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Longitudinal and Temporal Associations Between Daily Pain and Sleep Patterns After Major Pediatric Surgery

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Abstract: **Approximately 20% of children develop persistent pain after major surgery. Sleep disruption has been implicated as a predictor of children's acute postsurgical pain. However, perioperative sleep patterns have not been longitudinally assessed, and the role of sleep in persistence of postsurgical pain has not been explored. We aimed to examine sleep patterns over 4 months in children having major surgery, and temporal relationships between daily sleep and pain. Sixty children age 10 to 18 (mean = 14.7) years having major surgery completed 7 days of actigraphy sleep monitoring (sleep duration, efficiency), twice daily electronic diaries (sleep quality, pain intensity, medication use), and validated questionnaires at presurgery, 2 weeks, and 4 months postsurgery. Generalized linear models, controlling for age, sex, naps, and medication, showed sleep quality (β [B] = −.88, *P* < .001) and efficiency (B = −1.50, *P* = .036) were significantly reduced at 2 weeks compared with presurgery, and returned to baseline by 4 months. Poorer night-time sleep quality was significantly associated with greater next day pain intensity (B = −.15, *P* = .005). Sleep duration and efficiency were not associated with subsequent pain; daytime pain was not associated with subsequent sleep. Findings suggest sleep quality may be an important target for intervention after surgery in children; research is needed to understand how other sleep parameters may relate to recovery.**

Perspective: ***This study assessed longitudinal sleep patterns over 4 months after major pediatric surgery using actigraphy, diaries, and validated measures. Sleep quality and efficiency were significantly reduced at 2 weeks. Poorer sleep quality was associated with greater next day pain intensity suggesting that sleep quality may be an important target for intervention.***

Key words: *Postoperative pain, pediatric pain, scoliosis surgery, spine fusion, perioperative sleep.*

Despite dramatic advances in perioperative care, persistent pain is a frequent occurrence after surgery for individuals across the lifespan. Recent research in children has identified high rates (18–22%) of persistent postsurgical pain after major pediatric surgery.[3,24,32] Several biopsychosocial risk factors have been identified as important predictors of pain persistence and poor long-term recovery after surgery.[3,13,14,24,32] In adults, the role of sleep disruption has emerged as a relevant predictor of acute as well as chronic postsurgical pain.[29,42] Recent studies reported that sleep disruption mediates the relationship between acute postoperative pain and subsequent recovery,[4] and that sleep disturbance after surgery is associated with persistent pain.[2] This is consistent with research in other clinical populations showing that sleep plays a central role in development and maintenance of chronic pain,[7] likely because of a number of mechanistic pathways. In healthy adults, sleep deprivation is associated with sympathetic activation and increased stress response,[9] and sleep fragmentation leads to decreased endogenous pain inhibition and increased pain sensitivity.[33,35,36,38] Mechanistic human and animal studies also support significant interactions between sleep and

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inflammation,[18,22] which may be particularly relevant during recovery and healing after surgery. However, there has been limited assessment of perioperative sleep patterns in children.

In previous research assessing sleep in children after surgery using parent-reported questionnaires[11] and actigraphy monitoring of sleep patterns,[10] sleep disturbances were reported to occur commonly in young children in the initial days after surgery. In a cross-sectional study examining chronic pain in children after surgery a subgroup of children continued to perceive disrupted sleep several months after surgery.[8] Further, in our previous investigation in this sample of children undergoing major surgery, sleep disturbance before major surgery was a risk factor for acute postsurgical pain, with shorter duration of sleep in the week before surgery predicting higher acute postsurgical pain intensity at home after surgery.[30] A large portion of these children (18%) went on to develop persistent pain over 12 months after surgery.[32] However, perioperative daily sleep patterns have not been longitudinally assessed in children, and the role of sleep in persistence of children's pain after surgery has not been explored.

This gap in understanding of sleep in children undergoing surgery is important because in other pediatric pain populations daily temporal associations have been reported between sleep and pain, suggesting that sleep may be an important target for intervention. For example, in adolescents with chronic pain, greater sleep fragmentation measured using actigraphy was associated with higher next-day pain intensity. Interestingly, daytime pain was not associated with subsequent sleep, suggesting sleep may be a stronger predictor of pain than vice versa.[17]

Thus, the aims of the study were to examine longitudinal sleep patterns over 4 months in children having major surgery and to examine the temporal relationship between daily sleep and pain. A multimethod assessment including electronic diaries, questionnaire measures, and ambulatory actigraphy monitoring was used to comprehensively assess sleep during 3 data waves (baseline, 2 weeks, and 4 months) and control for factors that may affect the relationship between sleep and pain in the context of surgery such as daytime sleep (naps) and medications (eg, opioids). Understanding directional relationships between daily sleep and pain is critical to development of targeted interventions for children experiencing problems with pain, sleep, and recovery after surgery.

We hypothesized that children would show reduced sleep quality and sleep efficiency during the acute recovery period at home 2 weeks after surgery compared with baseline (presurgery). We expected to find bidirectional daily relationships between pain and sleep over 4 months; however, on the basis of research in other pediatric pain samples, we expected sleep to be a stronger driver of the relationship with poorer night-time sleep patterns (poorer sleep quality, shorter sleep duration, and poorer sleep efficiency) predicting greater next-day pain intensity.

Methods

Participants and Setting

Sixty children scheduled for major surgery at a single tertiary children's hospital in the Pacific Northwest were enrolled in the study over a 21-month period. Institutional review board approval was obtained, and children gave their assent and parents provided consent before study participation.

Inclusion and Exclusion Criteria

Children were eligible for inclusion in the study if they were: 1) 10 to 18 years of age, 2) undergoing major spine or chest wall surgery (spinal fusion, pectus correction surgery), and 3) able to understand English. Children were excluded from the study if they: 1) had developmental delay, 2) had a major comorbid illness (requiring a daily medication or previous major surgery), 3) did not reside with their legal guardian, or 4) the legal guardian was non-English speaking. Of children identified as meeting inclusion criteria, 32 were ineligible on the basis of exclusion criteria. The rate of participation was 67% among children approached for the study, with lack of time or interest cited as primary reasons for nonparticipation.

Procedures

Children completed 3 data waves (baseline, 2 weeks after hospital discharge, 4 months after surgery) during which sleep and pain was monitored using a 7-day actigraphy and daily diary protocol. Of the 60 children enrolled in they study, 59 (98%) completed the baseline assessment, 57 (95%) completed the 2-week assessment, and 54 (90%) completed the 4-month assessment. During each assessment period, children completed an electronic diary twice daily, once in the morning after waking, and once in the evening before going to bed, using a handheld customized diary program on a Palm PDA (Sunnyvale, CA). Children concurrently wore an Actiwatch 2 (Philips Respironics, Bend, OR) to monitor sleep patterns for 7 days. Children also completed the Adolescent Sleep Wake Scale (ASWS) assessing sleep quality over the previous month at baseline, 2 weeks, and 4 months after surgery. Parents completed a demographic questionnaire at baseline. Study materials were sent to participants and returned by courier. Participants received gift cards on completion of each data wave. Clinical data were collected from the medical record by study personnel.

Short-term and long-term pain data have been reported for this sample.[30,32] Baseline sleep duration was examined as a predictor of short-term outcomes.[30] The present article is the first to report on longitudinal sleep patterns and daily temporal relationships between sleep and pain after surgery for this sample.

Measures

Morning Diary; Sleep Quality

Upon waking each morning, children reported on sleep quality for the previous night on an 11-point