

Sleep actigraphy evidence of improved sleep after treatment of allergic rhinitis

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Background: Children with allergic rhinitis (AR) are reported to have disturbed sleep and daytime fatigue due to nasal obstruction.

Objective: To evaluate sleep impairment in children with AR using actigraphic evaluation.

Methods: Fourteen children aged 7 to 16 years with grass pollen-sensitized seasonal AR were enrolled. They completed the Total 4-Symptom Score (T4SS) scoring system for AR symptom score and the Pittsburgh Sleep Quality Index (PSQI) questionnaire for sleep quality, and they underwent actigraphy for 3 days in the pretreatment period. After topical corticosteroid and antihistaminic treatment for 8 weeks, actigraphy, the T4SS, and the PSQI were repeated. Fourteen healthy children aged 8 to 16 years underwent actigraphy and completed the PSQI questionnaire as controls.

Results: There were no significant age or sex differences between the AR and control groups. Pretreatment PSQI and actigraphy scores were worse in the AR group vs the control group. After treatment, sleep quality improved, and there were no differences in actigraphy and PSQI scores between the 2 groups. Before treatment, the T4SS was significantly correlated with the sleep efficiency, daytime napping episodes, and total nap duration variables of actigraphy ($r = -0.53$, $P = .004$; $r = 0.43$, $P = .02$; and $r = 0.39$, $P = .04$, respectively). The T4SS was correlated with the total PSQI score ($r = 0.67$, $P < .001$).

Conclusions: Sleep can be compromised in children with AR. There is a significant correlation of clinical symptom score with the actigraphic and PSQI variables. Therefore, actigraphy may be used as an objective tool to evaluate sleep disturbance in children with AR.

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INTRODUCTION

Allergic rhinitis (AR) has been demonstrated to be associated with poor sleep quality and daytime sleepiness, leading to daytime somnolence associated with decreased cognitive performance, attention deficit, and deterioration of school performance in children.^{1–5} These consequences highlight the importance of sleep evaluation in children with AR. AR may have a negative impact on not only physical but also psychological and social aspects of life.^{6–8} One of the most important end results is decreased health-related quality of life.^{7,8}

Sleep can be evaluated using subjective questionnaires, actigraphy, and the gold standard technique, polysomnography. Questionnaires about sleep, one of which is the Pittsburgh Sleep Quality Index (PSQI), are subjective methods of sleep evaluation that depend on self-reported results.^{9,10} Actigraphy investigates sleep pattern variations across time, the effects of different behavioral or medical interferences on sleep-wake patterns, and differences between clinical groups.¹¹ Actigraphic evaluation can identify certain sleep-wake disorders and yield ambulatory and continuous moni-

toring of movement. The actigraph is placed on the nondominant wrist. It has a miniaturized acceleration sensor that translates motor activity into a numeric value.¹² Thus, actigraphy provides an objective evaluation of sleep that depends on the detection of movements.⁹

The purpose of this study was subjective and objective evaluation of sleep impairment in children with AR using the PSQI questionnaire and the Total 4-Symptom Score (T4SS) scoring system as subjective methods and actigraphy as an objective method. In addition, we aimed to determine the correlation of sleep and clinical variables and to clarify the utility of actigraphy as an objective method for evaluating sleep impairment in children with AR.

METHODS

This study was approved by the ethics committee of the Celal Bayar University School of Medicine. Written informed consent was provided by the parents.

Participants

Fourteen children (10 boys and 4 girls) aged 7 to 16 years with seasonal AR were enrolled in the study. Diagnosis of seasonal AR depended on clinical findings of nasal itching, sneezing, nasal congestion, and rhinorrhea. Exclusion criteria included declining to participate, treatment with antihistamines or nasal corticosteroids during the previous 3 months, and the presence of a psychiatric illness or a chronic disease. Fourteen healthy children (10 boys and 4 girls) aged 8 to 16

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years were enrolled as the control group. Children with AR symptoms were excluded from the control group.

Study Design

Demographic characteristics of all the children, including age and sex, were recorded at the beginning of the study. Children in the AR group completed the T4SS and PSQI questionnaires and underwent actigraphy for 3 days at presentation when they were symptomatic. Repeated tests were performed after 8 weeks of topical corticosteroid (fluticasone) and antihistaminic (levocetirizine) treatment. Children in the control group also completed the PSQI questionnaire and underwent actigraphy.

Sleep diaries and the PSQI were used for subjective evaluation of sleep, and actigraphy was used for objective evaluation. All the children in the study were instructed to wear wrist actigraphs continuously except for the times of bathing. Children were taught to mark specific events, such as going to bed to sleep and waking up, by pressing the event button to allow determination of time spent in bed. In addition, they filled in a sleep diary during actigraphic evaluation. Diaries were used to detect daily bed times, times of sleep onset, frequency and duration of awakening periods, final awakening time, and napping (sleep times other than the principle period) times during the day, which were used to make interpretations about sleep latency, frequency, prolonged awakenings, and total sleep time.

Symptom Score

The T4SS is a subjective scoring system for determination of symptom severity in patients with AR. It includes nasal itching, ocular itching, sneezing, and nasal discharge scored from 0 (no symptoms) to 3 (severe symptoms). Total score is calculated by adding the scores for all 4 domains.¹³

The PSQI Questionnaire

In previous studies,¹⁴⁻¹⁷ the PSQI questionnaire was used for evaluation of childhood sleep quality. We used the PSQI questionnaire for subjective evaluation of sleep in children. The PSQI includes 19 questions to evaluate sleep quality, sleep duration, and the presence and severity of a sleep disorder. It was completed by one of the researchers via face-to-face interviews. The PSQI is composed of 7 domains: subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbance, use of sleep medications, and daytime dysfunction. All the questions are scored from 0 to 3 according to the frequency of the symptom: 0 indicates that the symptom did not occur in the past month; 1, it occurred less than once a week; 2, it occurred once or twice a week; and 3, it occurred 3 or more times a week. Subjective sleep quality is scored from 0 to 3, with 0 being very good and 3 being very bad. The global score ranges from 0 to 21, with higher values indicating worse sleep quality and a higher level of sleep disorder. Scores greater than 10 indicate a chronic sleep disorder.¹⁰ The Turkish adaptation of the PSQI has been performed by Agargün et al.¹⁸

Actigraphy

To evaluate sleep duration and continuity and to gather information about daytime naps, each child wore an actigraph on the nondominant wrist on the morning of the first day and did not take it off for 3 days except for bath times. All the watches were calibrated before testing. Settings of 30-second epochs and a maximum frequency of 32 Hz were used to gather data. The sensitivity of the actigraph was adjusted to determine awakening if motor activity values were 20 or greater. Sleep onset was defined as no motor activity for a minimum of 10 minutes after pressing the marker. During nap analysis, a motor activity value less than 5 was accepted as a sleep period. Sleep periods of 5 to 15 minutes during daytime were defined as nap times. Event marker pressing times during bed times and awakening were used to detect the primary sleep period. Total sleep time was defined as the time passing in bed during the night except awakening periods.¹⁹

Sleep latency, percentage of being awakened after onset of sleep, daily sleep and daytime activity variables, and total activity score variables were evaluated. Computer programs were used for evaluation of the levels of activity/inactivity and sleep/wakefulness. Sleep efficiency (nocturnal sleep time divided by time in bed), total awake time, nap times, number/frequency of awakenings, duration of awakenings, and percentage of time spent awake were also measured.¹⁹

Statistical Analysis

Statistical analysis was performed using a computer program (SPSS 10.0; SPSS Inc, Chicago, Illinois). The Wilcoxon signed rank test was used for pretreatment and posttreatment comparisons, and the Mann-Whitney test was used to compare AR and control patients. The χ^2 test was used for frequency comparisons. Spearman correlation analysis was used for the correlation analysis. The level of statistical significance was set at $P < .05$.

RESULTS

The patient group comprised 14 children (10 boys and 4 girls) aged 7 to 16 years (mean [SD], 10.92 [2.78] years), and the control group consisted of 14 healthy children (10 boys and 4 girls) aged 8 to 16 years (mean [SD], 10.71 [2.01] years). Age and sex were not significantly different between the groups ($P = .93$ and $P = .66$, respectively) (Table 1).

Table 1. Demographic Characteristics of All the Children in the Study

Characteristics	Patients with AR (n = 14)	Controls (n = 14)	P value
Age, mean (SD), y	10.92 (2.78)	10.71 (2.01)	.93
Sex, No. (%)			
Male	10 (71)	10 (71)	.66
Female	4 (29)	4 (29)	

Abbreviation: AR, allergic rhinitis.

Table 2. PSQI Results in the AR and Control Groups

PSQI domain	AR group ^a		P value ^b	Control group ^a	P value ^c	P value ^d
	Pretreatment	Posttreatment				
Subjective sleep quality	0.78 (0.80)	0.36 (0.63)	.08	0.21 (0.43)	.04	.61
Sleep latency	1.29 (0.83)	0.57 (0.76)	.01	0.50 (0.65)	.01	.88
Sleep duration	0.07 (0.27)	0.00 (0.00)	.32	0.07 (0.27)	>.99	.32
Sleep efficiency	0.00 (0.00)	0.00 (0.00)	>.99	0.00 (0.00)	>.99	>.99
Sleep disturbance	1.29 (0.61)	0.36 (0.49)	.004	0.43 (0.76)	.003	.91
Use of hypnotic medications	0.00 (0.00)	0.00 (0.00)	>.99	0.00 (0.00)	>.99	>.99
Daytime dysfunction	1.43 (0.85)	0.50 (0.65)	.004	0.29 (0.61)	<.001	.28
Total PSQI score	4.86 (2.21)	1.79 (1.67)	.001	1.5 (2.1)	.001	.40

Abbreviations: AR, allergic rhinitis; PSQI, Pittsburgh Sleep Quality Index.

^a Scores are given as mean (SD).

^b Comparison of pretreatment and posttreatment values of the AR group.

^c Comparison of pretreatment values of the AR group vs the control group.

^d Comparison of posttreatment values of the AR group vs the control group.

Comparison of PSQI Scores and Actigraphy Variables in the AR and Control Groups

The mean (SD) total PSQI score of the AR group before treatment was significantly higher than that of the control group (4.86 [2.21] vs 1.5 [2.1], $P = .001$) (Table 2). Similarly, the subjective sleep, sleep latency, sleep disturbance, and daytime dysfunction scores of the PSQI were significantly higher in the AR group vs the control group, indicating impaired sleep quality in the AR group before treatment ($P = .04$, $P = .01$, $P = .003$, and $P < .001$, respectively) (Table 2). On the other hand, this difference in PSQI scores between groups was lost after treatment of the AR group ($P > .05$) (Table 2).

Comparison of the actigraphy variables of the AR group before treatment with the control group revealed that mean (SD) sleep latency was significantly higher in the AR group (61.4 [40.3] minutes vs 13.6 [26.4] minutes, $P < .001$). Mean (SD) total sleep time and sleep efficiency were significantly higher in the control group (7.3 [0.6] hours vs 6.0 [1.5] hours, $P = .006$, and 88.7% [7.1%] vs 64.4% [14.9%], $P < .001$,

respectively). The mean (SD) fragmentation index was significantly higher in the AR group (28.1 [25.5] vs 11.3 [6.0], $P = .02$). Similarly, daytime napping episodes and total nap duration were significantly higher in the AR group before treatment ($P = .002$ and $P = .003$, respectively). On the other hand, comparison of the actigraphy variables in the control group with those in the AR group after treatment did not show significant differences ($P > .05$ for all) (Table 3).

Comparison of the PSQI Scores and Actigraphy Variables Before and After Treatment in the AR Group

There was a significant decrease in the total PSQI score of the AR group after treatment, indicating improvement in sleep quality (4.86 [2.21] vs 1.79 [1.67], $P = .001$). Similarly, sleep latency, sleep disturbance, and daytime dysfunction scores of the PSQI had decreased significantly with treatment ($P = .01$, $P = .004$, and $P = .004$, respectively) (Table 2).

There was a significant decrease in the sleep latency variable of actigraphy with treatment in the AR group (mean [SD]: 61.4 [40.3] minutes vs 17.8 [35.7] minutes, $P = .001$).

Table 3. Actigraphy Results in the AR and Control Groups

Actigraphy variable	AR group ^a		P value ^b	Control group ^a	P value ^c	P value ^d
	Pretreatment	Posttreatment				
Sleep latency, min	61.4 (40.3)	17.8 (35.7)	.001	13.6 (26.4)	<.001	.29
Total sleep time, hours/night	6.0 (1.5)	7.1 (0.9)	.04	7.3 (0.6)	.006	.29
Total activity score, No./night	25,510.5 (40,375.3)	5,631.6 (3,311.6)	.02	4,301.7 (2,410.1)	.056	.40
Actual wake time, min	74.1 (80.9)	33.1 (15.4)	.13	32.4 (16.6)	.38	.98
Fragmentation index, No./d	28.1 (25.5)	13.1 (8.3)	.01	11.3 (6.0)	.02	.67
Sleep efficiency, %	64.4 (14.9)	86.7 (5.9)	.001	88.7 (7.1)	<.001	.38
Daytime napping episodes, No./d	3.9 (2.6)	1.9 (2.1)	.03	1.1 (1.8)	.002	.21
Total nap duration, min/d	30.0 (20.3)	13.9 (15.0)	.03	8.8 (13.7)	.003	.30

Abbreviation: AR, allergic rhinitis.

^a Data are given as mean (SD).

^b Comparison of pretreatment and posttreatment values in the AR group.

^c Comparison of pretreatment values in the AR group vs the control group.

^d Comparison of posttreatment values in the AR group vs the control group.

Mean (SD) total sleep time increased significantly with treatment in the AR group (6.0 [1.5] hours vs 7.1 [0.9] hours, $P = .04$). Similarly, there was a significant decrease in the total activity score and the fragmentation index detected by actigraphy (25,510.5 [40,375.3] vs 5,631.6 [3,311.6], $P = .02$, and 28.1 [25.5] vs 13.1 [8.3], $P = .01$, respectively). The mean (SD) sleep efficiency of the AR group increased from 64.4% (14.9%) to 86.7% (5.9%) after treatment ($P = .001$). Daytime napping episodes and total nap duration also decreased significantly with treatment in the AR group ($P = .03$ for both) (Table 3).

Correlation of Self-reported Quality of Sleep and Actigraphy Variables With Symptom Score

The AR symptom score was significantly correlated with many of the actigraphy variables and with self-reported sleep quality scores before treatment. Sleep efficiency was significantly correlated with AR symptom score ($r = -0.53$, $P = .004$). Furthermore, AR symptom score was significantly correlated with daytime napping episodes and total nap duration ($r = 0.43$, $P = .02$; $r = 0.39$, $P = .04$, respectively). Of the self-reported variables, AR symptom score was correlated with the total PSQI score ($r = 0.67$, $P < .001$). The total PSQI score was negatively correlated with the sleep efficiency score of actigraphy ($r = -0.39$, $P = .01$). The fragmentation index of actigraphy also showed significant correlation with the total PSQI score ($r = 0.31$, $P = .04$).

DISCUSSION

AR has been demonstrated to be associated with poor sleep quality and daytime sleepiness in previous studies.^{20–24} Impaired sleep leads to daytime somnolence.^{1,2,23,24} Daytime somnolence has been shown to be associated with decreased cognitive performance and productivity not only in adults but also in children because these symptoms may lead to attention deficit and deterioration of school performance.^{1–5,25} The results of the present study demonstrate that subjective sleep quality, sleep latency, sleep disturbance, daytime dysfunction subscores, and total PSQI score determined by PSQI questionnaire were significantly worse in children with AR than in the control group. Similar differences between the 2 groups were demonstrated by sleep latency, total sleep time, fragmentation index, sleep efficiency, daytime napping episodes, and total nap duration as determined by actigraphy. Furthermore, differences between the 2 groups in terms of PSQI sleep quality and actigraphy variables at the beginning of the study disappeared after treatment, when symptoms of AR decreased. These results comply with those of previous studies^{1–5,20–23} that have reported impairment of sleep quality due to AR.

It has been reported previously that there is a poor correlation between sleep questionnaires completed by parents and actigraphy results in children aged 4 to 7 years.⁹ This had been explained by the fact that parents cannot predict awakenings of children at night if the child does not inform or signal them and by the presence of recall bias.⁹ The PSQI in

this questionnaire was filled in by the children themselves, who were older than those in the previously mentioned study,⁹ avoiding this kind of an interference with the results. Furthermore, PSQI questions about the last month decreased recall bias.

Actigraphy, with the device worn on the wrist or ankle, is a method for evaluation of sleep-wake patterns by measuring motor activity.²⁶ It has been reported to be correlated with polysomnography results and has been used in research previously to determine sleep patterns in various diseases.^{27–29} For example, actigraphy has demonstrated impaired sleep/wake cycles due to disrupted night sleep and daytime naps in children with chronic fatigue syndrome.³⁰ In a previous study that compared actigraphy, polysomnography, and subjective sleep questionnaires in the evaluation of sleep, it has been reported that actigraphy is sensitive in detecting sleep but overestimates total sleep time and sleep efficiency. However, it has been reported in the same study that the combination of subjective sleep evaluation with actigraphy significantly improves evaluation of total sleep time and sleep efficiency.²⁶ Therefore, both the PSQI questionnaire and actigraphy were used to evaluate sleep in this study, and total PSQI score was correlated with sleep efficiency and the fragmentation index of actigraphy.

Mansfield et al³¹ evaluated sleep using polysomnography and quality of life using the Rhinitis Quality of Life Questionnaire. They found that objective responses on the questionnaire showed improvements consistent with improved sleep and lessened rhinitis symptoms. Also, the mean number of sleep arousals per hour (all apneas and hypopneas) decreased from a baseline of 8.4 to 1.2 after treatment. The change was mainly in hypopneic episodes.³¹

In the present study, the PSQI was the subjective method and actigraphy was the objective method of sleep evaluation. The PSQI demonstrated significant improvement in sleep latency, sleep disturbance, and daytime dysfunction subscores and total score with treatment. Meanwhile, actigraphy, as an objective method of evaluating sleep impairment in children with AR, showed significant improvement in sleep latency, total sleep time, total activity score, fragmentation index, sleep efficiency, daytime napping episodes, and total nap duration.

Limitations of the Study

One limitation of this study was that we did not perform polysomnography, the gold standard for the evaluation of sleep. Polysomnography studies are expensive and time-consuming, requiring a special team and equipment. Actigraphy results have been reported to be correlated with polysomnography results, and actigraphy has been used in research previously to determine sleep patterns in various diseases.^{27–29} Actigraphy has been used by clinical sleep laboratories to evaluate sleep disorders over short and long periods at home.³² It has been reported that the actigraph provides an objective, nonobtrusive measure of sleep at home in patients with skin disease and can provide an important outcome

measure in clinical trials.³³ Actigraphy has also been used to evaluate sleep in children with attention-deficit/hyperactivity disorder.³⁴ Thus, we used actigraphy for objective evaluation of the sleep patterns in this study. The second limitation of this study was lack of reassessment of actigraphy in the control group. However, because they did not have any sleep disturbance described, we did not expect to find a change.

In conclusion, subjective sleep variables, including sleep latency, sleep disturbance, and daytime dysfunction, and the objective actigraphic variables of sleep efficiency, sleep latency, and total sleep time are significantly impaired in children with AR. There is a significant correlation of objective and subjective sleep variables with clinical symptom score. These results highlight the importance of evaluation of sleep and other clinical variables in children with AR. Also, actigraphy may yield objective data for the evaluation of sleep impairment in children with AR.

REFERENCES

1. Storms WW. Pharmacologic approaches to daytime and nighttime symptoms of allergic rhinitis. *J Allergy Clin Immunol.* 2004;114(suppl 5):146–153.
2. Fisher L, Ghaffari G, Davies M, Craig T. Effects of poor sleep in allergic rhinitis. *Curr Opin Allergy Clin Immunol.* 2005;5:11–16.
3. Kakumanu S, Glass C, Craig T. Poor sleep and daytime somnolence in allergic rhinitis: significance of nasal congestion. *Am J Respir Med.* 2002;119:195–200.
4. Santos CB, Pratt EL, Hanks C, McCann J, Craig TJ. Allergic rhinitis and its effect on sleep, fatigue, and daytime somnolence. *Ann Allergy Asthma Immunol.* 2006;97:579–586.
5. Craig TJ, McCann JL, Gurevich F, Davies MJ. The correlation between allergic rhinitis and sleep disturbance. *J Allergy Clin Immunol.* 2004;114(suppl 5):139–145.
6. Baiardini I, Braido F, Brandi S, Canonica GW. Allergic diseases and their impact on quality of life. *Ann Allergy Asthma Immunol.* 2006;97:419–428.
7. Thompson AK, Juniper E, Meltzer EO. Quality of life in patients with allergic rhinitis. *Ann Allergy Asthma Immunol.* 2000;85:338–347.
8. Passalacqua G, Canonica GW, Baiardini I. Rhinitis, rhinosinusitis and quality of life in children. *Pediatr Allergy Immunol.* 2007;18:40–45.
9. Werner H, Molinari L, Guyer C, Jenni OG. Agreement rates between actigraphy, diary, and questionnaire for children's sleep patterns. *Arch Pediatr Adolesc Med.* 2008;162:350–358.
10. Buysse DJ, Reynolds CF III, Monk TH, Berman SR, Kupfer DJ. The Pittsburgh Sleep Quality Index: a new instrument for psychiatric practice and research. *Psychiatry Res.* 1989;28:193–213.
11. Acebo C, LeBourgeois MK. Actigraphy. *Respir Care Clin N Am.* 2006;12:23–30.
12. Hourmand-Ollivier I, Piquet MA, Toudic JP, Denise P, Dao T. Actigraphy: a new diagnostic tool for hepatic encephalopathy. *World J Gastroenterol.* 2006;12:2243–2244.
13. Yuksel H, Yilmaz O, Sogut A, Ertan P, Onur E. Correlation of quality of life with clinical parameters and eosinophilic cation protein levels in children with allergic rhinoconjunctivitis. *Int Arch Allergy Immunol.* 2008;148:18–22.
14. Yuksel H, Sogut A, Yilmaz O, Demet M, Ergin D, Kirmaz C. Evaluation of sleep quality and anxiety-depression parameters in asthmatic children and their mothers. *Respir Med.* 2007;101:2550–2554.
15. Megdal SP, Schernhammer ES. Correlates for poor sleepers in a Los Angeles high school. *Sleep Med.* 2007;9:60–63.
16. Tagaya H, Uchiyama M, Ohida T, et al. Sleep habits and factors associated with short sleep duration among Japanese high-school students: a community study. *Sleep Biol Rhyth.* 2004;2:57–64.
17. Yang CM, Wu CH, Hsieh MH, Liu MH, Lu FH. Coping with sleep disturbances among young adults: a survey of first-year college students in Taiwan. *Behav Med.* 2003;29:133–138.
18. Agargün MY, Kara H, Anlar O. Pittsburgh Uyku Kalitesi İndeksinin geçerliliği ve güvenilirliği. *Türk Psikiyatri Derg.* 1996;7:107–115.
19. Yilmaz H, Iskesen I. Objective and subjective characteristics of sleep after coronary artery bypass graft surgery in the early period: a prospective study with healthy subjects. *Heart Surg Forum.* 2007;10:16–20.
20. Craig TJ, Hanks CD, Fisher LH. How do topical nasal corticosteroids improve sleep and daytime somnolence in allergic rhinitis? *J Allergy Clin Immunol.* 2005;116:1264–1266.
21. Craig TJ, Teets S, Lehman EB, Chinchilli VM, Zwillich C. Nasal congestion secondary to allergic rhinitis as a cause of sleep disturbance and daytime fatigue and the response to topical nasal corticosteroids. *J Allergy Clin Immunol.* 1998;101:633–637.
22. Conboy-Ellis K. Management of seasonal allergic rhinitis: comparative efficacy of the newer-generation prescription antihistamines. *J Am Acad Nurse Pract.* 2005;17:295–301.
23. Woods L, Craig TJ. The importance of rhinitis on sleep, daytime somnolence, productivity and fatigue. *Curr Opin Pulm Med.* 2006;12:390–396.
24. Blunden SL, Beebe DW. The contribution of intermittent hypoxia, sleep debt and sleep disruption to daytime performance deficits in children: consideration of respiratory and non-respiratory sleep disorders. *Sleep Med Rev.* 2006;10:109–118.
25. Fallone G, Acebo C, Arnedt JT, Seifer R, Carskadon MA. Effects of acute sleep restriction on behavior, sustained attention, and response inhibition in children. *Percept Mot Skills.* 2001;93:213–229.
26. Kushida CA, Chang A, Gadkary C, Guilleminault C, Carrillo O, Dement WC. Comparison of actigraphic, polysomnographic, and subjective assessment of sleep parameters in sleep-disordered patients. *Sleep Med.* 2001;2:389–396.
27. Sadeh A, Hauri P, Kripke D, Lavie P. The role of actigraphy in the evaluation of sleep disorders. *Sleep.* 1995;18:288–302.
28. Jean-Louis G, von Gizycki H, Zizi F, et al. Determination of sleep and wakefulness with the actigraph data analysis software (ADAS). *Sleep.* 1996;19:739–743.
29. Ancoli-Israel S, Cole R, Alessi C, Chambers M, Moorcroft W, Pollak C. The role of actigraphy in the study of sleep and circadian rhythms. *Sleep.* 2003;26:342–392.
30. Ohinata J, Suzuki N, Araki A, Takahashi S, Fujieda K, Tanaka H. Actigraphic assessment of sleep disorders in children with chronic fatigue syndrome. *Brain Dev.* 2008;30:329–333.
31. Mansfield LE, Diaz G, Posey CR, Flores-Neder J. Sleep disordered breathing and daytime quality of life in children with allergic rhinitis during treatment with intranasal budesonide. *Ann Allergy Asthma Immunol.* 2004;92:240–244.
32. American Sleep Disorders Association. Practice parameters for the use of actigraphy in the clinical assessment of sleep disorders. *Sleep.* 1995;18:285–287.
33. Bender BG, Leung SB, Leung DY. Actigraphy assessment of sleep disturbance in patients with atopic dermatitis: an objective life quality measure. *J Allergy Clin Immunol.* 2003;111:598–602.
34. Corkum P, Tannock R, Moldofsky H, Hogg-Johnson S, Humphries T. Actigraphy and parental ratings of sleep in children with attention deficit/hyperactivity disorder (ADHD). *Sleep.* 2001;24:303–312.

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