Polysomnographic and Actigraphic Evidence of Sleep Fragmentation in Patients with Irritable Bowel Syndrome

*Amit Y Rotem, MD[1,2]; Ami D Sperber, MD, MSPH[2]; Pavel Krugliak, MD[2]; Bruria Freidman, REEGT[1]; Asher Tal, MD[1,3]; Ariel Tarasiuk, PhD[1,4]

**This study was conducted in partial fulfillment of requirements for an MD degree.*

Soroka University Medical Center and Faculty of Health Sciences, Ben-Gurion University of the Negev, Beer-Sheva, Israel—[1]Sleep-wake Disorders Unit; [2]Department of Gastroenterology; [3]Department of Pediatrics B; [4]Department of Physiology

Study Objective: To characterize the function and quality of sleep in patients with irritable bowel syndrome (IBS).
Design: A prospective study with a historic comparison group.
Setting: A regional hospital that also serves as a tertiary referral center.
Patients: Eighteen patients with IBS and a comparison group of 20 matched adults with mild benign snoring.
Interventions: A polysomnography study and a wrist actigraphy study.
Measurements: All subjects underwent sleep studies and completed self-report questionnaires (IBS severity, psychosocial variables, sleep function, and Epworth Sleepiness Scale). Fourteen IBS and 11 comparison patients underwent actigraphy.
Results: The IBS patients had more than 70% less slow-wave stage sleep (4.5±7.3% vs 19.3±12.9%; P=0.006), compensated by increased stage 2 sleep (72.2±6.6% vs 60.1±16.8%; P=0.01). The IBS group had significant sleep fragmentation with a significantly higher arousal and awakening index (P<0.001), a longer wake period after sleep onset (P=0.02), and more downward shifts to lighter sleep stages (P=0.01). The 4-night actigraphy study supported the polysomnography findings. The sleep fragmentation index was significantly higher (P=0.008) in the IBS group. The IBS patients reported greater daytime sleepiness (9.0±4.8 vs 6.4±4.8, Epworth Sleepiness Scale score, P<0.01) and greater impairment in quality of life, which correlated significantly with the sleep fragmentation indexes. The difference between the groups was not due to differences in baseline anxiety/depression levels.
Conclusions: Patients with IBS have impaired sleep quality, reduced slow-wave sleep activity, and significant sleep fragmentation. The cause-and-effect relationship of these findings with patients' daytime symptoms should be studied further.
Key Words: Sleep, irritable bowel syndrome, polysomnography, actigraphy, fragmented sleep
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INTRODUCTION

IRRITABLE BOWEL SYNDROME (IBS), AS DEFINED IN THE ROME CRITERIA, IS CHARACTERIZED BY CHRONIC, RECURRING ABDOMINAL DISCOMFORT OR PAIN WITH IMPAIRED BOWEL HABITS THAT CANNOT BE EXPLAINED BY STRUCTURAL OR BIOCHEMICAL ABNORMALITIES.[1] The symptoms fluctuate over time and are associated with a serious impairment of quality of life.[2] Irritable bowel syndrome is the most common diagnosis made by gastroenterologists in the United States, with a lifetime prevalence ranging from 8% to 20% among adults.[3,4] The rates are affected by nationality and culture as well as research methodology and diagnostic criteria, which explain the large range of values.

Poor sleep quality and insomnia are commonly reported in IBS patients. This sleep impairment may be related to patients' symptoms, although the cause-and-effect relationship is not clear. Kumar et al[5] reported an increased proportion of rapid eye movement (REM) sleep in a sample of IBS patients who underwent nocturnal polysomnography (PSG), without a change in the sleep latency period or the number of REM episodes. Orr et al[6] confirmed these findings in 10 women with IBS and reported a significant increase in the percentage and duration of REM sleep. However, findings regarding REM sleep are not consistent. Some investigators[7] have reported a longer latency to REM with no significant differences in the REM period itself. Others[8] have concluded that IBS patients do not have any significant PSG abnormalities. Thus, there is no definitive evidence to date in support of the hypothesis that changes in the REM cycle are responsible for sleep impairment in IBS.

Despite the inconsistency of PSG findings, IBS patients are considered to be "poor sleepers" based on subjective reporting. Women with IBS report more nocturnal awakenings, general restlessness during sleep, and overall disturbed sleep.[7] Using a sleep diary, Goldsmith and Levin[9] tested the hypothesis that IBS symptoms are related to disturbances in sleep. They found that poor sleep function was associated with an exacerbation of IBS symptoms the following day, a conclusion that has been supported by others.[10]

Sleep disruption can lead to impairment of nocturnal and daily functioning, (ie, deterioration of sleep, excessive daytime sleepiness, and deterioration in quality of life[11]) all commonly reported in IBS patients. Little is known about sleep fragmentation in IBS patients. Previous studies have found no differences in indexes of disrupted sleep between IBS patients and controls.[8,10]

Actigraphy (activity-based sleep monitoring) is used to measure the sleep-wake schedule and sleep quality in the subject's natural sleeping environment.[12] It is not a primary diagnostic tool nor a tool to determine sleep stages. It can serve as a useful adjunct to confirm sleep patterns observed in standard PSG.[13] Actigraphy has not been used in the study of sleep patterns and quality in IBS.

We characterized sleep patterns of IBS patients compared to a control group, using self-administered questionnaires on IBS symptoms and sleep habits, a nocturnal PSG study, and actigraphy. We also assessed the potential confounding effect of factors such as age, sex, and baseline level of anxiety/depression on sleep quality.

Disclosure Statement
No significant financial interest/other relationship to disclose.

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Address correspondence to: Ami D. Sperber, MD, MSPH, Department of Gastroenterology, Soroka University Medical Center, Beer-Sheva, Israel 84101; Tel: 972-8-6400251; Fax: 972-8-6233083; E-mail: amy@bgumail.bgu.ac.il

METHODS

Study Population

Twenty patients (14 women and 6 men, mean age 43.7±12.6 years, body mass index <27, 70% married) who met the Rome I criteria for IBS[14] were included. Today the Rome II criteria have replaced the Rome I criteria for inclusion in most clinical studies on IBS. However, at the time this study was begun, the Rome II criteria were not available. The majority of patients had moderate to severe disease severity, assessed by the Functional Bowel Disorder Severity Index (FBDSI).[15] In a previous study, we reported that patients with moderate to severe FBDSI scores reported more severe sleep disturbances than did patients with mild scores.[16] No patient had a major psychiatric disorder or a chronic medical problem; none was taking psychiatric drugs, sleeping pills, or melatonin. Subjects were recruited from the roster of IBS patients treated by 2 senior gastroenterologists (ADS, PK) in the gastroenterology clinic of the Soroka Medical Center. A group of 40 patients was selected from a list of about 400 names using a table of random numbers. After patients with exclusion criteria were disqualified, the remaining patients were contacted and asked if they would like to participate in the study. Twenty-two patients at the top of the list were contacted, of whom 2 declined. The 20 who agreed to participate comprised the study group. Based on historical information, there was no indication of sleep-related medical problems such as obstructive sleep apnea syndrome or periodic leg movements in these patients. Sixteen of the IBS patients who agreed to undergo the actigraphy test also completed this aspect of the study.

After completion of the sleep studies, 2 of the 20 IBS patients were diagnosed with obstructive sleep apnea syndrome and were referred for further evaluation. In order to not confound the results of the study, these 2 patients were excluded, and all results are based on analysis of the final IBS group, consisting of 18 patients (13 women and 5 men, age 43.1±12.6, married 67%), 14 of whom completed the actigraph test.

The comparison group (11 women and 9 men, age 43.4±10.0 years, 85% married) was selected using a table of random numbers from a list of 50 patients who were matched by age, body mass index, and sex to the IBS patients and who had undergone PSG studies over the previous 6 months for suspected obstructive sleep apnea syndrome and were diagnosed as mild benign snorers with a respiratory disturbance index below 7 events per hour. None had a chronic disease or IBS. Eleven who agreed to undergo the actigraphy test also completed this prospective aspect of the study.

The Institutional Review Committee of the Soroka Medical Center (Helsinki Committee) approved the protocol, and signed informed consent was obtained from all participants in both groups.

Questionnaires

General Demographic Data and Medical History

Sociodemographic data and data relating to past and current medical history were obtained from all participants.

Gastrointestinal Symptoms

All participants completed a self-administered questionnaire, which included standardized questions for diagnosis of IBS in accordance with the Rome I criteria,[14] and a visual analogue scale of abdominal pain.

General Health-Related Questionnaires

All participants completed questionnaires regarding general well being, healthcare use (physician visits, hospitalizations, operations), psychological distress (revised Symptoms Checklist 90 [SCL-90R], with a modification to 87 questions, omitting 3 sleep-related items),[17] an anxiety state index,[18] the disease-specific quality of life IBS-QOL,[2] and Antonovski's Sense of Coherence.[19,20]

The Hebrew versions of the questionnaires were validated by a method developed and published by one of the investigators.[21]

Baseline anxiety and depression were assessed for the IBS patients using the anxiety state index and the anxiety and depression subscales of the SCL-90R (see data analysis below).

The FBDSI was calculated to assess the severity of IBS patients' bowel complaints.[15]

Sleep Evaluation

All subjects completed a validated 1-month sleep history questionnaire, including sleep hygiene, sleeping hours, sleeping habits, afternoon naps, and sleep quality, rating the severity of the symptoms on a scale from 1 to 5 (5 = the most severe). The Epworth Sleepiness Scale was used to evaluate daytime sleepiness.[11]

Polysomnographic Evaluation

All subjects underwent a single-night PSG study in our laboratory as previously described.[22] They reported to the laboratory at 8:30 PM and were discharged at 7:30 AM the following morning. Subjects were encouraged to maintain their usual daily routine and to avoid any caffeine or alcohol intake on the day of the study. Shift workers did not perform the PSG study in the week following shift duty.

Scoring of the PSG

Nocturnal sleep-wake and sleep stages were scored in accordance with the Rechtschaffen and Kales criteria.[23] Data were collected using a commercially available sleep-monitoring system and streamed through to an optical disk for later analysis. Signals were analyzed by a computerized system (SensorMedics Inc., 4100, USA), and 2 investigators (BF, ArT) edited the results. Sleep latency was defined as time from lights out to the first occurrence of 3 consecutive epochs (90 seconds) of stage 1 sleep or the first epoch (30 seconds) of any other stage of sleep. The REM sleep latency was defined as the time from sleep onset to the first epoch of REM sleep. Sleep efficiency was calculated as the ratio of total sleep time (TST) to time in bed (TIB). The time spent in each sleep stage was expressed as the percentage of TST. Wake after sleep onset (WASO) was defined as the percentage of time awake after sleep onset and until final awakening in the morning. Severe sleep impairment (fragmentation) was defined for the purposes of this study as an arousal or awakening index greater than 20 events per hour.

Arousals and awakenings were scored according to the American Sleep Disorders Association task force recommendation.[24] The arousal index and the awakening index were calculated as the number of arousals or awakenings per hour of sleep. In addition, all arousals and awakenings were designated as 1) associated with leg movement (jerks), 2) associated with apnea or hypopnea (see below), or 3) spontaneous, if not associated with either of the above. An awakening or arousal was designated as associated with leg movement if a jerk signal preceded the electroencephalogram or on submental electromyography signal.

The number of shifts to lighter sleep stages, as an additional index for sleep fragmentation, was recorded as the number of shifts from deeper to lighter non-REM sleep or wakefulness, or from REM sleep to any other sleep stage or wakefulness, according to methods previously described.[22,25]

Obstructive sleep apnea was reported when airflow ceased for more then 10 seconds but abdominal or thoracic movements continued in a paradoxical or nonparadoxical manner.

Actigraphy

Fourteen patients with IBS and 11 from the comparison group wore the actigraph (Somnitor™, Neurim Pharmaceuticals, Israel), a watch-size device placed on the subjects' nondominant wrist. The actigraph was programmed to run for 4 consecutive nights beginning the night after the PSG study for the IBS patients and upon receipt of consent for the comparison group. This discrepancy in timing stems from the

method of selection of the comparison group, as described above. The actigraph was set to record from 7:00 PM to 10:00 AM the following morning. Subjects were instructed to put the device on about 30 minutes before bedtime and to remove it shortly after getting up in the morning. All subjects were encouraged to maintain a regular schedule of activities. Two of the investigators (BF, ArT) analyzed and reviewed the data including the following aspects: TIB, TST, sleep period (total time from sleep onset to sleep offset including midsleep arousals), sleep onset and offset time, sleep efficiency (TST/TIB multiplied by 100), sleep latency, WASO, movement index (number of zero crossings/TIB multiplied by 100), fragmental index (percentage of number of quiet episodes that are shorter than 1 minute from the total quiet episodes), and awakenings index (number of awakenings/TST). For each subject, data were analyzed and mean values calculated separately for each of the 4 nights. Thus, mean data were used for all participants.

Data Analysis

To assess baseline anxiety, depression, or both anxiety and depression among the IBS patients, we converted the raw scores for each of the 3 scales (anxiety state and the anxiety and depression subscales of SCL-90R) to *t*-scores so that the mean was 50 and 1 SD was 10. Assuming that 2 SDs would be a logical cutoff for clinical abnormality, we categorized high anxiety/depression to be 2 SD or above for each scale. Since there was only 1 patient in the IBS group who met this definition of high anxiety and depression, we "lowered" the cut-off point by using (a) 1 SD and (b) the median. Only 1 additional patient met the 1-SD criteria for high anxiety/depression, but when the median cut-off was used to distinguish between low and high anxiety/depression, there were 6 patients with scores above the median on all 3 scales, 6 patients with scores above the median on at least 1 scale, and 6 IBS patients who scored below the median on all 3 scales. The latter 6 patients were defined as baseline low anxiety/low depression for further analyses. We then compared these 6 low anxiety/low depression IBS patients with the other 12 IBS patients for sleep function and with the comparison group. If anxiety, depression, or both were the reason for the differences in sleep patterns between the study groups, rather than IBS per se, these comparisons might introduce a conservative bias to the study, making it more difficult to prove the study hypothesis.

All data were tested for normal distribution (Kolmagorov-Smirnov test) and presented as mean ± SD. Data were compared using χ^2 (Fisher exact test), correlation analysis (Pearson's correlation coefficient) or 2-tailed *t*-tests for nonpaired groups, as appropriate. The frequency analysis of consecutive epochs as well as nonparametric score data were analyzed with the Mann–Whitney *U*-test. The null hypothesis was rejected at the 5% level.

Table 1—Sleep and respiratory patterns, by polysomnography

Parameters	Comparison group (N, 20)	IBS group (N, 18)	*P*
Sleep pattern			
Time in bed (min)	388.8±26.0	397.9±57.6	0.6
Total sleep time (min)	340.0±29.1	309.6±68.1	0.05
Sleep efficiency (%)	88.1±6.1	75.9±10.8	0.0001
Latency to sleep (min)	28.5±23.9	38.3±27.1	0.09
Stage 1 (%)	2.9±0.5	7.3±7.8	0.02
Stage 2 (%)	60.1±16.8	72.2±6.6	0.01
SWS (%)	19.3±12.9	4.5±7.3	0.006
REM (%)	17.9±5.2	14.6±5.6	0.06
Respiratory pattern			
RDI (events/hr)	1.4±0.9	2.8±2.6	0.27
DI (events/hr)	0.2±0.5	0.4±1.8	0.46
Wake SaO2 (%)	97.4±2.1	97.1±1.1	0.25
Nadir SaO2 (%)	94.0±3.3	92.3±2.8	0.12

Data are mean±SD. IBS, irritable bowel syndrome; SWS, slow wave sleep (stages 3+4); REM, rapid eye movement; SaO_2,oxygen saturation; DI, desaturation index; RDI, respiratory disturbance index

RESULTS

There were no significant differences between the study groups in mean age, sex, education, ethnic origin, or family status. Thirteen of the 18 participants in the IBS group and 11 of 20 in the comparison group were women (*P*=0.27). The gender composition of the IBS group was similar to the gender distribution in most epidemiologic studies in western countries.

The IBS patients' symptom severity, symptom characteristics, and quality of life were similar to other IBS groups studied by us.[26] The mean pain score (visual-analog scale) was 37.3±29.6 (0=no pain, 100=severe pain); the mean Global Severity Score (SCL-90-R using 87 items) was 0.8±0.6; the mean FBDSI (mild=1-36), moderate=37-110, severe=110) was 110.4±111.9, and the mean IBS-QOL score was 72.6±22.2 (0=worst, 100=best). A negative linear correlation was observed between the FBDSI (analyzed as a continuous variable) and IBS-QOL (R=–0.57, *P*<0.01).

Sleep Pattern

Based on the sleep history questionnaire, IBS patients reported more difficulty falling asleep than did the comparison group (2.9±0.9 vs 2.2±1.0; *P*=0.06). Significantly more sleep movements were observed by spouses of IBS patients than by spouses of comparison-group patients (4.2±3.0 vs 2.1±2.9; *P*=0.04), and parasomnia complaints, such as talking during sleep, were significantly more frequent in the IBS group (3.9±4.1 vs 0.8±2.2; *P*=0.02). The Epworth Sleepiness Scale revealed a significantly higher daytime sleepiness score of 9.0±4.8 in the IBS group compared to 6.4±4.8 in the comparison group (*P*=0.01).

Polysomnography

Sleep Pattern

Table 1 summarizes the PSG findings. Both groups spent approximately 6.5 hours in bed. The TST was significantly shorter in the IBS group by 33 minutes (*P*<0.05), and their sleep efficiency was reduced by 12% (*P*<0.0001). The cumulative percentage of stage 2 sleep was longer in the IBS group (*P*<0.01), while slow wave sleep (SWS) was considerably shorter in this group (*P*=0.006). The REM duration and latency to REM were similar in both groups.

Sleep Fragmentation

The arousal and awakening index was more than 2-fold greater in the IBS group (Figure 1). The calculated arousals/awakening ratio was approximately 10:1 for each of the groups. Both increased arousals

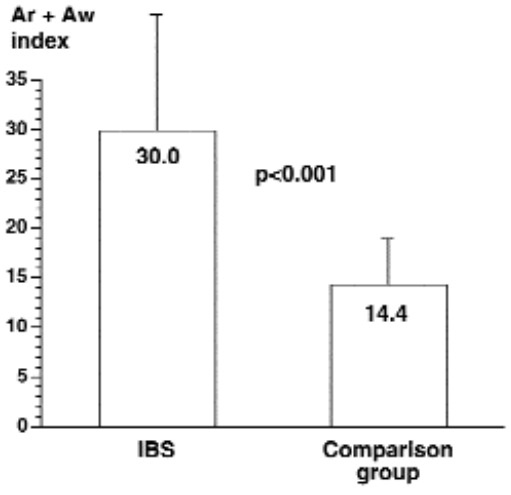

Figure 1—Increased sleep fragmentation in patients with irritable bowel syndrome (IBS) compared to comparison group: arousal (Ar) and awakening (Aw) index.

(events < 15 seconds) and increased awakenings contributed independently to this result. The arousal index was 29.4±9.6 events per hour in the IBS group compared to 13.1±4.3 events per hour in the control group (P<0.001). The awakening index (events > 15 seconds) was 3.1±1.2 and 1.7±0.9 events per hour in the IBS and comparison group, respectively (P<0.001). The IBS patients had close to 30% more shifts to lighter sleep stages (P<0.01) (Figure 2), reflecting a lighter sleep pattern than the comparison group. Finally, WASO was significantly longer in the IBS group (Figure 3).

Respiratory Pattern and Legs Movements

We found no evidence of clinically significant sleep-disordered breathing in the IBS patients and the comparison group, as a group; the observed respiratory disturbance index was below 10 events per hour (the minimal criterion for clinically significant obstructive sleep apnea),[27] and there was no indication of oxygen desaturation events or nadir in either group (Table 1).

Periodic leg movements were observed in 2 IBS patients. In 1, the movements were benign (6 events/h), and in the other mild (14 events/h). In both cases, the mean number of arousals induced by the leg movements was only 30% of the total amount observed. In neither of these 2 cases was obstructive sleep apnea syndrome diagnosed.

Association Between IBS Severity and Sleep Function

The FBDSI was significantly associated with WASO and sleep efficiency (R=0.49, P<0.04 and R=–0.54, P=0.02, respectively) so that patients with more severe IBS had more WASO episodes and lower sleep efficiency. Increased sleep fragmentation impaired quality of life in IBS patients. Sleep efficiency was linearly correlated with IBS-QOL (R=0.62, P=0.008) and global severity (R=–0.46, P<0.05), so that patients with better quality of life had greater sleep efficiency, while those with higher global severity scores had a more-impaired sleep efficiency.

Table 2—Polysomnographic parameters between the comparison group and patients with IBS with all 3 baseline anxiety/depression scores below the median (low anxiety/depression).

Parameters	Comparison group (N, 20)	IBS group (N, 6)	*P*
Sleep pattern			
Time in Bed (min)	388.8±26.0	428.8±30.3	0.009
Total sleep time (min)	340.0±29.1	351.8±52.1	0.65
Sleep efficiency (%)	88.1±6.1	81.7±8.5	0.04
Stage 1 (%)	2.8±0.5	5.1±6.6	0.22
Stage 2 (%)	60.1±16.8	71.5±87.5	0.14
SWS (%)	19.3±12.9	7.2±7.1	0.18
REM (%)	19.7±5.2	16.2±5.0	0.43
Downward shift (events)	13.1±4.4	20.0±3.9	0.002
Awakenings & arousals (index)	13.8±5.4	22.8±7.2	0.002

Data are mean ± SD. IBS, irritable bowel syndrome; min, minutes; SWS, slow wave sleep (stages 3+4); REM, rapid eye movement

Table 3—Actigraphy results

Parameter	Comparison group (N, 11)	IBS group (N, 14)	*P*
Sleep variables			
Sleep Period (min)	437.4±241.2	388.4±91.5	0.40
TST (min)	358.6±81.2	349.8±97.3	0.90
Sleep Latency (min)	23.8±10.5	52.8±58.4	0.09
Sleep Efficiency (%)	84.8±9.1	73.4±19.9	0.06
WASO (%)	24.0±11.1	38.6±22.9	0.09
SFI (events/hr)	20.8±5.2	38.1±20.1	0.01
AwI (events/hr)	5.1±1.9	7.6±4.8	0.17

Data are mean ± SD. IBS, irritable bowel syndrome; min, minutesTST, total sleep time; WASO, wake after sleep onset; SFI, sleep fragmentation index; AwI, awakening index

Association Between Sex and Sleep Function

The differences in PSG parameters between the study groups were still found when data from men and women were analyzed separately. The arousal and awakening index was 30.0±10.2 for women with IBS compared to 15.9±5.4 for women in the comparison group (P<0.001). Similarly, the arousal and awakening index was 27.0±9.6 for men with IBS compared to 11.3±3.6 for men in the comparison group (P<0.005).

Association Between Baseline Anxiety/Depression and Sleep Function Among IBS Patients Only

There were no differences in any PSG or actigraphy parameters between IBS patients with high or low baseline anxiety/depression using the median cut-off point.

Comparison of Sleep Function Between Low Anxiety/Depression IBS Patients and the Comparison Group

To further control for the potential confounding effect of baseline anxiety, depression, or both anxiety and depression, we compared the subgroup of 6 IBS patients who were below the median cut-off point for all 3 scales of anxiety and depression with the entire comparison group. The results are shown in Table 2. The pattern of significant differences between the groups observed was similar to that found when the full study groups were compared.

Actigraphy

Actigraphy revealed a significant, 2-fold difference between the study groups in sleep fragmentation, which was significantly greater (P<0.01) in the IBS group (Table 3).

DISCUSSION

In this study, we characterized the sleep pattern and quality of 18 IBS patients, all naïve to polysomnographic and actigraphic examinations and compared them to a matched comparison group. The results support the hypothesis that IBS patients suffer from a considerable degree of sleep fragmentation, including an elevated arousal index, more shallow sleep, and prolonged awakening during sleep. It is generally acknowledged that sleep disturbances can lead to impairment of daytime functioning and daytime sleepiness. Although in the present study we did not directly address this issue, symptoms indicative of IBS severity, such as pain and FBDSI, correlated significantly with sleep fragmentation. The actigraphy results support the PSG results in respect to the significant

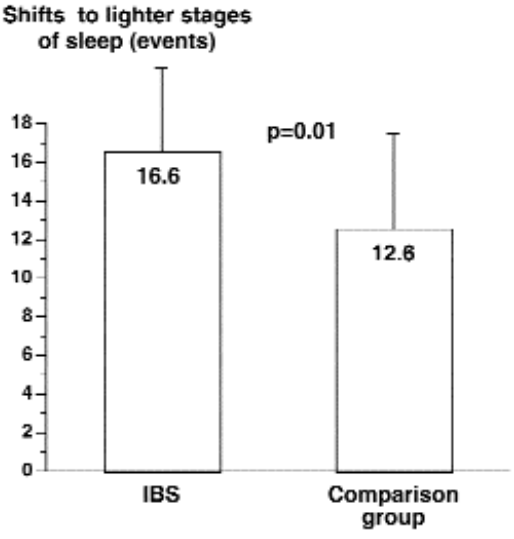

Figure 2—Increased sleep fragmentation in patients with irritable bowel syndrome (IBS) compared to comparison group: downward shifts from deeper to lighter sleep stages.

degree of sleep fragmentation.

Earlier studies reported an early onset of REM sleep and prolonged REM period among IBS patients.[5,6] We found no evidence to support these findings. Earlier studies[7] also reported that IBS patients have a longer latency to REM. The latency to REM and its duration were similar in our study groups but were longer than expected.

The sleep of IBS patients was lighter than the sleep of the comparison group. This was indicated by a significant increase in cumulative as well as continuous stage 2 sleep accompanied by a reduction of the SWS stage, which was more than 50% lower in the IBS group. In contrast, earlier reports found longer durations of SWS than we did, but with no differences between patient and control groups.[8,28] The differences between our findings and previous reports may be related to age, since the mean age of our patients was 10 years older.[29] However, analysis of the results within the patient group by age subset (≤ 44 years and > 44 years) revealed no difference in the percentage of SWS, the awakening and arousal index, WASO (all by PSG), or the fragmentation index by actigraphy.

The patients with IBS had more arousals and awakenings associated with frequent shifts to lighter sleep stages. These arousals were of short duration, and the patients were not aware of their existence the following day. The arousal and awakening index is an important parameter of sleep fragmentation. We found an awakening and arousal index of 30±11 events per hour in the IBS patients, more than twice that of the comparison group. Eighty-four percent of the IBS patients had an awakening and arousal index above 20 events per hour, compared with 15% in the control group. In adults, experimentally induced arousals at a rate of 20 events per hour lead to impairment of daytime alertness.[30,31] This striking difference between the groups cannot be explained, in our opinion, solely by the possibility that IBS patients have a higher level of baseline anxiety, depression, or anxiety and depression. We base this statement on the finding that there were no significant PSG differences between IBS patients with and without heightened baseline anxiety and depression. In addition, the difference between the IBS patients and the comparison group held true even when the IBS group included only those 6 patients who were below the median scores for the 3 baseline scales of anxiety and depression. However, it should be noted that this statement is based on small patient numbers, and this aspect of the study should be reinforced by further studies. We used the accepted guidelines[24] for scoring arousals and awakenings. These results are not consistent with findings in previous studies[8,28] that used similar protocols. The amount of sleep fragmentation noted in the IBS patients in this study can have a significant impact on daytime functioning. In a previous study of patients with juvenile rheumatoid arthritis, we noted that an arousal-awakening index of 28 events per hour led to an objective elevation of daytime sleepiness, as indicated by Multiple Sleep Latency Tests and reports of afternoon naps.[22] In light of these reports, we expected to find an indication of daytime sleepiness in IBS patients and, indeed, their Epworth Sleepiness Scale score was elevated.[11] However, further studies, particularly using the Multiple Sleep Latency Test, are needed to support this subjective evidence.

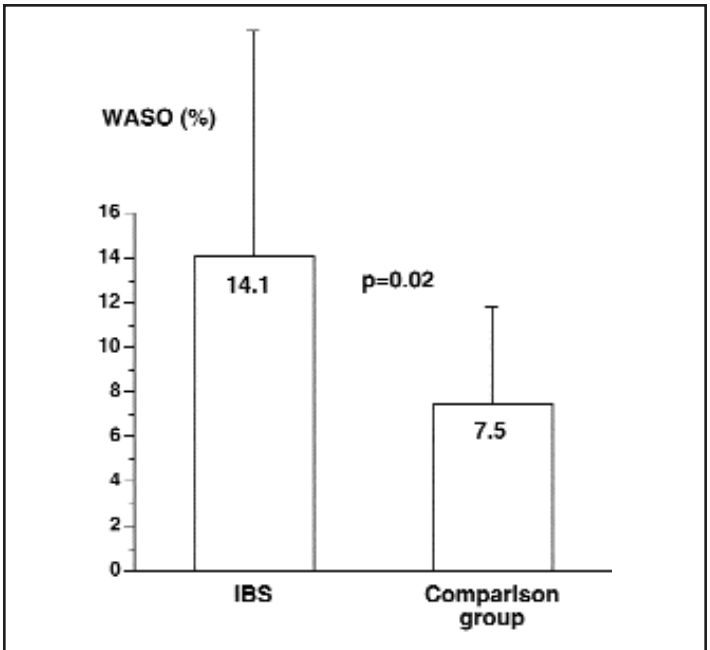

Figure 3—Increased sleep fragmentation in patients with irritable bowel syndrome (IBS) compared to comparison group: wake after sleep onset (WASO).

Poor sleep function may lead not only to daytime sleepiness,[32] but also to impairment of daily activities and mood and reduction in quality of life.[33] Previous studies, using questionnaires, have shown that self-reported poor sleep quality was associated with exacerbation of IBS symptoms.[7,9,10] In the current study, the reduction of IBS-QOL and FBDSI severity were related to impairment of WASO, which is a general indicator for sleep fragmentation.

Wrist actigraphy is used as a supplement to PSG to evaluate patients' levels of activity and to provide indirect evidence of sleep functioning in the setting of the patient's usual schedule.[12] The total TIB and the TST were statistically similar between the groups, but the sleep fragmentation index was higher in the IBS group. Thus, the actigraphy findings support the PSG data in respect to sleep fragmentation in IBS patients.

There are several potential methodologic problems that may limit the results of the present study. The first is the selection of controls. The comparison group was actually a historical group, which was not recruited prospectively and for whom we did not evaluate the presence of psychological or psychiatric disorders. In future studies, this limitation should be addressed. The participants in this group were screened for IBS and medications that could affect mood or sleep, and none had IBS or were taking medications of this type. The amount of arousals increases with age.[34] The arousal and awakening index of 14±4.5 events per hour found in our comparison group is similar to that of normal individuals in the same age group. It is also similar to various comparison groups previously investigated in our laboratory.[22,35,36] According to Mathur and Douglas[34] healthy individuals in the age range investigated here should have an arousal index of 14 to 15 events per hour, which is similar to that found in our comparison group. The comparison group used here did not exhibit symptoms of daytime sleepiness. The Epworth Sleepiness Scale score in this group was 6.4±4.8, which is within the range of normal controls or persons with primary snoring.[11] Therefore, we believe that they represent a valid comparison group for this study. If anything, this choice of a comparison group introduces a potential negative bias to the study, and it is reasonable to assume that if the comparison had been to totally healthy controls, the differences might have been even more significant.

Another possible limitation in this study is the "first-night" effect on sleep architecture, in which sleep disturbances are observed during the first night in a PSG laboratory. However, we do not believe that this seriously confounded the study results because the comparison group was tested under similar circumstances. It should be noted that all previously published reports on sleep function in IBS were also based on single-night PSG studies.

Finally, sleep apnea, which has been considered to be a potential confounder in studies of this type, cannot be considered a problem in the present study because there were no differences in respiratory variables between the groups, and obstructive sleep apnea was not found in the participants, so the number of arousals associated with apnea is negligible.

In conclusion, we found objective PSG and actigraphy evidence of abnormal sleep in patients with IBS. The sleep disruption was due to frequent arousals and awakenings, frequent sleep-stage shifts, and waking periods during sleep. In addition, there was considerable reduction of SWS. The sleep fragmentation may be the cause of daytime sleepiness, as reflected in the higher scores on the Epworth Sleepiness Scale in the IBS group. The impaired sleep function could also explain the impair-

ment in quality of life and associated symptoms among IBS patients. In order to overcome some of the limitations of the present study, we recommend conducting similar studies with consecutive-night PSG studies, including an objective evaluation of daytime sleepiness by the Multiple Sleep Latency Test, that will help to verify the association between daytime symptoms and objective PSG results.

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