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Subjective and objective sleep quality assessment in adolescent patients with inflammatory bowel disease

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A B S T R A C T

Objectives: There is a link between inflammatory bowel disease (IBD) and poor sleep quality that is presumed to be multifactorial. The purpose of this study was to identify factors that impact sleep quality in this group including clinical disease activity, depression, anxiety, quality of life, and disordered social media use through questionnaires.

Methods: This prospective study analyzed sleep quality in adolescent patients ages 13 to 18 with a diagnosis of IBD using objective data from wrist actigraphy and subjective report from the Pittsburgh Sleep Quality Index (PSQI). Additional screeners including the Short Pediatric Crohn's Disease Activity Index or Pediatric Ulcerative Colitis Activity Index, Pediatric Quality of Life Inventory Gastrointestinal Symptoms Module, Generalized Anxiety Disorder 7-item screener, Patient Health Questionnaire depression screener, and Social Media Disorder scale were also collected.

Results: Twenty-three subjects enrolled and 16 completed questionnaires. 62.5 % of participants were in clinical remission and the remaining 37.5 % had mild to severe clinical IBD activity. Poor subjective sleep quality was associated with a shorter duration of sleep time and an increased clinical disease activity score. Patients in clinical remission slept for a longer duration than those with mild IBD activity.

Conclusions: This study did not identify a significant relationship between sleep quality and psychosocial factors in the adolescent population with IBD, though their influence cannot be discounted. There was a connection between the presence of disease activity and shorter sleep duration. Similarly, PSQI scores correlated with sleep time but not sleep quality.

1. Introduction

Inflammatory bowel disease (IBD) is a chronic autoimmune disease that encompasses both Crohn's Disease (CD) and Ulcerative Colitis (UC). Both conditions affect the GI tract, but UC is limited to colonic inflammation; whereas, CD can affect any region of the GI tract and has multiple disease phenotypes including inflammatory, structuring and/or penetrating disease. A quarter of new IBD cases are diagnosed in patients under the age of 20 with peak incidence in adolescence [1]. The goal of treatment is to achieve remission with resolution of symptoms, restoration of normal growth, and prevention of complications.

Poor sleep and IBD have a reciprocal relationship. Individuals with IBD generally experience disturbed sleep [2]. Patients with active IBD suffer from poorer sleep quality than those with IBD in remission and healthy controls [2–4]. There is also evidence to suggest that poor sleep in CD patients in clinical remission is associated with an increased risk of disease flare [5]. This could potentially be explained by the theory that inflammation in IBD worsens sleep quality, and poor sleep exacerbates inflammatory cytokine production which further drives mucosal inflammation [6]. However, the psychological impact of chronic disease can also weigh heavily on individuals with IBD and impact sleep quality. Adults with IBD and poor sleep have reported low quality of life and increased incidence of depression [7]. Sleep quality in adolescents is also significantly impacted by screen and technology use and social media interactions, particularly at nighttime [8]. Therefore, it is likely that the influence on sleep quality in teenage patients with IBD is multifactorial.

The American Academy of Pediatrics (AAP) and the American Academy of Sleep Medicine consensus group recommends that teenagers 13–18 years of age should sleep 8–10 h per day to promote optimal physical, psychological, and immunological health [9]. Prior studies report that adolescents with IBD in remission met the recommendations for sleep duration while those with active disease generally did not [3]. Furthermore, adolescents with chronic health conditions often benefit from the higher range of sleep recommendations on account of the

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catabolic state of the body due to inflammation.

Several studies have evaluated variable associations with poor sleep quality in the IBD population, including adolescent patients. Most of these studies rely on self-reported sleep quality measurements such as the Pittsburgh Sleep Quality Index (PSQI) or similar tools [7,10] which may not accurately reflect the actual number of sleep hours. In contrast, actigraphy captures sleep-wake cycle patterns from home over multiple nights and allows for an objective assessment of sleep quality for research purposes [11]. Objective sleep data is important in this specific population, as it may vary significantly from self-reported sleep quality [12].

This study focuses on adolescent patients with an existing diagnosis of IBD and seeks to identify the factors that have the strongest influence on sleep quality. It is also the first of its kind to consider the impact of social media as it relates to sleep in this population.

2. Methods

2.1. Study design

The Louisiana State University Health Science Center and Children's Hospital New Orleans Institutional Review Boards approved this study. Adolescent participants ages 13–18 years with ICD-10 diagnosis of CD or UC followed by the Children's Hospital New Orleans Division of Pediatric Gastroenterology were recruited for participation. Patients were approached in the gastroenterology clinic and the hospital infusion center and enrollment took place during these appointments. Patients with intellectual disabilities per chart review who were assumed to be unable to answer surveys or report physical symptoms were excluded.

At enrollment, the subject provided written informed assent and the parent provided informed consent. Subjects completed Short Pediatric Crohn's Disease Activity Index (Short PCDAI) or Pediatric Ulcerative Colitis Activity Index (PUCAI) to assess disease activity according to their diagnosis. Subjects then completed the Pittsburgh Sleep Quality Index (PSQI) to evaluate sleep quality in the last one month prior to enrollment. Subjects also answered validated surveys including the Pediatric Quality of Life Inventory Gastrointestinal Symptoms Module (PedsQL-GI), Generalized Anxiety Disorder 7-item (GAD-7) screener, Patient Health Questionnaire (PHQ-9) depression screener, and Social Media Disorder (SMD) scale. These surveys are validated in pediatric and adolescent populations for evaluating quality of life as it relates to gastrointestinal symptoms [13], generalized anxiety and depression [14,15], and problematic social media use [16], respectively.

Objective sleep data was collected using wrist-worn accelerometers from ActiGraph™ LLC (Pensacola, FL, USA). Participants self-reported hand dominance to determine accelerometer placement. Demographics including height, weight, race, and sex as documented at that visit were recorded from the electronic medical record for ActiGraph wGT3X-BT® device programming. Study participants received instructions for accelerometer use and a sleep log to document time in and out of bed for 7 consecutive nights. Sleep data was recorded and analyzed with ActiLife® software by ActiGraph™ using the Cole-Kripke sleep algorithm. This algorithm distinguishes sleep from wakefulness in healthy patients and those with sleep disorders [18] and has been validated in adolescent patients [19].

A licensed psychologist was available for review of GAD-7 and PHQ-9 results. All participants whose screening questionnaires were positive for clinical anxiety and/or depression were reviewed. More specifically, a safety plan and evaluation were in place for any endorsement of suicidal ideation, question 9 on PHQ-9. When appropriate, participants met with the psychologist during the multidisciplinary IBD clinic.

2.2. Statistical analysis

Chi-squared tests were used for categorical variables. This study used linear models to estimate the effects of variables in relation to sleep. These associations were accessed using slope for continuous predictor variables using T-test to determine if the slope is different than zero. Exploratory analysis categorized sleep and used logistic models to estimate odds ratios for variables with Wald statistics used to test if odds ratios are different than zero.

3. Results

Thirty-one patients were approached for study inclusion. Survey data was collected from 23 participants with an age range from 13 to 18 years (mean 15.7), 16 (69.6 %) of which successfully completed data collection by wearing the ActiGraph™ wGT3X-BT device for a minimum of 4 nights and submitting a sleep diary. The participating population included 8 males (35 %) and 15 females (65 %), of which 5 and 11 completed data collection, respectively. The disease profile of participants included 20 (87 %) with a diagnosis of Crohn's disease and 3 with ulcerative colitis (13 %). Data collection revealed 14 (60.9 %) participants reporting clinical remission and 6 (26.1 %) with mild, 1 (4.3 %) with moderate, and 2 (8.7 %) with severe disease activity (Table 1). The group that completed the data collection closely resembles the entire enrolled group, which is important for data comparison for values not including the actigraphy results.

The PSQI uses multiple sleep components to generate a score between 0 and 21, with a score of 0–4 indicating "good" sleep and any score $\geq$5 as "poor." Subjective sleep data revealed PSQI scores indicating "poor" sleep for 12 (52.2 %) and "good" sleep for 11 (47.8 %) participants. Actigraphy evaluation of total sleep time was 449.16 min for participants with "good" sleep and 408.39 min for participants with "poor" sleep, a difference of 40.77 min. Sleep efficiency is calculated by dividing the time in bed by total sleep time, with a score of 85 % and above indicating good efficiency. In relation to PSQI within this population, sleep efficiency was adequate for both "good" and "poor" sleepers. Similarly, the number of awakenings and wake after sleep onset (WASO) did not differ between "good" and "poor" sleepers (Table 2). Within this population, the strongest difference between "good" and "poor" sleep was the total sleep time. This is reinforced by the negative linear relationship which indicates that a higher PSQI score correlates with a decrease in total sleep time (-0.25 min, $p = 0.02$).

Disease activity was assessed with the Short PCDAI and PUCAI scores as reported by subjects with CD and UC, respectively. Most subjects who completed actigraphy data collection were in clinical remission (62.5 %) or had mild clinical disease activity (31.25 %). There were no participants with moderate disease, and only one (6.25 %) with severe disease. Patients in remission slept an average of 26 min more than those with mild disease ($p = 0.46$). The patient with severe disease had the greatest

Table 1
Participant demographics describing the 23 enrolled participants and comparing them to the participants that completed data collection, noting no statistically significant differences between the two groups.

	Enrolled (n = 23)	Completed Data Collection (n = 16)	P-value
Sex			
Female	65 % [15]	68.8 % [11]	0.40
Male	35 % [8]	31.2 % [5]	
Race			
White	60.9 % [14]	56.25 % [9]	0.39
Black	34.8 % [8]	37.5 % [6]	
Other	4.3 % [1]	6.25 % [1]	
Diagnosis			
Crohn's disease	87 % (20)	81.25 % [13]	0.31
Ulcerative colitis	13 % [3]	18.75 % [3]	
Disease Activity			
Remission	60.9 % [14]	62.5 % [10]	0.46
Mild	26.1 % [6]	31.25 % [5]	
Moderate	4.3 % [1]	0 %	
Severe	8.7 % [2]	6.25 % [1]	

Table 2
Evaluation of objective sleep data as it relates to the subjective PSQI assessment of "good" or "poor" sleep quality.

Sleep Quality (PSQI)	Total Sleep Time (min)	Sleep Efficiency (%)	Number of Awakenings	Wake After Sleep Onset (min)
Good	449.16	85.94	17.37	72.34
Poor	408.39	85.63	17.15	61.68
p-value	*0.17*	*0.92*	*0.94*	*0.64*

total sleep time but was not significantly different from those with mild disease ($p = 0.21$) or those in remission ($p = 0.34$). For the overall population, including those without actigraphy data, an increase in clinical disease severity score correlated with an increase in PSQI score (0.43, $p = 0.0001$), which suggests a poorer quality of sleep for patients with worse disease activity. There was no significant relationship between disease severity and sleep efficiency when comparing remission to mild disease ($p = 0.62$) or mild to severe disease ($p = 0.91$) (Table 3). Likewise, there was no notable correlation between disease activity index scores and efficiency (−0.053, $p = 0.61$).

The PedsQL-GI symptom scale is scored 0–100 with lower scores indicating worse gastrointestinal symptoms and as such, health related quality of life [13]. The patients' scores did not have any influence on total sleep time or efficiency. This demonstrated an inverse relationship with sleep, as an increase in the PedsQL-GI score led to a marginal decrease in total sleep time (−1.28 min, $p = 0.20$) and efficiency (−0.02 %, $p = 0.83$). The GAD-7 screener was used to determine the likelihood of an anxiety disorder. Overall, 3 of the patients that completed objective sleep data collection screened positive for a probable anxiety disorder, which had no observable influence on total sleep time or efficiency. A similar finding was noted amongst the subjects who screened positive for depression with the PHQ-9. There was no significant difference between the total sleep time or efficiency between participants with moderate or mild depression and those without depression. Dependence on social media, as measured by the SMD screener, had little influence on total sleep time or efficiency (Table 4).

4. Discussion

The relationship between IBD and poor sleep quality compared to healthy peers is well established in adults and adolescents [2–4]. This study sought to specifically understand the factors that influence poor sleep quality in the adolescent population with IBD. Other reports note predictors for poor sleep to include disease activity, anxiety [3], depression, and low quality of life [7]. We included these variables in addition to an evaluation of social media use due to its association with poorer sleep for adolescents, as this relationship has not been studied in patients with IBD. This was the first study involving adolescent patients with IBD to evaluate the impact of sleep quality with that of risky or problematic social media use. We suspect that disease activity plays a role in sleep quality as well, whether from overt symptoms or underlying inflammation.

The AAP and the American Academy of Sleep Medicine consensus group described healthy sleep as having adequate duration, good quality, and absence of disturbances [9]. For this reason, total sleep time and sleep efficiency (time in bed divided by total sleep time) were used throughout the analysis to evaluate sleep quality. PSQI was also used to compare subjective with objective sleep quality, which demonstrated no statistically significant difference. However, subjects with "good" scores had an average of 40.77 min of sleep more than those with "poor" PSQI scores, which likely has clinical significance in the life of an adolescent patient (7.5 h vs 6.8 h of sleep). Regarding efficiency, the two groups were identical. Participants who completed actigraphy data collection slept less than the recommended amount of time, regardless of the presence of active disease. Again, there is a difference of 26.03 min between patients in remission and those with mild disease, which is clinically but not statistically relevant. The confounder in this group is the single participant with severe disease as measured by disease activity index. This participant slept the greatest amount of time, which did not reach statistical significance. Of note, this study participant was an outlier in other metrics including depression and quality of life score. This increase in total sleep time for a single person with severe disease cannot be extrapolated to make assumptions about other patients with severe disease activity. Other patients enrolled in the study with severe disease activity did not complete actigraphy data collection. Within the overall population, there was a statistically significant positive correlation between disease activity index scores and PSQI scores.

Table 3
Evaluation of objective sleep data as it relates to clinical disease activity as described by Short PCDAI and PUCAI.

Disease activity	Total Sleep Time (min)	Sleep Efficiency (%)
Remission	431.14	86.36
Mild	405.11	84.55
Severe	493.71	85.32

Table 4
Evaluation of objective sleep data as it relates to participant values for clinical screening tools for generalized anxiety disorder, depression, and social media disorder.

Variables	Total Sleep Time (min)	Sleep Efficiency (%)
GAD-7		
Probable anxiety disorder	426.98	85.34
No disorder	431.84	85.86
p-value	*0.91*	*0.91*
PHQ-9		
Moderate depression	493.69	85.37
Mild depression	412.79	89.94
No depression	426.59	84.51
p-value	*0.26*	*0.16*
SMD		
High	421.19	85.74
Low	434.21	85.81
p-value	*0.67*	*0.98*

This study did not demonstrate a significant relationship between sleep quality and psychosocial factors including quality of life, anxiety, depression, or social media disordered use. This did not align with the study hypothesis which expected a relationship among all measures as they relate to sleep quality. These conditions were common among the group that completed the actigraphy data collection with 31.25 % screening positive for depression, 18.75 % with probable anxiety disorder, and 50 % with risky or problematic social media use. It is important to consider that screening tools such as PHQ-9, GAD-7, and PedsQL-GI all include somatic complaints that may overlap with symptoms secondary to disease activity from IBD. While we did not find the anticipated connection between poor sleep and problematic social media use, we recognize that the average sleep duration for our entire population was less than what is recommended by the AAP and American Academy of Sleep Medicine. It is impossible to say that social media use is not impacting sleep in this group of adolescents, particularly because the SMD screener is a self-reported measure of disordered use and does not encapsulate the entire social media experience.

This study is limited by the small sample size, especially when considering that there is only one participant in the actigraphy group with severe disease activity and moderate depression. This study more accurately evaluates patients with IBD in remission compared to those with mild disease activity and patients with no depression versus mild depression. Actigraphy data was collected over 7 nights to capture the average baseline for the participants. However, many subjects completed data collection during school holidays or over the summer break, which may have influenced the sleep data in either direction, leading to a change in the total sleep time depending on their activities.

Subjects who recorded a minimum duration of 4 nights of data were included in analysis due to the small sample size. Sleep-onset latency was not analyzed within our study. This limits the assessment of objective sleep quality and comparison with other similar studies using actigraphy. Future directions for this study include capturing more patients with a range of disease activity and assessing activity with biomarkers of inflammation in addition to clinical evaluation.

The Pittsburgh Sleep Quality Index was selected to assess subjective sleep quality due to its popularity in IBD sleep studies, but it has limitations within this population. Presently a sleep questionnaire does not exist that is specific to IBD to account for the impact of gastrointestinal symptoms on sleep. The PSQI is well-established for use in adult subjects, but it lacks established psychometrics for pediatric patients [17]. Despite this, it addresses similar sleep components that actigraphy does, such as sleep duration and sleep latency. The 19 self-rated questions are appropriate for adolescents, but the use of an adult-specific sleep tool is a limitation in our study.

In conclusion, this IBD study population slept fewer hours than recommended for teenagers, but they had good quality sleep. The most notable difference between "good" and "poor" sleepers as determined by PSQI scores was the total sleep time. The same finding was noted among patients in remission, as their total sleep time was greater than the patients with mild active disease. Additionally, the patients with higher disease activity index scores also had higher PSQI scores, suggesting worse sleep. Overall, the groups had good sleep efficiency which should translate into good sleep quality. The other psychosocial factors assessed in this study had no influence on sleep patterns within this population. Generally, actigraphy data proved to provide more detailed information on adolescent sleep patterns than the PSQI alone.

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CRediT authorship contribution statement

Holly Breeden: Writing – original draft, Visualization, Methodology, Investigation, Funding acquisition, Data curation, Conceptualization. **Elizabeth McDonough:** Writing – review & editing, Visualization, Supervision, Project administration, Methodology, Investigation, Conceptualization. **Amanda Glinky:** Writing – review & editing, Supervision, Resources, Project administration, Methodology, Investigation, Conceptualization. **Rebecca Wallace:** Writing – review & editing, Supervision, Resources, Methodology. **Robbie Beyl:** Writing – review & editing, Formal analysis, Data curation. **Colleen LeBlanc:** Writing – review & editing, Visualization, Supervision, Project administration, Methodology, Investigation, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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