

Actigraphy in the Assessment of Insomnia

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Objective: The present study explores the clinical utility and sensitivity of actigraphy as an outcome measure in the treatment of chronic insomnia.

Design: Following a screening-adaptation night, polysomnography, actigraphy, and sleep-diary data were collected in the sleep laboratory for 2 baseline nights and 2 posttreatment nights.

Setting: A university-affiliated sleep disorders center.

Participants: Seventeen participants with chronic primary insomnia. Mean age was 41.6 years.

Interventions: Participants took part in a treatment protocol investigating different sequential treatments for insomnia (these results are reported elsewhere).

Measurements and Results: Compared to polysomnography, both actigraphy and sleep-diary instruments underestimated total sleep time and

sleep efficiency and overestimated total wake time. Also, actigraphy underestimated sleep-onset latency while the sleep diary overestimated it as compared to polysomnography. Actigraphy data were more accurate than sleep-diary data when compared to polysomnography. Finally, actigraphy was sensitive in detecting the effects of treatment on several sleep parameters.

Conclusions: These results suggest that actigraphy is a useful device for measuring treatment response and that it should be used as a complement to sleep-diary evaluation.

Key Words: Insomnia, actigraphy, accuracy, sleep-wake perception

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INTRODUCTION

THE UNDERSTANDING OF INSOMNIA REQUIRES THE EVALUATION OF MULTIPLE COMPONENTS SUCH AS NIGHTTIME SLEEP, DAYTIME FUNCTIONING, AND VARIABILITY IN SLEEP-WAKE PATTERNS.¹ Several assessment tools have been developed over the years to assess these components. Polysomnography (PSG) is considered the gold standard for the objective assessment of sleep, whereas the sleep diary is a standard procedure used for the subjective assessment of sleep.¹ Polysomnography provides an accurate measure of wake and sleep time, as well as of sleep stages. However, it is an expensive approach, and its ecologic validity is sometimes questionable. The use of a daily sleep diary is particularly useful for evaluating sleep over extended periods of time in the patient's home environment.¹ It also has the advantage of providing a measure of night-to-night variability in sleep-wake patterns; however, the accuracy of the sleep diary is entirely dependent on the patient's perception.² Therefore, objective assessment tools that are accurate, more accessible, and more economical than PSG for evaluating sleep in a natural environment are needed.

Wrist actigraphy was designed as an alternative assessment device to gather objective data on sleep-wake parameters (see Sadeh et al³ for more details). The actigraph is a small watch-like device that records movements. It is worn all night, typically on the wrist of the nondominant hand. The presence of movement is interpreted as time awake, and the absence of movement as sleep time. The actigraph has the advantage of being a nonintrusive tool for assessing sleep in a natural environment. In spite of this advantage, its accuracy and clinical usefulness for assessing insomnia is still equivocal.³ An adequate evaluation of the accuracy of actigraphy should be based on comparisons of same-night recordings of PSG and sleep-diary data. To be useful, actigraphy data should yield

data convergent with PSG measures and be more accurate than the sleep diary.⁴ Of the studies that have investigated the accuracy of actigraphy, 5 have used, actigraphy and sleep-diary data that were not obtained from the same nights as the PSG recordings.⁵⁻⁹ Only 2 studies^{10,11} have reported results on these 3 measures obtained from the same nights. Five studies compared actigraphy to sleep diary alone,^{7,12-16} and 3 studies^{9,10,13} evaluated actigraphy's sensitivity to treatment response.

These studies indicate that, depending on the participants' insomnia diagnosis (eg, psychophysiological or sleep-state misperception), actigraphy underestimates¹³ or overestimates total sleep time (TST)^{6,10,17} compared to PSG. The agreement coefficients between PSG and actigraphy for detecting TST vary from .81⁸ to .88¹⁷ and are lower than for good sleepers (above 90%³). The magnitude of the discrepancies between those assessment devices varies from 25 minutes⁵ to 49 minutes.⁶ Regardless of the direction of the discrepancies, actigraphy has been found to be sensitive to treatment effect.^{9,10,13} Moreover, data on time in bed (TIB) suggest that actigraphy is a reliable measure of adherence to behavioral treatment procedures.^{9,13}

Despite technologic improvements and innovations in recent years,^{11,18,19} the accuracy and clinical usefulness of actigraphy in the assessment of insomnia is still controversial. Discrepancies may result from the inclusion of subjects with sleep-state misperception, a factor that can contribute to the underestimation of sleep time,⁶ or the use of heterogeneous samples comprising subjects with other sleep disorders or coexisting psychological disorders.¹⁷ The paucity of studies using multiple PSG and parallel nights of actigraphy and sleep-diary recordings of sleep makes it difficult to understand these discrepancies. There is, therefore, a need to compare PSG, actigraphy, and sleep-diary data collected for the same nights of sleep and on more than 1 night using a homogeneous sample of insomnia patients both before and after treatment. The present study further evaluates the accuracy, sensitivity, and clinical utility of actigraphy in documenting treatment response in chronic insomnia. Polysomnography, actigraphy, and a sleep diary are used for a total of 4 nights, including 2 at baseline and 2 after treatment.

METHOD

Participants

Participants were recruited through newspaper advertisements or by physician referrals. Inclusion criteria were a) being between 30 and 50

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years of age; b) reporting insomnia, defined as a sleep-onset latency (SOL), wake after sleep onset (WASO), or early-morning awakening equal to or longer than 60 minutes at least 4 nights a week for the past 6 months; c) reporting significant distress or daytime impairment as evaluated by the Insomnia Severity Index (score of 2 or higher on a 0 [not at all] to 4 [very much] Likert scale); and (d) cessation, at least 1 month prior to treatment, of any sleep or other psychotropic medication that could alter sleep. Exclusion criteria were a) presence of another sleep disorder such as sleep apnea (respiratory disturbance index > 15), periodic limb movements during sleep (periodic limb movement index > 15), or circadian rhythm disorder; b) evidence that insomnia was related to a medical condition; c) presence of major depression, anxiety disorder, alcohol or substance abuse, or any other psychopathology as diag-

nosed with the Structured Clinical Interview for DSM-IV (SCID-IV²⁰); d) currently in psychotherapy; and (e) regular use of a medication interfering with sleep (eg, antihistaminic, corticosteroid). Although more stringent, these criteria are consistent with those of the DSM-IV²¹ for chronic primary insomnia.

The sample included 17 participants (7 men and 10 women) with a mean age of 41.6 years (SD = 5.7; range, 34-50). The average education level was 15.2 years (SD = 3.0; range, 10-19 years). Fourteen were working, and 3 were unemployed. The average insomnia duration was 11.8 years (SD = 6.2), and the mean age of insomnia onset was 29.8 years (SD = 7.7). One participant presented with sleep-onset insomnia, 9 with sleep-maintenance insomnia, and 7 with mixed insomnia.

Measures

Initial Screening and Clinical Evaluation

The initial screening included a 20-minute telephone questionnaire administered to determine participants' eligibility for the study. A subsequent multimeasure pretreatment evaluation was composed of a semistructured sleep-history interview²² to diagnose insomnia, the SCID-IV²⁰ to evaluate the presence of psychologic disorders, and a physical examination. Participants were enrolled in a 10-week treatment that comprised medication (zopiclone) and cognitive behavior therapy. Additional information about the treatment protocol and treatment outcome is reported elsewhere.²³

Polysomnography

The PSG montage included electroencephalographic, electromyographic, and electrooculographic monitoring. Sleep stages, respiratory disturbance, and limb movements were scored by an experienced clinician according to standard criteria.²⁴ Respiration (airflow, tidal volume, and oxygen saturation) and anterior tibialis electromyographic readings were recorded during the first night to detect sleep apnea and periodic limb movements. Variables used for the present study were total wake time (TWT), TST, SOL, sleep efficiency (SE: ratio of TST to TIB), and TIB.

Actigraphy

When participants slept in the laboratory, they also wore an actigraph from IM Systems (Individual Monitoring Systems, Inc., Baltimore, MD). Data were processed and scored for the following variables: TST, TWT, SOL, SE, and TIB with the IM Systems, Inc., software and algorithm (version 3.15a). The variable *WASO* was not used in the study because it was not directly computed by IM System's software.

Sleep Diaries

Following each night spent in the laboratory, participants completed their sleep diaries. From these

Table 1—Relative and absolute discrepancies between actigraphy and polysomnography and between sleep diary and polysomnography (N = 17).

	Relative discrepancies				Absolute discrepancies			
	Night 1		Night 2		Night 1		Night 2	
	Mean (SD)	d	Mean (SD)	d	Mean (SD)	d	Mean (SD)	d
<i>Total sleep time</i>								
ACT-PSG	-8.56 (59.97)	1.06	-38.29 (45.29)	0.19	44.57 (39.32)	-0.96	45.59 (37.36)	-0.36
SD-PSG	-72.23 (100.30)		-46.89 (72.41)		82.40 (91.52)		59.17 (62.02)	
<i>Total wake time</i>								
ACT-PSG	6.66 (60.12)	-0.99	35.36 (46.43)	-0.39	45.21 (38.37)	-0.90	43.31 (38.55)	-0.63
SD-PSG	66.39 (95.60)		53.49 (75.52)		79.65 (84.06)		67.67 (62.15)	
<i>Sleep efficiency, %</i>								
ACT-PSG	-2.74 (12.46)	1.08	-8.23 (9.81)	0.23	9.21 (8.51)	-1.02	9.93 (7.93)	-0.41
SD-PSG	-16.23 (22.24)		-10.48 (14.79)		17.93 (20.80)		13.16 (12.29)	
<i>Sleep-onset latency</i>								
ACT-PSG	-14.16 (21.59)	-1.79	-7.01 (11.77)	-2.50	14.16 (21.59)	-0.60	11.27 (7.41)	-1.63
SD-PSG	24.51 (32.13)		22.39 (20.63)		27.05 (29.86)		23.34 (19.47)	
<i>Time in bed</i>								
ACT-PSG	4.00 (8.13)	0.48	0.39 (7.58)	-0.35	6.28 (6.40)	-0.31	6.02 (4.33)	-0.39
SD-PSG	0.07 (11.24)		3.06 (10.97)		8.29 (7.25)		7.71 (8.16)	

ACT-PSG = discrepancy between actigraphy and polysomnography; SD-PSG = discrepancy between sleep diary and polysomnography. *d* = Cohen's *d* effect size (Cohen, 1988).

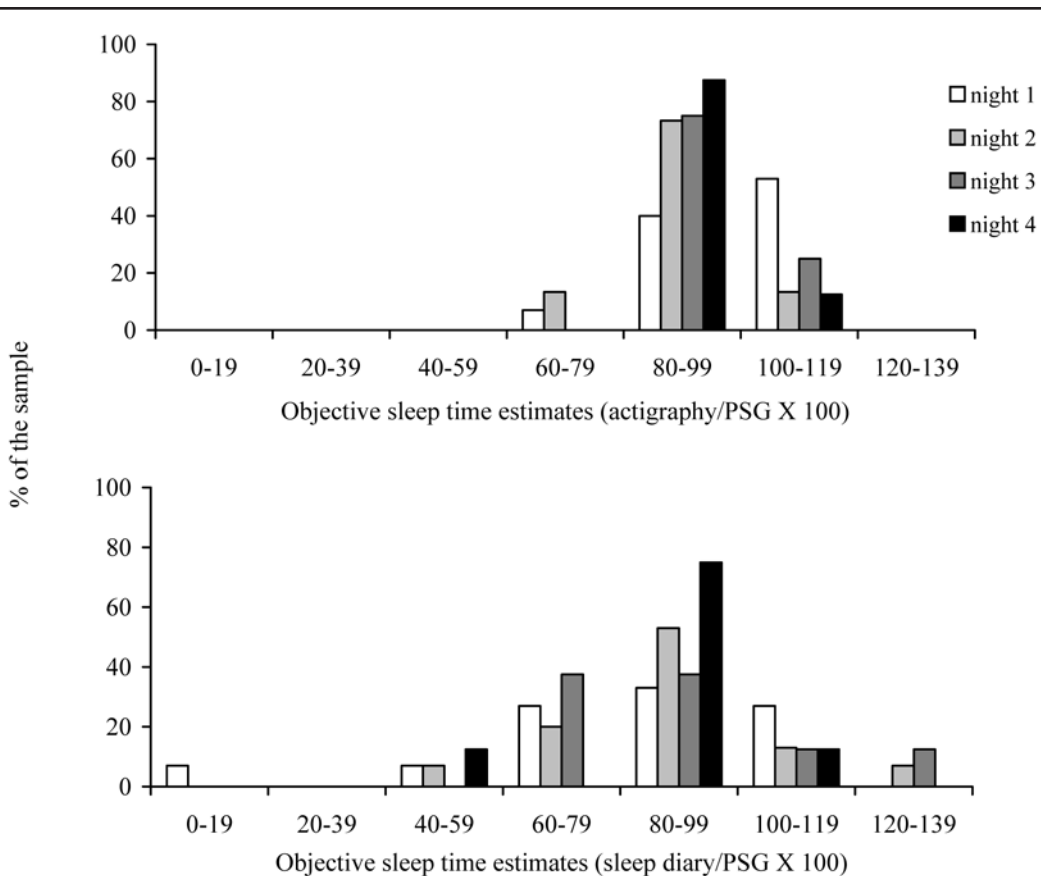


Figure 1—Ranges score of actigraph and sleep-diary objective estimates for total sleep time. PSG = polysomnography.

diaries, an estimate was computed for a nightly average of TWT, TST, SOL, SE, and TIB.

Procedures

Participants came to the laboratory for PSG recordings on 3 consecutive nights at baseline and 2 consecutive nights at posttreatment. On those same nights, they wore an actigraph, and the next morning, they completed their sleep diary. Same-night data from diaries, actigraphy, and PSG were compared. Data from the first baseline night were not used to allow for an adaptation to the laboratory. Thus, the 2 nights using the 3 devices (PSG, actigraphy, and sleep diary) before treatment and the 2 nights after treatment were used in the analysis. Pretreatment readings were obtained from 17 participants for a total of 34 nights. At posttreatment, the sample was smaller as 1 participant dropped out of treatment, 5 participants did not return for their laboratory evaluation, 1 came for only 1 night, 1 refused to wear the actigraph because it was uncomfortable to sleep with it during the night, and the data for 1 subject were unavailable due to a broken device. Thus, a total of 16 nights were obtained for 8 participants after treatment. The sleep variables compared across the 3 assessment tools were TST, TWT, SOL, SE, and TIB.

Data Analysis Plan

Data analysis included 3 steps. The first step involved computing relative and absolute discrepancies between actigraphy and PSG, and between sleep diary and PSG. Relative discrepancies were computed by retaining negative or positive signs of the differences between actigraphy and PSG. Absolute discrepancies were computed based only on absolute values of actigraphy minus PSG (ie, $|\text{actigraphy} - \text{PSG}|$). For example, if actigraphy recorded 350 minutes of sleep time and PSG 375 minutes, then the relative discrepancy was equal to -25 and the absolute discrepancy was equal to 25 . Means of relative and absolute differences were then computed. A repeated-measure analysis of variance (ANOVA) with 2 within-subject effects (2 nights and 2 differences) was used to evaluate the magnitude of the discrepancies (actigraphy – PSG and sleep diary – PSG). In addition, Cohen's d effect sizes were computed for each

dependant variable. This statistic expresses the difference between 2 means in standard deviation units.²⁵ Thus, Cohen's d provides a standardized magnitude of difference between means. The second step was to assess the accuracy of measurement of each device with the objective sleep time estimate (OSE) formula proposed by Edinger and Fins²: $\text{OSE} = (\text{MSE} / \text{MSA}) \times 100$. In this formula, MSE represents minutes of sleep estimated by the sleep diary or actigraphy and MSA represents the minutes of actual sleep time obtained by PSG. Therefore, an OSE value of 100% indicates a perfect concordance between the actigraphy or sleep diary and the PSG assessment. This formula was adapted to compute an objective estimate of each sleep variable for actigraphy and the sleep diary. Thus, MSE becomes the estimated value and MSA the actual value obtained by PSG. Descriptive statistics of the sample distribution were computed for the OSE for each variable. The next step to assess the accuracy involved computing a Spearman correlation coefficient between each device at the 2 baseline nights. The Spearman correlation coefficient was used because of the small sample size. The fourth and final step was to compute descriptive statistics for all dependent variables at baseline and after treatment in order to examine the sensitivity of the 3 devices to treatment effect. A repeated-measure ANOVA with 3 within-subject effects (2 times, 2 nights, and 3 devices) was used to control for the inter-night variability of each subject (intrasubject effect). In order to decrease type I error, the α was adjusted with Bonferroni to .01.

RESULTS

Relative and Absolute Discrepancies Between Devices

Means and SD of relative and absolute discrepancies for all sleep variables between actigraphy and PSG, as well as between sleep diary and PSG, are presented in Table 1. Repeated-measure ANOVAs with 2 within-subject effects (2 nights and 2 discrepancies) indicate significant differences for relative discrepancies for SOL, $F(1,14) = 26.21, p < .0001$. Therefore, relative discrepancies between actigraphy and PSG were significantly smaller than relative discrepancies between sleep diary and PSG at both nights. There was no other significant difference for absolute or relative discrepancies for any of the remaining variables. There was a large effect size on night 1 ($d = 1.06$) for relative discrepancies and a moderate effect size on nights 1 and 2 ($ds = -0.96$ and -0.36 , respectively) for absolute discrepancies. Magnitudes of the discrepancies between sleep diary – PSG and actigraphy – PSG for TIB were much smaller and nonsignificant.

Objective Estimates

The distributions of objective estimates of TST (OSE; sleep diary/PSG and actigraphy/PSG) for each night are illustrated in Figure 1. Visual inspection of the data revealed that the majority of the participants had an OSE slightly lower than or close to 100, indicating that sleep diary and actigraphy estimates of TST were slightly lower than the PSG measures. In addition, the range of actigraph OSE scores was narrower than the range of sleep-diary OSE scores. Objective estimates of TST from actigraphy were generally closer to PSG measures than were diary estimates. Descriptive statistics (medians, minimum, and maximum) of actigraphy and sleep-diary OSE for all sleep variables are presented in Table 2. Again, the data revealed that for all sleep variables, the range of OSE scores was smaller for actigraphy than for sleep diary. Medians for TST and SE were near 100 and were similar for both devices. However, the range of OSE scores for each sleep variable was more restricted for actigraphy than for sleep diary. The TWT medians indicated that both devices overestimated TWT relative to PSG. For SOL, objective estimates revealed that actigraphy underestimated SOL and sleep diary overestimated it.

Correlations Between Devices at Baseline

Spearman correlation analyses revealed significant positive correlations between PSG and actigraphy only at the second baseline night on

Table 2—Median, minimum, and maximum actigraphic and sleep diary objective estimates for each night and sleep variable

	Actigraphy/PSG			Sleep Diary/PSG		
	Median	Minimum	Maximum	Median	Minimum	Maximum
<i>Total sleep time</i>						
Night 1	103.71	62.70	119.10	89.92	0.00	113.55
Night 2	90.93	63.99	117.49	90.56	51.18	122.58
Night 3	89.36	80.30	107.40	91.17	69.59	121.11
Night 4	92.73	84.10	102.54	91.17	57.68	104.03
<i>Total wake time</i>						
Night 1	83.56	30.47	550.56	141.64	64.82	562.50
Night 2	163.66	63.19	563.64	194.15	24.83	727.27
Night 3	239.05	86.17	458.33	268.61	45.35	519.48
Night 4	218.42	75.85	432.00	161.24	80.00	652.17
<i>Sleep efficiency, %</i>						
Night 1	100.69	63.37	119.43	88.39	0.00	114.07
Night 2	89.34	63.60	115.61	90.88	51.24	122.47
Night 3	88.51	78.53	105.12	90.79	67.78	118.92
Night 4	91.96	83.77	103.53	91.88	60.47	101.00
<i>Sleep-onset Latency</i>						
Night 1	53.33	6.23	93.33	218.45	0.00	629.00
Night 2	33.33	3.38	243.48	235.60	58.48	1090.91
Night 3	57.14	0.00	88.89	162.34	66.67	857.14
Night 4	34.76	0.00	95.24	233.33	71.43	500.00
<i>Time in bed</i>						
Night 1	100.95	96.97	105.33	99.85	94.95	104.48
Night 2	99.53	97.49	103.52	100.04	97.11	106.36
Night 3	101.41	99.38	103.16	101.83	100.32	103.42
Night 4	99.92	97.27	102.55	100.34	98.26	103.04

For nights 1 and 2, $N = 17$ and for nights 3 and 4, $N = 8$. Actigraphy/PSG = ratio of actigraphy data to polysomnography data X 100; Sleep diary/PSG = ratio of sleep diary data to polysomnography data X 100. Both ratios were adapted from Edinger and Fins (1995) objective sleep estimate (OSE) formula.

TWT, TST, and SE ($r_s = .52, .71, \text{ and } .57$, respectively, $p_s = .05, .003, .03$). For TIB, there were significant positive correlations between devices at each of the 2 nights (for night 1: $r_s = .91, .90, \text{ and } .88$, $p_s = .0001$. For night 2: $r_s = .97, .94, \text{ and } .97$, $p_s = .0001$). There was no other significant correlation between devices.

Sensitivity of the 3 Devices to Treatment Effect

Table 3 presents means and SD for 5 dependent sleep variables (TST, TWT, SE, SOL, and TIB) as measured with the 3 devices (PSG, actigraphy, and sleep diary) for 2 nights at baseline and 2 nights after treatment. Repeated-measure ANOVAs with 3 within-subject effects (2 times, 2 nights, and 3 devices) revealed significant decreases for TWT and TIB and a significant increase for SE from baseline to posttreatment, $F_s(1,6) = 45.83, 31.80, \text{ and } 33.41$, respectively, $p_s < .001$. Repeated-measure ANOVAs also revealed a significant decrease in TST and SOL from baseline to posttreatment, $F_s(1,6) = 5.71 \text{ and } 6.30$, respectively, $p_s < .05$, which would have been significant at $p = .01$ with a sample size of 19. These time effects from baseline to posttreatment indicated that changes were detected over time with all these assessment devices.

Significant device effects were obtained for SOL, $F(2,12) = 8.16$, $p = .006$, as well as for TWT, SE, and TST, $F_s(2,12) = 4.39, 4.57, \text{ and } 3.68$, respectively, $p_s = .04$. These later effects would have been significant at $p = .01$ with a sample size of 22. These effects indicated that data collected with the 3 devices differed for these sleep variables. Pairwise comparisons revealed that only sleep-diary data differed significantly from PSG data ($p_s = .03$) for these 3 sleep variables. No night effect or interaction such as night by device or device by time effects was significant.

CONCLUSION

The present findings provide evidence supporting the sensitivity and clinical utility of actigraphy in objectively documenting treatment response in chronic insomnia. Indeed, actigraphy detected changes on all

sleep variables after treatment. Furthermore, discrepancies between actigraphy and PSG were smaller than those obtained between sleep diary and PSG, suggesting that actigraphy was more accurate than the sleep diary. Actigraphic data correlated positively with most of the PSG data. Correlations were higher for TST and TIB than for SOL or TWT, suggesting that actigraphy is more accurate for global than for more discrete sleep variables. Objective estimates of TST and SE were generally slightly lower than or close to 100% for actigraphy. Furthermore, the range of scores of OSE for actigraphy was smaller than those for the sleep diary.

Taken together, these results suggest that actigraphy is a reliable method for assessing sleep-wake patterns and for monitoring treatment response among insomnia patients. First, the results show that actigraphy is as sensitive to changes in sleep parameters as PSG and sleep diary. Second, the most important difficulty with actigraphy appears to be in estimating SOL, which is underestimated by actigraphy and overestimated by the sleep diary. Therefore, using actigraphy with patients with primarily sleep-onset difficulties may lead to an underestimation of insomnia severity. Such limitations need to be taken into account when interpreting SOL data without PSG. Third, actigraphy provides a reliable method for assessing TIB, an important treatment target when using sleep-restriction procedures. This result concurs with those of previous studies that have used actigraphy as an outcome measure^{9,10,13} and provides additional evidence supporting the use of actigraphy as a reliable measure of compliance with behavioral treatment for insomnia. Actigraphy may actually promote treatment compliance. Indeed, because patients know that the actigraph monitors movement, they may be more inclined to adhere to prescribed behavioral recommendations. Therefore, actigraphy not only is an assessment tool to monitor outcome, but can also promote treatment compliance at home.

The findings regarding discrepancies show that using absolute discrepancies alone may mask important differences between PSG and actigraphy. Indeed, our results on absolute discrepancies concur with those of previous studies,^{6,10,17} where it was shown that actigraphy relative to PSG inflated sleep time. On the other hand, examinations of the relative discrepancies (-8.56 and -38.29 minutes) and of the OSE suggest that actigraphy compared to PSG underestimates TST, which is also consistent with at least 1 other study.¹³ Therefore, there is a need to develop other methods to analyze data collected from different assessment devices and methods that will lead to more convergent findings about the underestimation or overestimation of sleep-wake parameters with actigraphy. Additional investigations are needed on this issue.

The present results should be interpreted cautiously given some methodologic limitations, including the small sample size and missing data due to technical problems. In addition, the results may not generalize to samples of patients with insomnia secondary to medical¹⁶ or psychiatric disorders. The fact that the actigraph was damaged during treatment underscores the importance of using more than 1 assessment device to measure sleep and wakefulness. Furthermore, since insomnia is a complex syndrome including physiologic and psychologic components,¹ it is necessary to use multiple measures to capture all of its different components.²⁶

In conclusion, this study provides additional evidence supporting the clinical utility of actigraphy for assessing sleep among insomnia patients. Our findings are consistent with the conclusions of a recent update of practice parameters on the role of actigraphy in the study of sleep.²⁷ The potential impact of actigraphy on promoting adherence to behavioral treatment should also be investigated in additional studies. Finally, these preliminary findings should be replicated with larger samples, and, until then, actigraphy should be used only as an adjunct to PSG or the sleep diary.

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Table 3—Polysomnography, actigraphy, and sleep-diary data for each night and each sleep variable (N = 8).

	Polysomnography		Actigraphy		Sleep Diary	
	Mean	(SD)	Mean	(SD)	Mean	(SD)
<i>Total sleep time (minutes)</i>						
Night 1	391.63 ^a	(52.64)	362.57 ^a	(49.95)	327.14 ^a	(94.11)
Night 2	388.03 ^a	(56.07)	349.00 ^a	(50.13)	309.43 ^a	(53.41)
Night 3	349.00 ^b	(52.85)	316.29 ^b	(30.74)	307.14 ^b	(67.69)
Night 4	362.76 ^b	(49.53)	333.43 ^b	(34.65)	322.86 ^b	(81.64)
Total	372.85	(17.78)	340.32	(10.16)	316.64	(24.21)
<i>Total wake time (minutes)</i>						
Night 1	75.56 ^a	(51.57)	104.29 ^a	(50.37)	136.43 ^a	(92.63)
Night 2	71.20 ^a	(30.49)	109.29 ^a	(55.42)	165.71 ^a	(78.82)
Night 3	36.29 ^b	(24.40)	72.00 ^b	(19.33)	80.00 ^b	(49.24)
Night 4	24.51 ^b	(12.23)	50.29 ^b	(15.48)	61.43 ^b	(45.53)
Total	51.89 ^y	(8.58)	83.96 ^{yz}	(12.49)	110.89 ^z	(17.07)
<i>Sleep efficiency (%)</i>						
Night 1	84.49 ^a	(10.99)	77.86 ^a	(10.43)	70.60 ^a	(19.74)
Night 2	85.00 ^a	(7.65)	76.43 ^a	(10.66)	67.53 ^a	(12.17)
Night 3	91.06 ^b	(7.64)	81.43 ^b	(4.16)	78.96 ^b	(13.20)
Night 4	94.09 ^b	(4.17)	85.86 ^b	(3.98)	83.16 ^b	(13.67)
Total	88.66 ^y	(2.35)	80.39 ^{yz}	(2.41)	75.06 ^z	(4.09)
<i>Sleep-onset Latency (minutes)</i>						
Night 1	16.40 ^a	(8.87)	6.57 ^a	(2.88)	30.00 ^a	(20.41)
Night 2	17.70 ^a	(7.83)	4.43 ^a	(5.00)	40.00 ^a	(27.84)
Night 3	9.73 ^b	(7.12)	4.00 ^b	(3.27)	30.71 ^b	(40.04)
Night 4	6.86 ^b	(1.82)	3.29 ^b	(3.45)	17.86 ^b	(13.18)
Total	12.67 ^y	(2.21)	4.57 ^{yz}	(0.73)	29.64 ^z	(8.15)
<i>Time in bed (minutes)</i>						
Night 1	463.87 ^a	(22.54)	466.86 ^a	(22.77)	463.57 ^a	(24.28)
Night 2	455.23 ^a	(34.89)	458.29 ^a	(40.07)	460.86 ^a	(38.99)
Night 3	381.73 ^b	(33.66)	388.29 ^b	(35.41)	387.14 ^b	(34.14)
Night 4	384.31 ^b	(39.91)	383.86 ^b	(41.01)	385.71 ^b	(41.07)
Total	421.29 ^y	(10.46)	424.32 ^z	(10.03)	424.32 ^y	(10.59)

For each variable, means in the same column and in the same row that do not share the same subscripts (^a and ^b or ^y and ^z) differ at $p < .05$.

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