J Community Hosp Intern Med Perspect. 2014; 4(5): 10.3402/jchimp.v4.24983. PMCID: PMC4246141
Published online 2014 Nov 25. doi: 10.3402/jchimp.v4.24983

How to interpret the results of a sleep study

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Received 2014 May 20; Revised 2014 Oct 13; Accepted 2014 Oct 16.

Abstract

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With an increased level of awareness of sleep disorders among the public, there has been an increase in requests for sleep studies, and consequently, more referrals made to sleep specialists by primary care physicians and other health care providers. Understanding technical and clinical information provided in the sleep study report is crucial. It offers significant insight in to sleep pathophysiology in relation to patient symptoms. The purpose of this article is to provide a simple and easy method to interpret the reported results of polysomnography for primary care physicians. This will facilitate better understanding and management of patients with sleep disorders and related complications.

Keywords: polysomnography, sleep efficiency, REM, sleep latency, obstructive apnea hypopnea index

Polysomnography (PSG), popularly known as a ‘sleep study’, has been used for decades to diagnose and evaluate the severity of sleep-disordered breathing. There is a significant increase in the demand for sleep-related evaluations and sleep studies, due to the heightened public awareness of sleep disorders. Sleep-disordered breathing is a common public health problem that affects an estimated 10% of 30- to 49-year-old men; 17% of 50- to 70-year-old men; 3% of 30- to 49-year-old women; and 9% of 50- to 70-year-old women (1). The potential life-threatening cardiovascular (2), neurocognitive, and metabolic complications (3) related to untreated sleep-disordered breathing have intensified the need for making an early diagnosis. An increasing number of referrals are made to the sleep specialists by primary providers after initial history, assessment of sleep hygiene, and screening with an Epworth Sleepiness Scale (ESS). The ESS provides a validated measure of the patient's general level of daytime sleepiness and provides the physician with an initial screening tool to help assess the sleep debt. The patient self-rates the chances that they would fall asleep while in eight different situations commonly encountered in daily life. The total ESS score is based on a scale of 0 to 24, with a score equal to and above 16 considered to be very sleepy and warrants further investigation. Total ESS score along with correlations from PSG testing are highly useful in diagnosing sleep disorders. In patients with obstructive sleep apnea, ESS scores significantly correlate with an increased respiratory disturbance index (4).

A review of the lifestyle practices that contribute to good quality sleep, also called sleep hygiene, is important before scheduling a sleep study. A discussion with the patient about a healthy diet, caffeine (and less obvious

sources of caffeine such as chocolate, pain relievers with caffeine, and herbal supplements) and nicotine restriction 6 hours before bedtime, adequate exercise, maintaining a darkened and quiet environment suitable for sleeping, coping strategies with shift work, avoiding napping, and having a consistent bed time can be valuable in giving the patient a starting point in sleep improvement. If a patient's concern is more that of insomnia, an assessment with Insomnia Severity Index (5) may be useful. An assessment of comorbid conditions (i.e., emotional disorders, gastrointestinal disturbances, musculoskeletal pain, Restless Leg syndrome) and review of medications that contribute to insomnia (i.e., oxycodone, codeine, methylphenidate, ephedrine, pseudoephedrine, phenylephrine, amphetamines, albuterol, theophylline, beta blockers, alpha receptor antagonists, SSRIs, venlafaxine, and duloxitine) is invaluable (6). A discussion about the use of alcohol before sleep is important. Although alcohol shortens sleep latency, it can lead to multiple awakenings throughout the sleep cycle (sleep fragmentation). Several contributors to daytime sleepiness may exist concomitantly and may need further evaluation.

Once the sleep study is completed, the sleep study report is sent to the referring physician with a recommendation for treatment. Currently, there is no standardization of the reporting process; reports are based on certain elements that provide quantitative information regarding the patient's sleep and its deviation from the normal. The primary physician's understanding of these results is instrumental in clinical decision making and continuous management of the patients. The intention of this article is to provide a simple and easy method to interpret reported results of the PSG.

Components of a sleep study report

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The sleep study reports are typically arranged into sections containing patient information, which includes their sleep-related symptoms, the technical details, quantitative data regarding distribution of different stages of sleep called sleep architecture and sleep staging. The technical details document the number of electroencephalographic (EEG), electro-oculogram, chin and leg electromyogram, electrocardiogram, and air flow at the nose and mouth. The chest and abdominal wall movements are recorded by plethysmographic strain belts. The oxygen saturation is sampled by continuous pulse oximetry and the snoring microphone is used for recording the snoring and its intensity. Multiple simultaneous parameters are recorded using an arrangement of wires and belts called a Montage. The indications for the study are recorded in the context of patient complaints, history, medical, psychosocial, and sleep-related problems as well as their medications. Each of these elements has a significant impact on the recording of the data and the interpretation of the sleep study.

Definitions

The next section of the report generally includes sleep architecture; including total recording time and/or time in bed along with total sleep time. The total recording time is the total amount of time during which the patient is in bed with recording equipment activated. The amount of time actually spent in bed is an important limiting factor for the total sleep time and sleep stages. A patient who spends only three to four hours in bed cannot reasonably accumulate normal amounts of sleep and may not go to all normal stages and cycles of sleep. Therefore, a low total time in bed may be of clinical significance and may support a diagnosis of insufficient sleep.

Sleep latency is perhaps one of the most important parameters in a sleep study. The duration of time between when the lights are turned off (lights out) as the patient attempts to sleep, until the time patient actually falls asleep, as evidenced by EEG and behavioral parameters changes consistent with sleep, is reported as sleep latency. Sleep latency is the time in minutes from ‘lights out’ that marks the starting of total recording time to the first epoch scored as sleep. Sleep latency also indicates if reasonable attention was paid to the patient's sleep diary and the ‘lights out’ time was close to the patient's routine bedtime at home. Clearly, if the lights are turned out earlier than the patient's usual bedtime, sleep latency would be spuriously long, and the patient may not fall asleep until his/her usual sleep time is reached. Similarly, if the ‘lights out’ time is later than the patient's usual bedtime, the patient will be sleepy and a spuriously short sleep latency will be recorded. It is of utmost importance that the patient's usual habitual

sleep time is incorporated into the patient's sleep study design and 'lights out' time is approximated.

The total sleep time is the total amount of sleep time scored during the total recording time. This includes time from sleep onset to sleep offset and is distributed throughout the sleep time as minutes of Stage N1 sleep, Stage N2 sleep, Stage N3, and rapid eye movement (REM) sleep. All these times are described in minutes. A low total sleep time may indicate that the patient slept for an insufficient period of time due to non-medical/non-physiological reasons, certain medical or sleep disorders, or as a result of the effect of medications. Long total sleep time may suggest prior sleep deprivation, medical conditions, or effects of medications. High levels of sleep fragmentation, as defined by recurrent awakenings and/or stage shifts may result in complaints of non-restorative sleep even when an apparently normal total sleep time is present.

Sleep efficiency is another important parameter that refers to percentage of total time in bed actually spent in sleep. It is calculated as sum of Stage N1, Stage N2, Stage N3, and REM sleep, divided by the total time in bed and multiplied by 100. Sleep efficiency gives an overall sense of how well the patient slept, but it does not distinguish frequent, brief episodes of wakefulness. A low sleep efficiency percentage could result from long sleep latency and long sleep offset to lights on time with otherwise normal quantity and quality of sleep in between. Many laboratories report total wake time, that is, the amount of wake time during the total recording time in minutes after the sleep onset. The total amount gives a general estimation for overall quality of sleep. Total wake time is the reciprocal of total sleep time. A high total sleep time percent is always associated with low total wake time percent and vice versa.

An important reported parameter is wake after sleep onset, also known as 'WASO'. This refers to periods of wakefulness occurring after defined sleep onset. This parameter measures wakefulness, excluding the wakefulness occurring before sleep onset. WASO time is a better reflection of sleep fragmentation.

Wake time after sleep offset is known as 'WASF' and refers to wakefulness that occurs after sleep offset. Long periods of wakefulness following an atypically early morning awakening could be consistent with one of the classic diagnostic signs of depression. This can be found in elderly patients who have no difficulty in falling asleep, but wake up after three to four hours of sleep and are unable to return to sleep. This pattern may be seen in patients who suffer with depression or anxiety and possibly an effect of medications.

Another crucial reported parameter is rapid eye movement latency also known as REM latency. Rapid eye movement latency is the time from the sleep onset to the first epoch of REM sleep; therefore, it depends on the patient's sleep latency. The REM sleep cycles every 90 to 120 min intervals throughout the night. The changes in REM sleep latency are considered potential biological markers for a number of sleep-related disorders. REM sleep is very sensitive to the effects of medication, sleep deprivation, and circadian rhythm disorders. The knowledge of patients' current medications and the quality of sleep the night before the sleep study therefore, is extremely important to review. A short REM latency time may result from withdrawal from tricyclic anti-depressants (TCAs) or Monoamine Oxidase Inhibitor (MAOI) medications. Withdrawal from amphetamines, barbiturates, and alcohol can also cause a shortened REM latency period. Patients with a history of narcolepsy, sleep apnea, and depression may also have short REM latency. Similarly, long REM latency may result from use of REM-suppressing medications, including TCAs, MAOIs, amphetamine, barbiturates, and alcohol. Sleep apnea and periodic limb movement of sleep can also lead to long REM sleep latency.

Stages of sleep

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A sleep study report describes the percentages of various sleep stages. The normal percentage of each stage is reported with the number of total REM Stage sleep cycles recorded overnight. In adults, approximately 5% of the total sleep time is Stage N1; 50% Stage N2; and 20% is Stage N3 sleep. The remaining 25% is REM stage sleep (7, 8).

Non-rapid eye movement sleep

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Sleep staging is described in a separate section of the report. Stage N1 sleep is associated with the transition from wakefulness to sleep and is considered a direct measure of daytime alertness and the subjective refreshing quality of sleep. The quantity and the percentage Stage N1 sleep is an estimate of the degree of sleep fragmentation. A high percentage of the Stage N1 sleep is generally a result of frequent arousals caused by sleep disorders, like sleep apnea, periodic movement of sleep, or snoring. Other causes of sleep disruption, including environmental disturbances, may also lead to increased amount of Stage N1 sleep.

Stage N2 sleep predominates the sleep stages with 50% of the total sleep time. It follows the Stage N1 sleep and continues to recur throughout the night. A low percentage of Stage N2 sleep may be a result of sleep fragmentation, increased REM, Stage N3 or a result of obstructive sleep apnea-related arousals. An increased amount of Stage N2 sleep may also be noted in age-related changes in sleeping pattern and may be a result of medication effect.

Stage N3 is considered as ‘deep sleep’. It is sometimes referred as slow wave sleep. The Stage N3 sleep generally cycles frequently in the first third of the night and begins to reduce towards the second half of the night. A high amount of Stage N3 sleep is noted during rebound sleep (such as recovery sleep after sleep deprivation, initiation of nocturnal CPAP treatment, or treatment of periodic limb movement syndrome). Less Stage N3 sleep is noted as a side effect of certain medications, including benzodiazepines, TCAs, and barbiturates. Episodes of night terror sleep walking, sleep talking, and confusion arousals also occur during Stage N3 sleep (9). Stage N3 is also known to suppress the occurrence of sleep-disordered breathing (10).

Rapid-eye movement sleep

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The exact function of the REM is uncertain. However, it occupies approximately 25% of the total sleep time. REM sleep cycles occur every 90 to 120 min throughout the night with progressively increasing periods of time. REM sleep is associated with more frequent and longer duration apneas, hypopneas, and severe hypoxemia. REM sleep suppresses periodic leg movements of sleep (11). Certain medications suppress the REM sleep including amphetamines, barbiturates, TCAs, MAOIs, anticholinergics, and alcohol. Certain sleep disorders, including sleep apnea, REM behavior sleep disorder, and nightmares occur in REM sleep. A higher amount of REM sleep is notable during recovery sleep after selective deprivation of REM sleep. REM sleep ‘rebound’ occurs after discontinuation of REM sleep suppressing medications, alcohol, and initiation of CPAP therapy.

Practice implications

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An overall review of the sleep study report provides an excellent account of what was recorded over 6 to 8 hours of sleep. It is important for the referring physician to review the sleep study report and correlate patient's presenting sleep complaints to the results. Patients may also report their posttreatment residual problems and complications to their health care provider. Multiple recommendations can be made based on the observations made in the sleep study report. The clinical management decisions regarding normalizing the long sleep latency may be made by practicing good sleep hygiene, thus avoiding over the counter sleep aids and prescription hypnotics. Improvement in sleep efficiency can be accomplished with increase in total sleep time in relation to total time in bed, as well as exploring potential causes of poor sleep efficiency. A good example of this is when adequate pain management is applied in chronic pain syndrome, resulting in improved sleep quality.

An understanding of the effect of medications on sleep architecture and staging helps the primary care physician manage sleep disorders, as well as the primary disorder for which these medications were started in the first place. In general, REM sleep is suppressed by MAO inhibitors and tricyclide antidepressant, amphetamines, barbiturates, and alcohol. Withdrawals from these medications cause rebound and excessive REM sleep. Benzodiazepines increase the amount of Stage N2 sleep and reduce Stage N3 sleep.

Sleep reports are concluded with recommendations regarding the management plan including the use of CPAP

therapy, consideration of other treatment modalities like oral appliances, and surgical intervention. If the patient is a candidate for CPAP, management plans include recommendations for the type and the size of the mask and whether a warm or cold humidifier is recommended for patient comfort and to prevent drying of secretions. 'Ramp time', a gradual increase in CPAP pressure over many minutes as the patient tries to fall asleep, is recommended for patients who may not tolerate high CPAP pressures. If a mouth air leak is noted while using a nasal mask, a chinstrap is recommended to keep the jaw from falling open.

Multiple variables affect the sleep pattern including the 'first-night effect' when the patient cannot sleep well in the sleep laboratory and has a different sleeping pattern than usual (12). First-night effect can increase both Stage N1 sleep and REM latency recorded in the sleep study. The 'reverse first-night effect' is when the patient sleeps better in the sleep laboratory compared to their home, as in case of psycho-physiologic insomnia and frequently observed 'night to night variability' in sleep (13). It is therefore important to realize that in a patient with high pre-test probability of sleep-disordered breathing, a negative sleep study may not rule out the condition (14).

A clear understanding of the sleep study report facilitates appropriate patient follow up. It enables the physician to recognize the need for arranging an appointment with a sleep specialist for the patient to address any equipment-related trouble-shooting, or to address any non-compliance issues. Identifying and addressing these issues early facilitates appropriate treatment and management, leading to an improvement in the patient's feeling of overall well-being, and potentially to reduce the many complications associated with sleep-disordered breathing.

Conflict of interest and funding

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The authors have not received any funding or benefits from industry or elsewhere to conduct this study.

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