UNCL
SECURITY

(2)

AD-A207 151

NTATION PAGE

Form Approved
OMB No. 0704-0188

1a. REPOI
Unc.

1b. RESTRICTIVE MARKINGS

2a. SECURITY CLASSIFICATION AUTHORITY

2b. DECLASSIFICATION / DOWNGRADING SCHEDULE

3. DISTRIBUTION / AVAILABILITY OF REPORT
Approved for public release; distribution is unlimited.

4. PERFORMING ORGANIZATION REPORT NUMBER(S)
USAFSAM-JA-88-27

5. MONITORING ORGANIZATION REPORT NUMBER(S)

6a. NAME OF PERFORMING ORGANIZATION
USAF School of Aerospace Medicine

6b. OFFICE SYMBOL (If applicable)
USAFSAM/NGN

7a. NAME OF MONITORING ORGANIZATION

6c. ADDRESS (City, State, and ZIP Code)
Human Systems Division (AFSC)
Brooks Air Force Base, TX 78235-5301

7b. ADDRESS (City, State, and ZIP Code)

8a. NAME OF FUNDING / SPONSORING ORGANIZATION
USAF School of Aerospace Medicine

8b. OFFICE SYMBOL (If applicable)
USAFSAM/NGN

9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER

8c. ADDRESS (City, State, and ZIP Code)
Human Systems Division (AFSC)
Brooks Air Force Base, TX 78235-5301

10. SOURCE OF FUNDING NUMBERS

PROGRAM ELEMENT NO.	PROJECT NO.	TASK NO.	WORK UNIT ACCESSION NO.
62202F	7755	27	01

11. TITLE (Include Security Classification)
Evaluation of the Sleepy Crewmember: USAFSAM Experience and A Suggested Clinical Approach

12. PERSONAL AUTHOR(S)
Katchen, Marc S., and Gronseth, Gary S.

13a. TYPE OF REPORT	13b. TIME COVERED	14. DATE OF REPORT (Year, Month, Day)	15. PAGE COUNT
Interim	FROM 87/11 TO 88/04	1989, March	5

16. SUPPLEMENTARY NOTATION
Published in Aviation, Space, and Environmental Medicine, 60(3): 263-267 (March 1989)

17. COSATI CODES		
FIELD	GROUP	SUB-GROUP
06	10	
06	05	

18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
Sleep Disorders, Pilots, Excessive Daytime Sleepiness, Narolepsy, Hypersomnia

19. ABSTRACT (Continue on reverse if necessary and identify by block number)
This paper presents a review of USAFSAM experience with rated aircrew as referred for excessive sleepiness. It contains a literature review of sleep disorders and presentation of a paradigm for working up excessive daytime sleepiness.

20. DISTRIBUTION / AVAILABILITY OF ABSTRACT
☒ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT. ☐ DTIC USERS

21. ABSTRACT SECURITY CLASSIFICATION
Unclassified

22a. NAME OF RESPONSIBLE INDIVIDUAL
Marc S. Katchen, Major, USAF, MC

22b. TELEPHONE (Include Area Code)
(512) 536-3537

22c. OFFICE SYMBOL
USAFSAM/NGN

DD Form 1473, JUN 86 Previous editions are obsolete.

SECURITY CLASSIFICATION OF THIS PAGE
UNCLASSIFED

(2)

Clinical Medicine

Evaluation of the Sleepy Crewmember: USAFSAM Experience and a Suggested Clinical Approach

MARC KATCHEN, M.D., and GARY S. GRONSETH, M.D.

KATCHEN M, GRONSETH GS. *Evaluation of the sleepy crewmember: USAFSAM experience and a suggested clinical approach.* Aviat. Space Environ. Med. 1989; 60:263–7.

From 1958 to 1986, 27 crewmembers with suspected sleep disorders were referred to the USAF School of Aerospace Medicine. The presenting complaint in most cases was excessive daytime sleepiness (EDS). Prior to 1984, evaluations included neurologic and psychiatric testing, screening laboratory studies, and awake and asleep electroencephalography. Polysomnography and sleep latency studies were included after 1984. In the majority of cases, the etiology of the complaint could not be determined. The prevalence of EDS is estimated to be between 0.3% and 4.0% of the adult population. Major causes cited in the world literature include the sleep apnea syndromes, narcolepsy, parasomnias interrupting sleep, hypersomnia secondary to systemic or affective disorders, and essential hypersomnia. Current sleep lab techniques and human leukocyte antigen (HLA) typing are reported to make the diagnosis in up to 90% of sleep disorders. Evaluation of EDS should begin with a history emphasizing sleep habits, work schedules, daytime naps, and presence of vegetative signs. A sleep diary will allow a more accurate estimate of the quantity of nocturnal sleep. This diary may reveal poor sleep hygiene or insomnia. Polysomnography and/or multiple sleep latency determination can then be used to diagnose sleep apnea, parasomnias, and narcolepsy. Reprints (KT/AW)

EXCESSIVE DAYTIME sleepiness (EDS) or hypersomnia is the most common sleep-related complaint after insomnia, with an estimated prevalence of up to 4% (2). It is defined as a tendency to easily fall asleep during the day, often in unusual, embarrassing, or even dangerous circumstances. EDS is distinguished from daytime fatigue or malaise without episodes of sleep.

Although the complaint of chronic fatigue is very common, the number of patients presenting because they cannot stay awake during the day is not. According to most sleep disorder specialists, over 90% of patients complaining of excessive daytime sleepiness, in contrast to those complaining of fatigue or insomnia, are found to have an underlying organic explanation of their symptoms (16).

In the United States, the sleep apnea syndromes are considered the leading cause of EDS (1,13). Most of these patients feel that the quantity and quality of their nocturnal sleep is adequate. Despite this, they do not feel rested after awakening, and fall asleep unintentionally or must take naps during the day. Patients with obstructive variety of apnea are often, but not always, obese. Family members may note disruptive nocturnal snoring. Nocturnal polysomnography consists of monitoring several EEG channels, respiratory air flow, blood oxygen saturation by ear oximetry, and audiovisual recording of the patient's behavior for a full night's sleep; it demonstrates multiple apneas lasting more than 10 s, when patients descend into the deeper stages of sleep, often associated with significant blood oxygen desaturation (up to 30% less than waking levels) (3,9,16). These apneas are followed by a lightening of sleep and, at times, complete awakening; sleep is disrupted. In the obstructive type of sleep apnea, apneas are caused by intermittent upper airway obstruction; in the central type, there is presumably a decreased CNS respiratory drive with sleep. Mixed varieties, combining central and obstructive features, are common.

Narcoleptics also complain of falling asleep during the day. Narcolepsy is considered the second most common cause of hypersomnia, with an estimated incidence per year of 4:10,000. As opposed to the sleep apnea patient, narcoleptics' episodes of sleep tend to come on suddenly, in irresistible attacks, are brief (typically lasting minutes), and more often occur in embarrassing or dangerous situations (14). This distinction is not always easily made in a given case. The association

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This manuscript was received for review in May 1988. The revised manuscript was accepted for publication in September 1988.

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of sleep attacks with cataplexy (sudden loss of motor tone with emotional stress), hypnogogic hallucinations (vivid dreams with sleep onset) or sleep paralysis helps distinguish narcolepsy from other causes of EDS. However, 25%–30% of narcoleptics have monosymptomatic narcolepsy, at least initially, in which they do not have these associative features (17). Most narcoleptics will have the onset of REM sleep within 10 to 15 min of sleep onset (SOREM) in 3 out of 4 trials as measured with the MSLT. In contrast, other patients with EDS will have short latencies to non-REM sleep onset (5–10 min as compared to controls at ≥20 min), but will not have SOREM (3,7). Another clinically useful feature of narcolepsy is its association with certain human leukocyte antigens, especially HLA-DR2, which is reported to be positive in 95%–100% of all cases with narcolepsy (5,8,12), compared to 20% in controls.

Those patients with EDS not having narcolepsy or sleep apnea are often diagnosed with essential, or idiopathic, hypersomnolence. In the United Kingdom, it is considered the most common cause of EDS after narcolepsy (14,15). These patients have short latencies to non-REM sleep onset on MSLT and they have normal or nonspecific abnormalities on nocturnal polysomnograms, with no other explanation for their sleepiness.

A minority of patients with EDS, according to U.S. sleep lab experience, are sleepy because of an inadequate quantity of sleep from poor sleep hygiene or nocturnal insomnia (14,16). Poor sleep hygiene is normally characterized by episodic hypersomnia associated with periods of decreased nocturnal sleep from overwork, situational anxiety, or a change in the sleep-wake cycle. Insomniacs generally complain primarily of their inability to sleep at night rather than hypersomnia, and do not present a diagnostic dilemma.

Certain parasomnias interfere with the quality of sleep in a way analogous to the sleep apnea syndromes. Patients with these disorders often present with EDS (11). Sleep histories from bed partners or nighttime sleep recordings usually make the diagnosis. A sleep history should include the hours of sleep per night with the time of sleep onset and awakening, number of awakenings (recorded by patient and spouse), quality of sleep, and description of daytime sleep events.

A variety of primarily medical or neurologic disorders may produce daytime sleepiness. These include hypothyroidism, uremia, liver failure, hypercalcemia, chronic pulmonary disease with hypercapnia, encephalitis, obstructive hydrocephalus, and tumors in the region of the hypothalamus (14,16). The associated features of these disorders usually, but not always, make the diagnosis clear.

Occasionally, EDS is an early and predominant symptom of depression (9). Often, other vegetative signs are present, or the patient admits to being depressed. Diagnostic confusion arises when a patient with hypersomnolence from another cause develops a secondary depression because of the severity of his illness, or when hypersomnolence is the only apparent manifestation of a primary depression. In this setting, nocturnal sleep recordings may be of help because the primarily depressed individual commonly demonstrates multiple spontaneous arousals, in contrast to the patterns of the other causes of hypersomnolence (4).

Although often underemphasized by the formal sleep literature, sedating drugs account for a portion of hypersomnolent patients (7). These drugs include alcohol as well as prescription and over-the-counter medications.

Many of the diseases causing EDS first present at the age range of active aircrew. This population is subjected to frequently changing sleep-wake schedules and high environmental stressors, or they experience poor sleep hygiene. Since the effects of EDS on flight safety are significant, we reviewed the experience of the USAF School of Aerospace Medicine (USAFSAM) with crewmembers referred for sleep disorders, and we present a clinical approach to the evaluation of the sleepy crewmember.

METHODS

All cases of flying crewmembers referred to USAFSAM for suspected sleep disorders were identified using the School's computerized data base. All clinical records from these referrals were retrospectively reviewed by one of the authors. Specific items evaluated included the presenting complaint, referral diagnosis, nature of the evaluation, final diagnosis, and aeromedical disposition. Whenever possible, information on the crewmembers' status following their USAFSAM evaluations was obtained.

RESULTS

From 1958 to 1986, 27 crewmembers with suspected sleep disorders were referred for evaluation. Of the charts reviewed from these referrals, 6 were judged to have insufficient information for analysis and were eliminated from the study. Table I summarizes the presenting complaints, referral diagnoses, final diagnosis, and aeromedical dispositions of the 21 remaining cases.

In general, the evaluation included, but was not limited to, a detailed history of the complaint; general physical examination; cardiologic evaluation; psychiatric evaluation, including neuropsychiatric testing; neurologic examination; routine screening blood work, including thyroid function tests; and standard awake and asleep 16- or 21-channel electroencephalography (EEG). In only 3 cases, all referred after 1984, were daytime multiple sleep latency tests (MSLT) and/or nocturnal polysomnograms obtained. In 8 cases, detailed information regarding usual sleep habits, including a history of snoring, was obtained. In no case was a sleep diary requested.

Of the 15 patients presenting with EDS, 5 patients were diagnosed as having narcolepsy, 1 patient was diagnosed as having insomnia, 1 patient was diagnosed as having epilepsy, and 1 patient was diagnosed as having primary control nervous system (CNS) hypersomnolence. The cause of hypersomnia in 6 crewmembers was not determined. One patient was judged to have no disease.

TABLE I. CLINICAL SUMMARY OF CREWMEMBERS EVALUATED FOR SLEEP DISORDERS.

Case no.	Age	Compliant	Referral diagnosis	Final diagnosis	SS	Disp.
1	26	sleep paralysis	epilepsy	narcolepsy	N	DQ
2	28	daytime sleepiness	narcolepsy	narcolepsy	N	DQ
3	41	daytime sleepiness	narcolepsy	narcolepsy	N	DQ
4	29	daytime sleepiness	hypersomnolence	narcolepsy	N	DQ
5	34	daytime sleepiness	narcolepsy	narcolepsy	N	DQ
6	28	daytime sleepiness	narcolepsy	sleep disorder NOS	N	DQ
7	18	daytime sleepiness	hypersomnolence	sleep disorder NOS	N	DQ
8	39	daytime sleepiness	hypersomnolence	sleep disorder NOS	N	Q
9	28	daytime sleepiness	narcolepsy	CNS hypersomnolence	Y	DQ
10	27	daytime sleepiness	insomnia	insomnia/anxiety	N	Q
11	27	abnormal behavior	somnambulism	situation reaction	N	Q
12	27	sleepwalking	somnambulism	sleep deprivation	N	FWW
13	26	sleepwalking	somnambulism	stress reaction	N	DQ
14	25	sleepwalking*	somnambulism*	somnambulism*	N	FWW
15	24	sleepwalking	somnambulism	somnambulism	N	DQ
16	27	sleepwalking	abn. behavior	sleep deprivation	N	FWW
17	27	daytime sleepiness	narcolepsy	sleep deprivation	N	FWW
18	41	daytime sleepiness	narcolepsy	sleep disorder NOS	Y	FWW
19**	45	daytime sleepiness	hypersomnolence	sleep disorder NOS	Y	DQ
20	37	daytime sleepiness	narcolepsy	seizure disorder	N	DQ
21	34	daytime sleepiness	narcolepsy	no disease	N	Q

* The complaint, referral diagnosis and final diagnosis were all "history of."
** This patient also had atrial fibrillation.
SS = sleep study (Y = yes, N = no)
Disp. = Disposition (Q = qualified; DQ = disqualified; FWW = flying with waiver)
NOS = not otherwise specified

DISCUSSION

A more detailed presentation of 3 cases summarized in Table I serves to illustrate several of the points made in the introduction.

Case Reports

CASE 4: This subject was a 29-year-old male B-52 pilot with over 1,500 h of flying time. His reported history of EDS began when he presented to the flight surgeon's office complaining of falling asleep easily, and being moody and drowsy. No workup was performed. The pilot continued to fly until 7 months later, when he, with his commander, went to the flight surgeon's office because the pilot had fallen asleep during a routine mission. The pilot had fallen asleep several times previously, once while he was in command of the aircraft during a low-level mission. He was referred for a psychiatric evaluation which did not yield a diagnosis.

At USAFSAM, the cardiovascular and pulmonary tests were normal. EEG and enhanced cranial computer tomography images were normal. Thorough review of his history revealed excessive irresistible sleepiness beginning in high school. At the USAF Academy, he frequently had to stand against the wall to stay awake. In addition to sleeping during flights, he admitted to episodes of sleeping while driving. His wife had stopped him from driving because of these episodes. He described times when he would awaken from sleep and feel as if he could not lift his arms or legs from the bed. He also described sensory distortions while awake. There was no family history of narcolepsy or epilepsy. He was diagnosed as having narcolepsy and was disqualified from flying duties.

CASE 9: This subject was a 28-year-old pilot with over 1,200 h of flying time. He was reported to have fallen asleep as copilot and missed several landing checklist items and radio calls. He also demonstrated channelized attention to the exclusion of other external inputs. Further review of his record revealed that he had been removed from flying duties by his commander on a previous period of temporary duty (TDY) for similar problems. The pilot stated that the irregular hours during the TDY had worsened his usual tiredness. Periods of decreased external stimulation induced his episodes of sleepiness. He had at least one episode of falling asleep while driving. He further admitted to frequent sleeping during classes in high school and college. He did not have episodes of cataplexy, hynogogic hallucinations, or sleep paralysis.

At USAFSAM, his cardiovascular and internal medicine workups were unremarkable. On neurologic examination, there was evidence of mild posturing of the left hand with decreased arm swing while walking. Neuropsychological testing demonstrated a deficiency in processing auditory information. Nocturnal polysomnography revealed disturbed nocturnal sleep and reduced REM sleep. This pattern was not specific for any one cause of EDS. A diagnosis of nonspecific sleep disorder was made, and a recommendation for permanent disqualification from flying duties was given.

CASE 17: This subject was a 27-year-old KC-135 pilot with 959 h of flying time. He was referred to USAFSAM with the diagnosis of depression and possible narcolepsy. The diagnosis of narcolepsy was first considered at the USAF Academy because of his excessive falling asleep in class. The evaluation ascribed the problem to poor sleep hygiene and eating habits. He stated that he had a tendency to fall asleep when the environment was not stimulating. Re-evaluation at the USAF Academy 2 years later was also unrevealing, and he was cleared for Undergraduate Pilot Training (UPT). He had no episodes of falling asleep while flying in UPT, but often fell asleep during classes. After graduating, he had one episode of falling asleep during a flight while being evaluated by the squadron commander; he had slept only 2 hours the night before. This episode led to another USAFSAM re-evaluation, which included normal thyroid functions, normal glucose tolerance, and a normal EEG. The third USAFSAM evaluation revealed only possible mitral valve prolapse. The patient was given the diagnosis of "intermittent history of daytime drowsiness" and a waiver for flying duties was recommended. Since 1983, he has continued to fly, and has not had problems with EDS or developed other symptoms of narcolepsy.

From clinical criteria, the authors agree with the diagnosis of narcolepsy in Case 4 because of the history of sleep paralysis and hypnogogic hallucinations. The presence of hypnogogic hallucinations, sleep paralysis and/or cataplexy was noted in all five crewmembers ultimately diagnosed with narcolepsy. The absence of

sleep latency studies in the majority of patients presenting with hypersomnolence raises the possibility that the diagnosis of monosymptomatic narcolepsy in some crewmembers may have been missed.

Case 9 appears to be an example of a patient with primary CNS hypersomnolence. These individuals probably have an intrinsic disturbance in their brain stem reticular sleep-wake mechanisms and, despite "adequate" nocturnal sleep, easily fall asleep. As in this case, many of these patients have soft neurologic findings supporting the impression of an underlying, though as yet undefined, CNS abnormality (15).

Case 17 most likely represents a crewmember with episodic hypersomnia related to intermittent poor sleep hygiene. With improvement of nocturnal sleep habits, the daytime sleepiness resolved.

Because many of the referred crewmembers were evaluated at a time when sleep latency studies and nocturnal polysomnograms were not widely used, it is difficult to reach conclusions regarding the relative frequency of etiologies of EDS among flying crewmembers from the USAFSAM data presented here. What is clear is that, of the aircrew members referred to USAFSAM with the chief complaint of hypersomnolence, over two-thirds were permanently disqualified from flying. The implications of this complaint for flying careers and flight safety are obvious, as is the importance of an accurate diagnosis to distinguish those crewmembers with benign, potentially reversible causes of EDS from those with potentially incapacitating causes.

Based on USAFSAM's experience with the sleepy crewmember and our review of the literature, we propose the algorithm in Fig. 1 as a general guideline for the evaluation of the crewmember with excessive daytime sleepiness. We feel the consistent application of this paradigm will allow an accurate determination of the range of EDS in crewmembers.

The evaluation of a patient presenting with excessive daytime sleepiness is complicated by two observations: almost everyone feels that he would function better if he had a little more sleep, and the average amount of required daily sleep to allow normal functioning varies greatly between individuals, from 4 to 10 h (10,15,16). It can often be difficult to distinguish between a pathologic change in sleeping habits and a normal variation.

When confronted with a patient complaining of excessive daytime sleepiness [Fig. 1(a)], the evaluating clinician should proceed with the expectation that the underlying cause will probably be found. A historical assessment of the patient's sleep habits provides the best diagnostic clues [Fig. 1(b)]. In contrast to patients presenting with insomnia, patients with EDS often overestimate the quantity and quality of their sleep (15). A formal sleep diary, completed with the assistance of family members, will assure an accurate measure of sleep quantity. Additional data obtained at the time of the initial visit includes a search for vegetative signs of depression, symptoms of narcolepsy (sleep paralysis, hypnogogic hallucinations, cataplexy), general physical examination, screening blood work, and thyroid function tests. Attention should also be paid to the crewmember's history of alcohol use, and the use of prescription or over-the-counter medications potentially causing drowsiness. Evidence of significant medical, neurological, or psychiatric disease obtained at this stage should prompt the appropriate referral [Fig. 1(c)].

Patients found to have inadequate sleep quantity are suffering from insomnia or poor sleep hygiene [Fig.

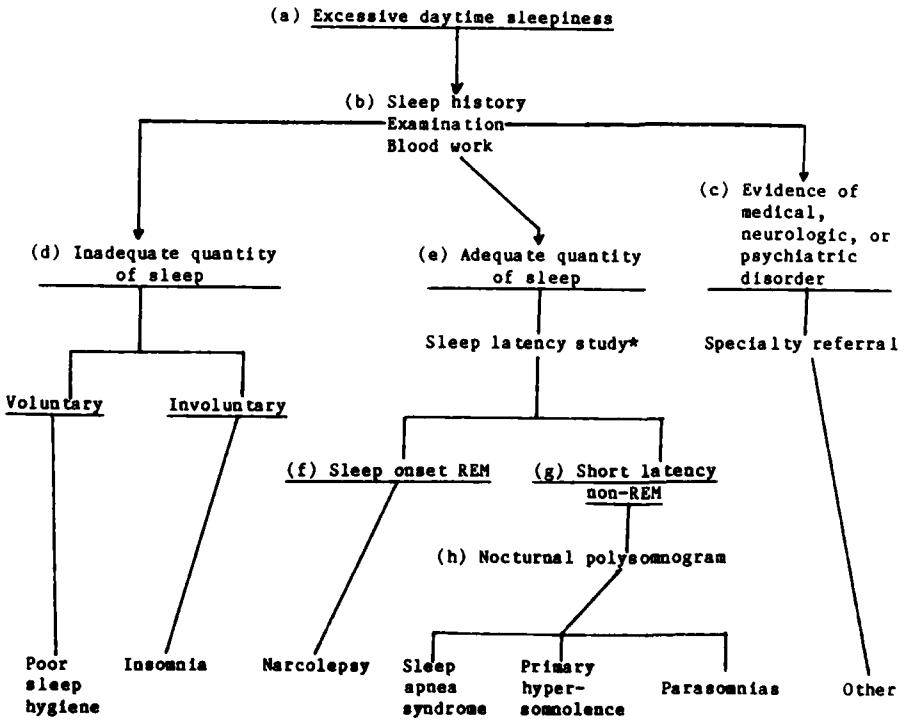

Fig. 1. Suggested algorithm for evaluating excessive daytime sleepiness. *A normal sleep-latency study suggests that the patient's complaint is related to fatigue or malaise and not to a formal sleep disorder.

1(d)]. Adequate evaluation of these patients requires knowledge of the working and social environment. Psychiatric evaluation is often invaluable at this stage to elicit underlying stressors, to exclude serious psychopathology, and to assist with behavior modifications. Specific details on the treatment of insomnia are beyond the scope of this discussion.

Patients who have hypersomnia, despite apparently adequate sleep quantity [Fig. 1(e)], should be referred to a sleep lab for MSLT. An HLA-DR2 determination is also appropriate at this point. A patient complaining of EDS who demonstrates consistently normal sleep latencies is most likely complaining of fatigue, a much less specific symptom. A short latency to REM sleep is diagnostic of narcolepsy [Fig. 1(f)]. When interpreting short-latency sleep onset [Fig. 1(g)], it is important to exclude recent sleep deprivation and medication effects.

Crewmembers demonstrating short latency to non-REM sleep—confirming hypersomnolence—need nocturnal polysomnograms [Fig. 1(h)]. Despite their expense and inconvenience, sleep latency studies and nocturnal polysomnograms are critical for diagnosing the cause of EDS in patients with historically adequate sleep. Based on the nocturnal polysomnogram results, the remaining patients can be categorized as indicated in the algorithm.

The aeromedical disposition of a crewmember evaluated for EDS depends on the underlying cause; more specifically, on its reversibility. Although every case is unique, some generalizations can be made. Crewmembers with EDS secondary to poor sleep hygiene or insomnia (in the absence of serious underlying psychopathology) can be returned to flying status if normal sleep habits are established. In contrast, patients with narcolepsy, sleep apnea, or essential hypersomnolence should not return to the cockpit. Although some of these conditions are treatable, the response in any given patient is unpredictable, and the maintenance medications used could compromise flight safety. Similarly, treatment of the more common parasomnia interfering with sleep requires maintenance medications which are disqualifying (e.g., clonazepam).

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