Polysomnography and Self-reported Sleep, Pain, Fatigue, and Anxiety in Children with Active and Inactive Juvenile Rheumatoid Arthritis

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Objective To compare polysomnography (PSG) and self-reported sleep, symptoms (pain and fatigue), and anxiety between children with active and inactive juvenile rheumatoid arthritis (JRA) and examine relations among sleep, symptoms, and anxiety. Methods Two consecutive nights of PSG, self-reported sleep, and symptoms were obtained in 70 children 6–11 years of age with active (n = 35) or inactive (n = 35) JRA. Results On the second (study) night, PSG and self-reported sleep variables were not different, but pain and fatigue were significantly higher (both p < .02) in children with active compared to inactive disease. In a stepwise regression, age, medications, disease status, anxiety, evening pain, total sleep time, and arousals explained 36% of the variance in fatigue and age, disease status, and evening pain were significant (all p < .04) predictors of fatigue. All children showed longer sleep latency and reduced sleep efficiency on the first night in the laboratory. Conclusions Sleep was not altered in children with active JRA, however, the “first night effect” suggests that valid laboratory sleep assessments require an adaptation night.

Key words fatigue, pain, anxiety; juvenile rheumatoid arthritis; polysomnography; sleep; sleep disturbance.

Introduction

Juvenile rheumatoid arthritis (JRA), also termed juvenile idiopathic arthritis, is one of the most common rheumatologic conditions in children; estimated to affect approximately 300,000 children in the United States (Arthritis Foundation, 2007). JRA is divided into three main subtypes based on the number of joints involved during the first 6 months of illness and the presence or absence of any systemic features. These subtypes include: oligoarticular (arthritis in less than four joints); polyarticular (arthritis in more than five joints); and systemic (arthritis in association with spiking fever, and other systemic features, including rash, hepatosplenomegaly, lymphadenopathy, and serositis) (International League of Associations for Rheumatology Classification, 2004). JRA is an important cause of short- and long-term disability in children (Cassidy & Perry, 2006). The course of JRA is unpredictable with fluctuating periods of active and inactive disease. Children with JRA fatigue easily, experience joint inflammation and swelling, pain and tenderness, morning stiffness, and limited mobility. They also report sleep disturbances including difficulty falling asleep, fragmented sleep with more nightly awakenings, and daytime sleepiness, (Amos, Curry, Drutz, Frost, & Warren, 1997; Bloom et al., 2002; Labyak, Stein, Bloom, Owens & Lunsford, 2001; Passarelli et al., 2006; Zamir, Press, Tal, & Tarasiuk, 1998). Parents often report on questionnaires symptoms suggestive of sleep disorders, including insomnia (difficulty falling asleep, frequent nighttime, and early morning awakenings), parasomnias (sleep terrors, walking), sleep-disordered breathing, and daytime sleepiness (Bloom et al., 2002; Labyak et al., 2001). Further, greater disease severity has been associated with parental reports of more pain and greater interference with daily activities (Bloom et al., 2002).

Disturbed sleep in JRA may be associated with anxiety and pain, and negatively impact fatigue and a child’s ability to engage in daily physical and social activities, but few studies have obtained measures of these symptoms in
conjunction with polysomnography (PSG) and self-report measures of sleep from children (Labyak et al., 2001; Passarelli et al., 2006; Zamir et al., 1998). A recent PSG study by Passarelli and colleagues (2006) found that compared to healthy controls, children with JRA had reduced total sleep time (TST), more transient electroencephalogram (EEG) arousals (brief shifts in the EEG to fast frequency without an awakening), and increased limb movements. Morning stiffness was associated with increased limb movements and pain was associated with a higher number of brief arousals during sleep. Compared to healthy controls, Zamir and colleagues (1998) also found more arousals and a higher number of awakenings in children with JRA. Previous studies based on daily diary reports have shown associations among anxiety, pain, and fatigue in children with JRA (Schanberg, Anthony, Gil, & Maurin, 2003). However, relations among sleep disturbance, symptoms (pain and fatigue), and anxiety in children with JRA have been not been well studied.

The aims of this cross-sectional study were (a) to compare PSG and self-reported sleep, symptoms (pain and fatigue) and anxiety between children with active and inactive JRA, and (b) to examine relations among sleep, symptoms, and anxiety. Based on previous studies of children with JRA, we hypothesized that compared to children with inactive disease, children with active disease would show more disturbed sleep (e.g., reduced TST, longer sleep latency, decreased sleep efficiency (SE), more awakenings of longer duration WASO (wake after sleep onset), and more frequent arousals), and have greater pain, fatigue, and anxiety. As regards the secondary aim, based on a preliminary examination of bivariate correlations, we hypothesized that anxiety and evening pain would explain a significant portion of the variance in disturbed sleep manifested by arousals, and that disturbed sleep (e.g., TST, arousals) would explain a significant portion of the variance in fatigue.

As children age, they sleep less and have reduced slow wave sleep. Based on previous published reports of developmental effects on sleep in healthy preadolescent children (Bes, Schultz, Navelet, & Salzarulo, 1991; Gaudreau, Carrier, & Montplaisir, 2001; Montgomery-Downs, O’Brien, Gulliver, & Gozal, 2006), and because we found inverse correlations between age and TST and Non-rapid eye movement (NREM) sleep stages 3 and 4 (i.e., slow wave sleep), we explored possible interactions among sleep, age, and disease status. Both cognitive and physical developmental changes occur during preadolescence, yet there is a paucity of data about age-related changes in sleep of children with JRA.

Methods

Participants

Approval for this study was obtained from the Institutional Review Board at the Children’s Hospital and Regional Medical Center (CHRMC) in Seattle, WA, USA. From April 2004 through January 2007, a convenience sample of 73 children (64 girls) 6–11 years of age with active or inactive JRA (pauciarticular, polyarticular, and systemic), and their parents were recruited from the Pediatric Rheumatology Clinic at CHRMC. During a routine clinic visit, a rheumatologist informed a parent and child about the study, and if interested, a trained research coordinator explained the purpose of the study and scheduled them for a visit to the Clinical Research Center (CRC) at CHRMC and to the Sleep Research Laboratory at the University of Washington. Children were excluded if they had a diagnosis of a psychiatric condition, diabetes, asthma, cancer; a sleep disorder or family history of narcolepsy in the first-degree relative.

Of the 135 families approached, 62 declined to participate; 48% cited parental time constraints, 52% declined for various reasons (e.g., home residence at a great distance, child was afraid of staying the laboratory, or lack of interest). Of the 73 children enrolled in the study, PSG was obtained on 70 children. Three children (i.e., two children with inactive disease and one with active disease) did not complete the PSG portion of the study because of scheduling conflicts.

General Procedures

On the first day of the study, children were admitted to the CRC where height and weight measures and a blood sample were obtained, and the children and parents completed questionnaires. A pediatric rheumatologist examined the child and rated disease activity (physician global rating) according to standard clinic procedures: active disease was defined as inflammation of one or more joints with swelling, limited range of motion, or tenderness (≥1 on a scale of 0–10); inactive disease was defined as a lack of inflammation, limited range of motion, or tenderness (0 on a scale of 0–10) (Schanberg et al., 2003).

PSG Sleep Recordings

All children and their parents slept in the sleep research laboratory for 2 consecutive nights and arrived at the laboratory ~3 hr prior to the child’s usual bedtime. The first night served as an adaptation night to the laboratory and the second night was the study night. A parent stayed overnight in a separate bed in the same room with the child, or on occasion in an adjoining room with...
a connecting door. Parents did not interact with their child during the night, unless the child required their assurance. A schedule for bedtime and rise time was established based on a child’s usual schedule for a school night, except during summer months when most children followed a similar schedule every night of the week.

Electrodes to record the EEG, electro-oculogram, electrocardiogram, electromyelogram, leg movements, and devices for respiratory (nasal air flow, chest and abdominal movement, oxygen saturation, and snoring sensor) monitoring were placed according to standard criteria (American Academy of Sleep Medicine Task Force, 1999; Rechtschaffen & Kales, 1968). Electrophysiological signals were recorded and digitized by the EMBLA Somnologica data acquisition recording system (A10, MedCare, Reykjavic, Iceland) and displayed and stored on a desktop (Dell Pentium III) computer. Data were continuously displayed in 30 s intervals during each recording.

**Sleep Stage Scoring and Variables**

Sleep recordings from both laboratory nights were scored manually into wake and sleep stages by one technologist according to standard criteria (Rechtschaffen & Kales, 1968). Apneas (absence of airflow for at least two breaths) and hyponeas (50% decrease in nasal airflow with a corresponding 3% decrease in oxygen saturation and/or associated arousal) were scored according to published criteria for children (Montgomery-Downs et al., 2006), and expressed as an apnea/hyponea (AHI) index/hour of TST. Periodic leg movements (PLM, more than four leg movements, of 0.5–5 s duration with an interval of 5–90 s) (American Sleep Disorders Association & Sleep Research Society [ASDA], 1993), and arousals (shift to a fast EEG frequency lasting 3–15 s (ASDA, 1992) were scored manually and each expressed as an index/hour of TST.

Standard sleep variables were calculated. The amount of time in each NREM (1, 2, 3, and 4) and REM sleep stage and WASO were expressed as percentages of sleep period time (SPT) (time from sleep onset until final awakening). TST was the amount of time in NREM stages 1–4 and REM. Sleep latency was the time from lights out to first epoch of NREM stage 2. SE was expressed as a ratio of TST/time in bed. Finally, a fragmentation index (number of times a change from any sleep stage to stage 1 or wake) was expressed per hour of TST (Landis et al., 2001).

**Self-report Laboratory Sleep**

Self-reported sleep was assessed each morning on awakening with a 9-item rise time questionnaire modified from our previous laboratory studies in adults (Landis, Lentz, Tsuji, Buchwald, & Shaver, 2004). Sleep quality was rated on a 5-point Likert scale from (1) “much better” to (5) “much worse” in response to the statements “how did your sleep last night compare to your usual sleep at home”, “how do you think your sleep last night will affect the way you feel today”, and “did you wake up during the night”. Children also were asked how long it took them to fall asleep, the number of night awakenings, and how long they thought they were asleep. Laboratory staff assisted the children to complete this questionnaire.

**Sleep Self Report (SSR)**

Children completed the SSR in the CRC and those <9-years old were interviewed to obtain responses. The SSR is a 26-item retrospective survey of a child’s sleep behavior over the previous week and has established reliability in school-aged children (Bloom et al., 2002; Owens, Spirito, McGuinn, & Nobile 2000). We used five items (“do you think you have trouble sleeping”; “do you fall asleep in about 20 minutes”; “do you wake up at night when your parents think you’re asleep”; “do you have trouble falling back asleep if you wake up during the night?”; “do you feel rested after a night’s sleep”) that were similar to items in the laboratory questionnaire. Survey items are rated on a 3-point scale ranging from 0 to 3 (i.e., 0–1 = “rarely”, 2–4 = “sometimes”, and 5–7 = “usually”); higher scores indicate more disturbed sleep.

**Daily Symptom Diary**

With the assistance from laboratory staff, each morning and evening, children completed questions about their symptoms for the previous night or day in a diary (Labyak et al., 2001). Instruments for reporting pain intensity and location and fatigue were included in the diary.

**Pain Intensity and Location**

Pain intensity was measured with the Oucher Faces Rating Pain Scale (Beyer, Denyes, & Villarruel, 1992); a series of six faces that range from (0) “doesn’t hurt at all” to (10) “hurts as much as you can imagine.” Children placed an “X” on a face that best described their pain. Reported reliability and validity for the Oucher scale are adequate in children 3–12 years of age (Beyer et al., 1992; Beyer & Aradine 1988) and the Cronbach α-coefficient in this sample was .91. Pain location was measured by an investigator-developed skeletal figure, (Mr Bones).
Children circled the joints on Mr Bones that corresponded to the location of their pain (Labyak et al., 2001). The number of joints circled was summed to yield a total “joint hurt” score for each morning and each evening.

**Fatigue**

Children completed the fatigue scale each evening before they went to bed. The Child Fatigue Scale (CFS) is a 14-item, two-part instrument that measures both fatigue frequency (“yes” or “no”) and “bothersome” (intensity, 5-point Likert scale from “not at all” to “a lot”) (Hockenberry et al., 2003). Frequency scores range from 0 to 14 and “bothersome” total scores, range from 0 to 70; higher scores indicate greater amounts of fatigue. In previous studies of children 7 to 10-years old with cancer, Cronbach \( \alpha \)-coefficient was .73 for frequency and .84 for intensity (Hockenberry et al., 2003; Hinds & Hockenberry, 2001). In this study, the Cronbach \( \alpha \)-coefficient was .72 for frequency and .98 for intensity.

**Anxiety**

Children completed the Revised Children’s Manifest Anxiety Scale (RCMAS) (Reynolds & Richmond, 1997), a 37-item self-report scale that assesses the level and nature of anxiety in children from 6 to 19 years of age, in the CRC prior to coming to the sleep laboratory. Raw scores were converted to scaled scores based on the child’s age and sex, and higher scores are indicative of increased anxiety. The RCMAS total anxiety score was used in this study. Reliability and validity of the RCMAS has been well established in a number of pediatric studies and in this study the Cronbach \( \alpha \)-coefficient was .89 for total anxiety.

**Disease-related Variables**

**Functional Status**

Parents completed the Childhood Health Assessment Questionnaire (CHAQ) (Singh, Athreya, Fries, & Goldsmith, 1994), a 30-item scale of disease-related functional status, in the CRC prior to coming to the sleep laboratory. The CHAQ measures level of difficulty in performing tasks in eight domains: dressing, arising, eating, walking, hygiene, reach, grip, and daily activities on a scale of 0 (no difficulty) to 3 (unable to do). The final score for the CHAQ, termed the disability index, is the average of the scores for each domain and was used as a measure of functional disability in this study (Dempster, Porepa, Young, & Feldman, 2001). The reliability and validity of the CHAQ instrument was previously established in children with JRA (Singh et al., 1994) and in this study the Cronbach \( \alpha \)-coefficient was .80 for the total CHAQ scale.

**Medications**

Parents completed a daily diary of medications their child received. Medications were classified into categories: (a) NSAIDS (nonsteroidal anti-inflammatory drugs); (b) Corticosteroids; (c) Folic Acid Pathway Inhibitors (Methotrexate, Arava); (d) TNF alpha inhibitors (enbrel, humira, remicade); and Other (i.e. vitamins) and None. Each medication category was scored as “yes” or “no” depending upon whether the child received a medication in that category anytime during the study.

**Statistical Analyses**

Data were analyzed using SPSS for Windows version 14.0 (SPSS Inc, Chicago, IL, USA). The first set of analyses was conducted to address group differences in study variables between children with active and inactive disease (aim #1). Given the different types of variables measured in this study, data analyses were blocked into conceptual categories and then analyzed (e.g., demographics, disease related variables, symptoms (pain and fatigue), anxiety, self-report habitual and laboratory sleep, and PSG sleep) for group differences. Each category was considered a separate analysis with significance set at \( p < .05 \) (2-sided). Paired \( t \)-test or chi-squared test was used to test for group differences.

Second, we examined relations among sleep and symptoms (aim #2) with a series of stepwise regression models. We explored how much of the variance in disturbed sleep (arousals) was explained by baseline anxiety and evening pain, and how much of the variance in fatigue intensity was explained by anxiety, evening pain, and disturbed sleep (TST and arousals). Age, medications, and disease status were used as control variables.

Finally, we explored developmental changes in sleep with age. General linear model (GLM) analyses (i.e., repeated measures analyses) were used to evaluate main effects and interactions with sleep stages (i.e. stage 1, stage 2, stage 3, stage 4, REM, and wake) and sleep disturbance variables (TST, SE, sleep latency) as
Within-subjects factors, and age and disease condition as the between-subjects factors.

**Results**

**Clinical Characteristics**

The clinical characteristics of the children are presented in Table I. The sample was 84% White, which is representative of the Seattle area. There were similar numbers of children in the active and inactive disease groups and no differences between groups in age or sex. As might be expected, compared to children with inactive disease, children with active disease had higher mean physician global rating, were taking more NSAIDS ($\chi^2 = 10.6, p < .001$) and other medications ($\chi^2 = 5.5, p < .02$). Pain and fatigue were higher in children with active compared to those with inactive disease, but there were no differences in sedimentation rate, disease duration, disability, number of painful joints, or anxiety.

**PSG and Self-report Sleep by Disease Condition**

Table II shows PSG and self-report sleep measures by disease condition. There were no group differences in PSG variables, e.g., TST, SE, sleep latency, WASO, arousals, or in sleep-related events, e.g., apnea/hypopnea index (AHI) and periodic limb movements. More children with active disease reported usually having trouble sleeping and waking up at night, but their sleep latency and how rested they felt in the morning were similar to those of children with inactive disease. In the laboratory, children with active disease reported longer sleep latency and more WASO, but these differences were not statistically significant.

**Predictors of Sleep Disturbance and Daytime Symptoms**

In the first regression model testing predictors of the dependent variable disturbed sleep (arousals), age and medications, anxiety, and evening pain explained 18% of variance, but neither anxiety or pain had a significant effect (both $p > .05$) (Table III). In the second regression model testing predictors of the dependent variable fatigue, age, medications and disease status, anxiety, evening pain, TST, and arousals explained 36% of the variance, and only age, disease status and evening pain had a significant effect (all $p < .04$).

**First Night Effect**

As shown in Table III, all children had reduced mean TST, lower SE, and increased WASO on the adaptation compared to the study night despite a similar time in bed on both nights. Because SE of $\leq 85\%$ is often used as PSG indicator of poor sleep (Coates et al., 1982; Frankel, Coursey, Buchbinder, & Snyder, 1976), we grouped all the children into those above and below 85% and compared mean SE and sleep latency for the adaptation and the study night. SE was lower on the adaptation

**Table I. Demographic and Clinical Characteristics**

<table>
<thead>
<tr>
<th></th>
<th>Inactive disease ($n = 32$)</th>
<th>Active disease ($n = 38$)</th>
<th>95% Confidence interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, years</td>
<td>8.1 ± 1.8</td>
<td>8.9 ± 2.0</td>
<td>−1.6, 0.2</td>
</tr>
<tr>
<td>Ethnicity, n (%)</td>
<td></td>
<td></td>
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<tr>
<td>White</td>
<td>27 (84)</td>
<td>34 (89.4)</td>
<td></td>
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<tr>
<td>Other</td>
<td>5 (15.6)</td>
<td>4 (10.5)</td>
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<tr>
<td>Sex, n (%)</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Girls</td>
<td>8 (87.5)</td>
<td>31 (81.6)</td>
<td></td>
</tr>
<tr>
<td>Boys</td>
<td>4 (12.5)</td>
<td>7 (18.4)</td>
<td></td>
</tr>
<tr>
<td>Disease Type, n (%)</td>
<td></td>
<td></td>
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<tr>
<td>Oligoarticular</td>
<td>5 (46.8)</td>
<td>11 (28.9)</td>
<td></td>
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<tr>
<td>Polyarticular</td>
<td>16 (50)</td>
<td>24 (63.2)</td>
<td></td>
</tr>
<tr>
<td>Systemic</td>
<td>1 (.03)</td>
<td>3 (.08)</td>
<td></td>
</tr>
<tr>
<td>Disease duration, years</td>
<td>3.8 ± 2.7</td>
<td>3.4 ± 3</td>
<td>−9.1, 1.8</td>
</tr>
<tr>
<td>Physician Global Rating (0–10)</td>
<td>0.06 ± 0.2</td>
<td>2.8 ± 2</td>
<td>−3.4, −2.1**</td>
</tr>
<tr>
<td>Sedimentation Rate, mm/hour</td>
<td>6.2 ± 6</td>
<td>8.2 ± 8</td>
<td>−5.9, 1.9</td>
</tr>
<tr>
<td>Functional Status (disability index)</td>
<td>0.4 ± 0.4</td>
<td>0.4 ± 0.45</td>
<td>−0.16, 0.25</td>
</tr>
<tr>
<td>Medications, n (%)</td>
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<tr>
<td>NSAIDSa</td>
<td>9 (28)</td>
<td>26 (71)</td>
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<tr>
<td>Corticosteroids</td>
<td>7 (22)</td>
<td>12 (34)</td>
<td></td>
</tr>
<tr>
<td>Folic acid pathway Inhibitors</td>
<td>16 (50)</td>
<td>21 (55)</td>
<td></td>
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<tr>
<td>TNF alpha inhibitors</td>
<td>9 (3.3)</td>
<td>9 (13)</td>
<td></td>
</tr>
<tr>
<td>Otherb</td>
<td>7 (22)</td>
<td>19 (50)</td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>8 (25)</td>
<td>2 (53)</td>
<td></td>
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<tr>
<td>Pain intensity, (0–10)</td>
<td>0.3 ± 0.9</td>
<td>1.2 ± 2.1</td>
<td>−1.7, 0.14*</td>
</tr>
<tr>
<td>A.M.</td>
<td>1.1 ± 1.9</td>
<td>1.4 ± 2.3</td>
<td>−1.3, 0.74</td>
</tr>
<tr>
<td>P.M.</td>
<td>0.4 ± 0.9</td>
<td>1.0 ± 2.4</td>
<td>−1.4, 0.34</td>
</tr>
<tr>
<td>Painful joints</td>
<td></td>
<td></td>
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<tr>
<td>A.M.</td>
<td>0.2 ± 0.8</td>
<td>0.9 ± 2.5</td>
<td>−1.6, 0.13</td>
</tr>
<tr>
<td>P.M.</td>
<td>0.4 ± 0.9</td>
<td>1.0 ± 2.4</td>
<td>−1.4, 0.34</td>
</tr>
<tr>
<td>Fatigue</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Frequency (yes/no)</td>
<td>3.1 ± 1.9</td>
<td>3.4 ± 2.5</td>
<td>1.4, 0.80</td>
</tr>
<tr>
<td>Bothersomeness (not at all, to a lot)</td>
<td>6.4 ± 3.8</td>
<td>9.4 ± 5.8</td>
<td>−5.6, 0.46*</td>
</tr>
<tr>
<td>Anxiety (x + SD)</td>
<td>42.0 ± 10.8</td>
<td>44.0 ± 10.5</td>
<td>−7.5, 3.6</td>
</tr>
</tbody>
</table>

Data are mean ± SD or n (%).

*a$\chi^2 = 10.6, p < .001$.

*b$\chi^2 = 5.5, p < .02$.

*Both $p < .02$, **$p < .001$.
night compared to the study night; 36% of the children had a mean SE of 77% and a mean sleep latency of 44 min. In the children with active disease and a SE of ≤85%, significantly (χ² = 6.8, p < .009) more were in the older (64%) compared to the younger (17%) age group.

### Developmental Aspects of PSG Sleep

Based on previous published reports of age-related effects on sleep in healthy children (Bes et al., 1991; Gaudreau et al., 2001; Montgomery-Downs et al., 2006) and our findings of a first night effect in children with JRA, we examined the amount of sleep stages and wake as well as indicators of sleep disturbance (TST, sleep latency, SE, WASO, and arousals) as a function of age, night, and disease condition. Table IV shows the PSG data by age group (6–8 years and 9–11 years), night, and disease condition. Although differences were not found for the percentage of time children spent in each sleep stage and wake for both nights, marginal residuals showed an age-related effect in that the percentage of NREM stage 2 was increased, while those of NREM stages 3 and 4 (slow wave sleep) were decreased in the 9- to 11-year-old children during both nights. As regards sleep disturbance variables, TST was affected only by age; however, an age by disease condition interaction was found both for sleep latency and SE. We conducted these analyses controlling for medications with similar results.

### Discussion

In this study of children with JRA, although there were few differences in PSG and self-reported sleep between children with active versus inactive disease, we found a prominent “first-night” effect and evidence that age, disease status and pain, but not sleep, contribute to fatigue. Further, we found an age-related decrease in sleep duration (TST), and interactions between age and
disease in time to fall asleep (sleep latency) and overall SE. Younger children with active disease slept a bit more and fell asleep more quickly than older children with active disease. We discuss these findings relative to those of others.

Sleep and Disease Condition

We were surprised that there were no differences between children with active versus inactive disease both for PSG and self-report sleep measures. Based on previous studies, we anticipated that children with active disease would show more disturbed sleep compared to those with inactive disease. Compared to previous studies (Zamir et al., 1998; Passarelli et al., 2006), children in our study had a similar number of arousals, fewer periodic limb movements, but a higher AHI (>1) that is indicative of mild sleep disordered breathing (Redline et al., 2007). These findings may reflect particular child characteristics, distinct mechanisms, or a combination of medication use, disease type, and severity. Children in our study had longer mean TST (8.7 hr) and slightly higher mean SE (90%) compared to previous laboratory studies (6.3–7.9 hr; 86–88%) of children with JRA (Amos, 1997; Coble, Kupfer, Taska, & Kane, 1984; Labyak et al., 2001; Passarelli et al., 2006; Zamir et al., 1998). The differences in TST and SE in our study may be attributed to the addition of an adaptation night, and time in bed was based on their usual sleep at home, not on a set laboratory schedule. Alternatively, children in our study may have had milder disease compared to children in other published studies. Amounts of stage 1 and REM sleep were similar to previous published reports (Passarelli et al., 2006; Zamir et al., 1998), but the amount of NREM stage 2 was lower and that of slow wave sleep (NREM stage 3 and 4) was higher in our study (Passarelli et al., 2006; Zamir et al., 1998). Age, medications, treatment modalities, and more generous scoring of slow wave sleep in our study may explain differences in the reported amounts of NREM sleep stages. Further study is warranted to compare PSG sleep stages in children with JRA and healthy children of the same age.

A marked “first-night” effect was evident in this study. Compared to the study night, more than a third of the children had longer sleep latency, less TST, and more nocturnal wakefulness leading to reduced SE on the first night in the laboratory. We attribute this to reactions of the children to sleeping in a new environment. This interpretation is supported by the observation that only 10% of the children exhibited reduced SE on the second night. These findings are similar to those from Coble and colleagues (1984) and Carskadon and colleagues (Carskadon, Keenan, & Dement, 1987) who also reported a “first-night” effect in healthy school-aged children. Most of the reported PSG data in children are based on a single night in a sleep laboratory, which may overestimate the extent of sleep disturbance and not

### Table IV. Polysomnography Sleep Variables for Adaptation and Study Nights by Disease Status and Age

<table>
<thead>
<tr>
<th></th>
<th>Active disease</th>
<th>Inactive disease</th>
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<td>9–12 years</td>
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<td></td>
<td>n = 16</td>
<td>n = 22</td>
<td>n = 19</td>
<td>n = 13</td>
<td>n = 16</td>
<td>n = 22</td>
</tr>
<tr>
<td>SPT min&lt;sup&gt;a&lt;/sup&gt;</td>
<td>602 ± 10</td>
<td>553 ± 8</td>
<td>566 ± 9</td>
<td>542 ± 11</td>
<td>610 ± 9</td>
<td>575 ± 7</td>
</tr>
<tr>
<td>TST min&lt;sup&gt;b&lt;/sup&gt;</td>
<td>548 ± 13.6</td>
<td>481 ± 11.2</td>
<td>501 ± 12.1</td>
<td>494 ± 14.6</td>
<td>563 ± 9.6</td>
<td>537 ± 8.0</td>
</tr>
<tr>
<td>Sleep efficiency,%&lt;sup&gt;c&lt;/sup&gt;</td>
<td>89 ± 2.1</td>
<td>82 ± 1.8</td>
<td>84 ± 1.9</td>
<td>88 ± 2.3</td>
<td>91 ± 1.2</td>
<td>90 ± 0.9</td>
</tr>
<tr>
<td>Sleep latency, min&lt;sup&gt;d&lt;/sup&gt;</td>
<td>16 ± 5.4</td>
<td>42 ± 4.4</td>
<td>27 ± 4.8</td>
<td>21 ± 5.8</td>
<td>13 ± 4.0</td>
<td>23 ± 3.3</td>
</tr>
<tr>
<td>WASO,% SPT</td>
<td>8.6 ± 2.1</td>
<td>12.7 ± 1.8</td>
<td>11.2 ± 1.9</td>
<td>8.5 ± 2.3</td>
<td>7.5 ± 1.1</td>
<td>6.4 ± 0.9</td>
</tr>
<tr>
<td>NREM stage 1,% SPT</td>
<td>7.0 ± 7.0</td>
<td>6.7 ± 60</td>
<td>6.2 ± 64</td>
<td>8.0 ± 78</td>
<td>5.8 ± 62</td>
<td>5.8 ± 51</td>
</tr>
<tr>
<td>NREM stage 2,% SPT</td>
<td>18.3 ± 2.1</td>
<td>29.8 ± 1.8</td>
<td>22.2 ± 1.9</td>
<td>30.1 ± 2.3</td>
<td>19.4 ± 2.1</td>
<td>30.5 ± 1.7</td>
</tr>
<tr>
<td>NREM stage 3,% SPT</td>
<td>15.9 ± 99</td>
<td>9.6 ± 84</td>
<td>14.5 ± 91</td>
<td>10.7 ± 1.1</td>
<td>17.0 ± 1.1</td>
<td>11.1 ± 89</td>
</tr>
<tr>
<td>NREM stage 4,%SPT</td>
<td>29.8 ± 1.6</td>
<td>21.1 ± 13</td>
<td>28.9 ± 1.4</td>
<td>24.3 ± 1.7</td>
<td>29.9 ± 1.7</td>
<td>22.3 ± 1.4</td>
</tr>
<tr>
<td>REM,% SPT&lt;sup&gt;e&lt;/sup&gt;</td>
<td>20.3 ± 1.1</td>
<td>20.0 ± 93</td>
<td>16.9 ± 1.0</td>
<td>18.4 ± 1.2</td>
<td>20.4 ± 95</td>
<td>23.7 ± 7.8</td>
</tr>
<tr>
<td>Arousals, #/h</td>
<td>9.8 ± 2.1</td>
<td>8.6 ± 1.8</td>
<td>12.5 ± 1.9</td>
<td>8.9 ± 2.3</td>
<td>9.4 ± 1.1</td>
<td>7.6 ± 9.0</td>
</tr>
</tbody>
</table>

<sup>a</sup>SPT, sleep period time; TST, total sleep time. Data are mean ± SEM. Sleep efficiency % = TST/time in bed × 100.

<sup>b</sup>F<sub>(1,65)</sub> = 6.3, p < .02 main effect by disease condition and F<sub>(1,65)</sub> = 17.6, p < .001 by age group.

<sup>c</sup>F<sub>(1,65)</sub> = 14.2, p < .001 main effect by age group.

<sup>d</sup>F<sub>(1,65)</sub> = 5.1, p < .03 age group and disease condition interaction.

<sup>e</sup>F<sub>(1,65)</sub> = 9.5, p < .003 age group and disease condition interaction.

<sup>f</sup>F<sub>(1,65)</sub> = 53, p < .02 main effect by disease condition (adaptation night).
represent the most valid sleep assessment. A first night effect suggests that some children may be vulnerable to reduced sleep quality under conditions of "mild stress" (i.e., environmental change in sleep). It also is possible that parental reports of usual bedtimes were inaccurate, leading to artificially prolonged sleep latency and time in bed. However, we were careful in establishing each child’s laboratory schedule and used the same bedtime and rise time such that time in bed was similar for both nights.

Relations Among Sleep, Pain, Anxiety, and Fatigue

Anxiety, pain, and fatigue are associated with disturbed sleep but few studies have examined these variables together. Previous studies (Bloom et al., 2002; Labyak et al., 2001; Lewin & Dahl, 1999; Palermo & Kiska 2005; Passarelli et al., 2006; Palermo 2000) report various associations among sleep, pain, and anxiety and several studies report higher levels of anxiety in children with JRA and pain (Schanberg et al., 2003; Varni et al., 1996), and in children with musculoskeletal pain syndromes (Meltzer, Logan, & Mindell, 2005). Pain, even low levels of pain intensity, has been linked to shorter TST, longer sleep onset, and reduced sleep continuity. In this study, compared to children with inactive disease, we found that children with active disease had more pain and fatigue, but no differences in anxiety. Anxiety and pain prior to sleep onset, explained a small amount of the variance in nocturnal arousals as an indicator of sleep disturbance on the study night, but neither pain nor anxiety had an important effect. When these variables were examined together in one model, a modest amount of the variance in fatigue was explained, but anxiety and disturbed sleep did not have important effects. Rather age, disease status, and pain were the best predictors of fatigue. The lack of a negative impact of sleep on fatigue is probably related to the observation that children slept fairly well on the second night in the laboratory. Alternatively, we obtained measures of fatigue in the evening. Effects of disturbed sleep on fatigue might be more apparent if measures had been obtained in the morning on awakening.

It is of note that in our sample, mean fatigue frequency and intensity scores were lower than those previously reported in children with cancer, the population for whom the instrument was developed (Hinds & Hockenberry 2001; Hinds et al., 1999). This instrument has been widely used in 7 to 12-year-old children with cancer; however, the symptoms of fatigue may vary in children with different chronic illnesses (i.e., cancer vs. JRA vs. sickle cell disease) (Davies, Whitsett, Bruce, & McCarthy 2002; Hinds et al., 1999; Hockenberry-Eaton et al., 1998; White, 2001). Additional research on fatigue in children with JRA is needed to further our understanding of the interplay among fatigue, pain, and sleep.

Developmental Aspects and Sleep

Children with JRA showed age-related (developmental) changes in sleep amount and NREM sleep stages. Compared to younger children, older children with JRA had less total sleep and showed increased stage 2 sleep and decreased slow wave sleep (stages 3 and 4). These findings provide support for the notion that age-related changes occur in NREM sleep in preadolescent children with JRA. Typically compared to preadolescent children, adolescents show large reduced amounts of slow wave sleep, and these changes are usually attributed to changes in neuroendocrine function with puberty (Carskadon et al., 1987; Dahl 1996; Dahl & Lewin 2002). There is a paucity of research pertaining to sleep and age-related changes in children 8–11 years. Few studies of healthy children have been reported with which to compare our results. Most of the research on sleep patterns stem from parental report or one night of PSG that may not accurately depict developmental changes in preadolescent sleep patterns. Future studies comparing children with JRA or other chronic illnesses to healthy children are needed to verify our observations.

Limitations

There are several limitations worth noting in this study. First, the convenience sample was primarily Caucasian that limits generalizability to all children with JRA, but our sample is fairly representative of children with active and inactive JRA and who live in the Pacific Northwest. Second, a cross-sectional design limits directionality, as all the associations are potentially bidirectional. Third, depression was not measured in this study and could have influenced sleep outcomes. Fourth, we did not have a healthy control group for comparison to adequately address developmental changes in preadolescent sleep patterns.

Conclusion and Future Direction

In summary, few studies have examined both PSG and self-reported sleep in children with JRA, and the impact of disturbed sleep on symptoms of pain and fatigue, anxiety, and daytime function. Poor sleep quality associated with arousals or sleep-related respiratory disturbance can lead to fatigue and decrements in daytime functioning that may negatively impact a
child’s well being and quality of life. Further studies are warranted to examine objective and self reports of sleep in relation to daytime functioning in children with JRA.

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Conflicts of interest: None declared.

References


