize to youth with chronic pain who have not sought specialty care.

Sleep assessment has important clinical implications for youth with chronic pain because of its association with pain and daily function (e.g., Lewandowski et al., 2010). Clinicians working with this population should conduct a detailed assessment of daytime and nighttime sleep patterns, perception of sleep quality, and screening for sleep disorders. Actigraphy could be integrated with subjective measures in the clinical evaluation of sleep to track patterns of sleep over time and in response to intervention.

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Table 1

Sociodemographic and clinical characteristics.

	Chronic Pain n=61	Healthy n=60	Total Sample n=121
Characteristic	n (%) / M (SD)	n (%) / M (SD)	n (%) / M (SD)
Age (years)	15.10 (1.69)	14.82 (1.76)	14.97 (1.72)
Gender			
Male	17 (27.9%)	17 (28.3%)	31 (27.0%)
Female	44 (72.1%)	43 (71.7%)	84 (73.0%)
Child Racial Background			
Caucasian	53 (86.9%)	47 (78.3%)	100 (82.6%)
African American	0 (0.0%)	7 (11.6%)	7 (5.8%)
Am. Indian/Alaska Native	2 (3.3%)	1 (1.7%)	3 (2.5%)
Asian	1 (1.6%)	1 (1.7%)	2 (1.7%)
Other/biracial	4 (6.6%)	4 (6.7%)	8 (6.5%)
Missing	1 (1.6%)	0 (0.0%)	1 (0.9%)
Primary Pain Location			
Head/neck	23 (37.7%)	10 (16.7%)	33 (27.3%)
Abdomen	17 (27.9%)	7 (11.7%)	24 (19.8%)
Musculoskeletal	21 (34.4%)	31 (51.7%)	52 (43.0%)
None	0 (0.0%)	12 (20.0%)	12 (9.9%)
Pain Frequency			
<1 x/mos	0 (0.0%)	22 (37.9%)	22 (18.5%)
1–3 x/mos	0 (0.0%)	13 (22.5%)	13 (10.9%)
Weekly	14 (23.0%)	21 (36.2%)	35 (29.4%)
Daily	47 (77.0%)	2 (3.4%)	49 (41.2%)
Usual Pain Intensity	6.44 (1.72)	3.12 (2.08)	4.81 (2.53)
Activity Limitations (CALI-21 total score)	29.71 (14.94)	17.00 (16.09)	17.96 (16.44)
Prescription Medications			
Anticonvulsants	28 (45%)	0 (0%)	28 (23%)
Antidepressants	23 (38%)	0 (0%)	23 (19%)
Opioids	20 (33%)	0 (0%)	20 (17%)

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Table 2

Group differences on daytime and nighttime sleep patterns.

Sleep Variable	Chronic Pain M (SD) or %	Healthy M (SD) or %
Total sleep time	6 h 54 min (49 min)	7 h 7 min (37 min)
Minutes awake after sleep onset	62.77 min (18.25 min)	61.49 min (18 min)
Sleep efficiency	84.90 (4.29)	85.20 (4.05)
Nap duration **	56 min (65 min)	27 min (43 min)
Number of naps *		
0	26 (42.6%)	37 (61.7%)
1	35 (57.4%)	23 (38.3%)
Bedtime	11:45 PM (105 min)	11:30 PM (105 min)
Wake time	8:15 AM (90 min)	7:30 AM (105 min)

* $p < .05$

** $p < .01$