Diagnostics methods for sleep disorders

Métodos diagnósticos nos distúrbios do sono

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Abstract

The aim of this manuscript is to describe the procedures, recommendations, findings and value of the diagnostic methods used in sleep disorders, including questionnaires, actigraphy, polysomnography and the multiple sleep latency test. Specific questionnaires, including those evaluating sleep quality, hypersomnolence, respiratory sleep disorders and sleep-wake cycle are generally used to screen for sleep disorders and as indicators for inclusion in sleep studies. Polysomnography and the multiple sleep latency test are considered the gold standard methods for the diagnosis of most sleep disorders and of narcolepsy, respectively. Criteria for these disorders are reported herein.

Keywords: *Sleep Disorders/diagnosis; Polysomnography; Questionnaires; Disorders of excessive somnolence*

Resumo

O objetivo deste artigo é o de descrever os procedimentos, as recomendações, os achados e o valor dos métodos diagnósticos utilizados em transtornos do sono, incluindo questionários, actigrafia, polissonografia e teste múltiplo de latência do sono. Questionários específicos incluindo avaliação da qualidade do sono, hipersonolência, transtornos respiratórios do sono e ritmo sono-vigília são utilizados, em geral, para triar transtornos do sono e como indicação para estudos sobre o sono. A polissonografia e o teste múltiplo de latência do sono são considerados como métodos padrão-ouro na maioria dos transtornos do sono e narcolepsia, respectivamente. Os critérios para tais transtornos são relatados abaixo.

Descritores: *Ritmo circadiano/fisiologia; Transtornos do sono/diagnóstico; Polissonografia; Questionários; Distúrbios do sono por sonolência excessiva*

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Introduction

The diagnostic methods utilized in the investigation of sleep disorders range from subjective assessment, through the application of specific questionnaires, to daytime or nighttime actigraphic or polysomnographic recordings.

1. Questionnaires

Various questionnaires can be used for routine clinical diagnosis, for monitoring the response to the treatments initiated, for epidemiological studies and for clinical research. Most are international and few have been validated for use in Portuguese, which leads us to believe that misinterpretations, as well as cultural differences, may influence the specificity and sensitivity of these methods. In view of this, if validated for the population in question, such questionnaires can be used to predict and estimate the severity of sleep disorders, serving as screening for the objective diagnoses (Table 1).

There are questionnaires that assess sleep in its general aspects, focusing on the time required for sleep initiation (sleep latency), sleep quality, behavioral aspects, nighttime awakenings and daytime sleepiness. Notable among such questionnaires are the Sleep Disorders Questionnaire[1] (featuring quantitative and qualitative evaluation questions), the Pittsburgh Sleep Quality Index[1] (evaluating the quality of sleep in the preceding month, providing an index of severity and nature of the disorder), the Mini-sleep Questionnaire[1] (assessing the frequency of complaints), the Basic Nordic Sleep Questionnaire[2] (analyzing the most common complaints in terms of frequency and intensity in the last three months, with quantitative specification) and the self-reporting sleep questionnaire[1] utilized in psychopharmacological research. Some questionnaires are more focused on specific disorders, the most well-known and utilized of which are the Epworth Sleepiness Scale[3] - with scores ranging from 0 to 24, values higher than 10 indicating excessive sleepiness (Table 2) - and the Stanford Sleepiness Scale,[1] which describes the feeling of sleepiness at a given moment. Others, such as those developed by Hoffstein, Douglass, Deegan & Fletcher and Luckett, are used for the assessment of sleep-related breathing disorders[4-5] (Table 3). There are also questionnaires used to assess the sleep-wake cycle,[5-7] whereas still others are specific to pediatric use.

2. Actigraphy

Actigraphy is technique for evaluating the sleep-wake cycle that allows the recording of motor activity through determining limb movements over a 24-hour period. It involves the use of an actometer, which is a motion-sensing device worn around the wrist (like a wrist watch), producing digitalized data that can be transferred to a computer, thus providing information on parameters such as total time asleep, total time awake, number of awakenings and sleep latency.[8] Although it does not replace polysomnography, actigraphy presents a reliability coefficient of 0.8 to 0.9 and provides a more economical option for collecting information regarding circadian rhythms when several days of data recording are necessary. It is particularly useful in the study of individuals such as small children, insomniacs and elderly people, who do not tolerate sleeping in laboratories.

3. Polysomnography

All-night polysomnography carried out in the laboratory is the gold standard method for the diagnosis of sleep disorders, and there is an increasing diversity of systems on the market. The polysomnographic setting[9] makes it possible to use a polygraph to record results of electroencephalograms (EEGs), electro-oculograms (EOGs) and electromyograms (EMGs) of the mentalis and limbs, as well as electrocardiogram (ECG) results and measurements of oronasal flow, thoracoabdominal movement and pulse oximetry (Figures 1 and 2).

Additional channels may be available for the recording of other parameters, such as body position, esophageal pressure, snoring and supplementary derivations of EEG.

Sleep staging is based on the brain wave patterns, mentalis activity and EOGs analyzed every 20 to 30 seconds, periods known as "epochs". This staging follows the international norms established by Rechtschaffen & Kales,[10] enabling the characterization of each sleep stage.

Stage 1 sleep is characterized by a predominance of low-frequency, low-amplitude brain waves (theta waves), lower muscle activity than during waking, and slow eye movements. Stage 2 is characterized by the presence of K-complex and sleep spindles and by the absence of eye movements. Stages 3 and 4 (slow-wave sleep) present high-amplitude, low-frequency waves (delta waves). In REM sleep, there is a significant reduction in or absence of muscle tone, rapid eye movements and sawtooth waves (Figure 3). Other parameters, such as respiration, oxyhemoglobin saturation and heart rate, are also routinely analyzed. Although most polysomnographic systems are digital and their software analyzes these parameters automatically, it is mandatory that they be checked by a professional, certified in polysomnography.

Polysomnographic parameters

The main data presented in polysomnography are:

1) Total sleep time, wake time, total recording time;

2) Sleep efficiency (total sleep time/total recording time);

3) Latency for sleep onset, latency for REM sleep and other sleep stages;

4) Duration (in minutes) and proportion of total-sleep-time sleep stages (proportions vary according to age, and slow-wave sleep is physiologically decreased in the elderly);

5) Frequency of apneas and hypopneas per hour of sleep (apnea-hypopnea index);

Table 1 – Sleep questionnaires

Questionnaires	General sleep quality	Sleep-related respiratory disorder	Daytime sleepiness	Wake-sleep cycle assessment
Names/Authors	1. Pittsburg sleep quality index	1. Hoffstein	1. Epworth sleepiness scale	1. Questionnaire for the identification of morning and evening type individuals
	2. Nordic sleep questionnaire	2. Douglas	2. Stanford sleepiness scale	2. Sleep Timing Questionnaire
	3. Sleep disorders questionnaire	3. Deegan		
	4. Sleep self-assessment questionnaire	4. Fletcher & Luckett		

6) Saturation values and events of oxyhemoglobin desaturation (drops of > 3% or 4%, for 10 seconds);

7) Total number and index of periodic lower limb movements per hour of sleep;

8) Total number and index of micro-arousals per hour of sleep and their relationship with breathing events or lower limb movements;

9) Cardiac rhythm and frequency.

The distribution and proportion of the stages of sleep can be represented in a graphic known as a hypnogram (Figure 4).

The normality values for the above-mentioned parameters are shown in Tables 3 and 4.[11-12]

Simultaneous video recording makes it possible to identify abnormal behaviors during sleep, such as in REM and NREM sleep parasomnias.

1. Polysomnographic findings

The clinical and polysomnographic characteristics of sleep disorders are cataloged in the International Classification of Sleep Disorders.[13] Sleep fragmentation due to micro-arousals secondary to sleep apnea (Figure 2) or to periodic lower limb movement (Figure 5) may result in reduction of slow-wave sleep and REM.

There is a reduction of total sleep time in insomnias and, if secondary to depression, it is possible to detect reduced latency for REM sleep, an increase in spontaneous micro-arousals, a reduction of slow-wave sleep and an increase in rapid eye movements.

Narcolepsy presents significantly reduced latency for REM sleep, as well as a fragmented sleep pattern. Chronic pain profiles, use of benzodiazepines, and fibromyalgia may intrude on rapid electroencephalographic rhythms, mainly during slow-wave sleep.

Regarding REM sleep behavioral disorders, it can be observed that muscle tone is maintained during this sleep stage. Concerning sleepwalking, such abnormal behavior occurs during slow-wave sleep.

Polysomnographic systems

Portable systems for home sleep monitoring are quickly becoming widely available on the market and are principally being used for the diagnosis of obstructive sleep apnea and hypopnea. The American Sleep Disorders Association recommends that this monitoring be restricted to patients with acute clinical symptoms or when classic polysomnography is not available. It is also acceptable in the treatment of patients who have already been diagnosed through conventional means.[14] Although its cost is lower than that of classic polysomnography, home sleep monitoring presents limitations such as the lack of trained personnel to solve the technical problems that appear during the recording, as well as those due to lack of precision in the assessment of the cases of sleep apnea or upper airway resistance syndrome.[14]

An American Sleep Disorders Association Committee published a review of the polysomnographic systems currently available, classifying them into several levels according to their respective resolution levels:[14]

1) Level I (standard polysomnography)

- Parameters: minimum of 7 channels, including EEG, EOG, submental EMG, ECG, oronasal airway flow, respiratory movement and oxyhemoglobin saturation.
- Body position: documented or objectively measured
- Lower limb movement: EMG (optional)
- Supervision: constant
- Interventions: possible

2) Level II (portable polysomnography)

- Parameters: minimum of 7 channels, including EEG, EOG, submental EMG, ECG (or heart rate recording), oronasal airway flow, respiratory movement, oxyhemoglobin saturation.
- Body position: can be objectively measured
- Lower limb movement: EMG (optional)
- Supervision: no
- Interventions: no

Studies in literature validate these systems in the diagnosis of obstructive sleep apnea and hypopnea syndrome, using different cutoff points of breathing event indices, but the system is not efficient with regard to other sleep disorders. Orr et al.[15] observed that, when the apnea-hypopnea index was fixed at 15/h, the sensitivity and specificity for the diagnosis of obstructive apnea was 100% and 93%, respectively, using a Level II equipment. When comparing conventional polysomnography with Level II polysomnography, the former showed more accuracy in the assessment of the stages of sleep.

3) Level III (modified portable system for the diagnosis of obstructive sleep apnea and hypopnea syndrome)

- Parameters: minimum of 4 channels, including ventilation (at least two channels for respiratory movement or respiratory movement and oronasal airway flow), ECG (or heart rate

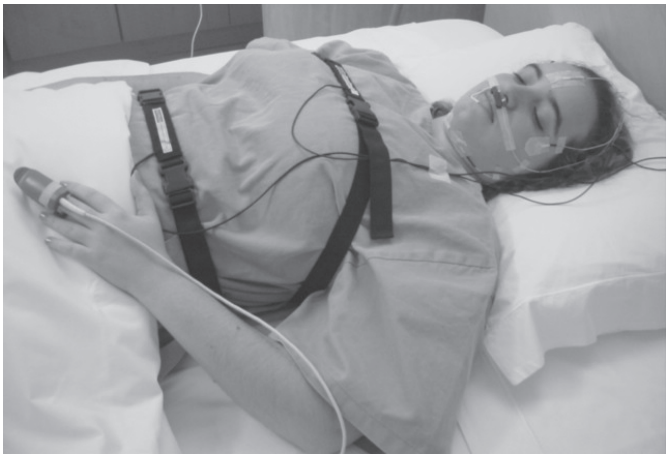


Figure 1 - Polysomnographic setting

Table 2 – Epworth daytime sleepiness scale

READ CAREFULLY: How likely are you to doze off or fall asleep, as opposed to simply feeling tired, in the following situations? Even if you have not done some of these things recently, try to imagine how they would have affected you. Use the following scale to choose the most appropriate number for each situation:

0 = No chance of dozing
1 = Slight chance of dozing
2 = Moderate chance of dozing
3 = High chance of dozing

SITUATION	CHANCE OF DOZING
Sitting and reading	( )
Watching TV	( )
Sitting in a public place (waiting room, cinema, theater, church, etc.)	( )
As a passenger in a car, bus, or train for an hour without a break	( )
Lying down to rest in the afternoon when circumstances permit	( )
Sitting and talking to someone	( )
Sitting quietly after a lunch without alcohol	( )
In a car, while stopped for a few minutes in traffic	( )

Total: _____

recording), and oxyhemoglobin saturation.

- Body position: no
- Lower limb movement: no
- Supervision: no
- Interventions: no

In this system, only the cardiorespiratory variables are assessed, not enabling the analysis of sleep parameters. The system presents high sensitivity and specificity for sleep apnea when applied to a symptomatic population.[14]

4) Level IV (continuous, single or dual, parameter recording)

- Parameters: minimum of one (oxyhemoglobin saturation by oximetry, with or without recording cardiac frequency)
- Body position: no
- Lower limb movement: no
- Intervention: no

This system includes devices ranging from a simple oximeter to the most sophisticated devices with algorithm analysis. The available studies indicate that the continuous recording of one or two of these parameters for the diagnosis of obstructive sleep apnea varies considerably in terms of precision. Pulse oximetry, combined with a clinical score, has proven useful as a triage test in the selection of patients for standard polysomnography.[16-17]

5) Advanced monitoring Level IV

This system consists of equipment which records oximetry and one more respiratory channel (airway flow, snoring). Recently, interest in the use of the Auto-set continuous positive airway pressure for the diagnosis of sleep apnea has increased. Classically, this system is used as a means of treating obstructive sleep apnea, for which the pressure adjustment of the nasal continuous positive airway pressure is obtained automatically. The system also has a diagnosis mode which

Table 3 – Fletcher & Luckett questionnaire

Sleep	Snoring
Sleep hours/night: Onset: _____ Awakening: ____ 1. Does it take you long to initiate sleep? N ( ) VR ( ) O ( ) F ( ) NA ( ) 2. Time to initiate sleep:_____ to _____ 3. In what period of sleep: Onset _____ middle _____ awakening _____ 4. Do you feel tired after a night's sleep? N ( ) VR ( ) O ( ) F ( ) NA ( ) 5. Is your sleep troubled by frequent abrupt movements? N ( ) VR ( ) O ( ) F ( ) NA ( ) 6. Do you talk in your sleep? N ( ) VR ( ) O ( ) F ( ) NA ( ) 7. Have you ever had an episode of sleepwalking? N ( ) VR ( ) O ( ) F ( ) NA ( ) 8. Do you grind your teeth during the night? N ( ) VR ( ) O ( ) F ( ) NA ( ) 9. Do you feel paralyzed at sleep onset or upon awakening? N ( ) VR ( ) O ( ) F ( ) NA ( ) 10. Do you move your legs during the night? N ( ) VR ( ) O ( ) F ( ) NA ( ) 11. Have you had strange dreams at the beginning or end of the night? N ( ) VR ( ) O ( ) F ( ) NA ( ) 12. Have you had short fainting spells, falling on the floor or becoming too weak to hold your arms or head up? N ( ) VR ( ) O ( ) F ( ) NA ( )	1. Do you snore or has anyone told you snore loud? N ( ) VR ( ) O ( ) F ( ) NA ( ) 2. Is your snoring loud, with a period of silence followed by louder snoring? N ( ) VR ( ) O ( ) F ( ) NA ( ) 3. Does your spouse or partner sleep in another room because you disturb their sleep? N ( ) VR ( ) O ( ) F ( ) NA ( ) 4. Do you suffer from stuffy nose, runny nose or sneezing? N ( ) VR ( ) O ( ) F ( ) NA ( ) 5. Has putting on weight worsened snoring? N ( ) VR ( ) O ( ) F ( ) NA ( ) 6. Does sleeping on your stomach, on your side or with an elevated headboard reduce snoring? N ( ) VR ( ) O ( ) F ( ) NA ( ) 7. Does the use of alcohol worsen snoring? N ( ) VR ( ) O ( ) F ( ) NA ( ) 8. Does the use of sleeping pills worsen snoring? N ( ) VR ( ) O ( ) F ( ) NA ( )
Daytime sleepiness	**Apnea**
1. Do you doze off while watching TV or while at the movies? N ( ) VR ( ) O ( ) F ( ) NA ( ) 2. Do you doze off while reading the newspaper, books or magazines? N ( ) VR ( ) O ( ) F ( ) NA ( ) 3. Do you doze off while talking to someone in person or on the telephone? N ( ) VR ( ) O ( ) F ( ) NA ( ) 4. Do you get extremely sleepy while driving or do you doze off while waiting at traffic lights? N ( ) VR ( ) O ( ) F ( ) NA ( ) 5. Have you ever had a car accident or pulled out of the road because of sleepiness? N ( ) VR ( ) O ( ) F ( ) NA ( ) 6. Have you ever dozed off while doing your usual work? N ( ) VR ( ) O ( ) F ( ) NA ( ) 7. Have you ever slept in public places? N ( ) VR ( ) O ( ) F ( ) NA ( )	1. Have you ever woken during the night to find yourself sitting up in bed? N ( ) VR ( ) O ( ) F ( ) NA ( ) 2. Has your spouse or partner ever told you that you stop breathing during the night? N ( ) VR ( ) O ( ) F ( ) NA ( )
	Associated complaints
	1. Do you wake up at night because of a headache? N ( ) VR ( ) O ( ) F ( ) NA ( ) 2. Have you been waking up in the morning with a headache? N ( ) VR ( ) O ( ) F ( ) NA ( ) 3. Have you ever felt confused when waking up, taking a long time to become conscious of what you are doing? N ( ) VR ( ) O ( ) F ( ) NA ( ) 4. Have you been forgetful lately? N ( ) VR ( ) O ( ) F ( ) NA ( ) 5. Do you feel that you do not think as quickly as you used to? N ( ) VR ( ) O ( ) F ( ) NA ( ) 6. Have other people told you that you have been quite irritable, short-tempered or depressed? N ( ) VR ( ) O ( ) F ( ) NA ( ) 7. Do you have problems having sexual intercourse? N ( ) VR ( ) O ( ) F ( ) NA ( ) 8. Do you get up at night to go to the bathroom? N ( ) VR ( ) O ( ) F ( ) NA ( ) 9. Do you experience shortness of breath upon exertion? N ( ) VR ( ) O ( ) F ( ) NA ( ) 10. Do you have chest pain? N ( ) VR ( ) O ( ) F ( ) NA ( ) 11. Have you had swollen ankles lately? N ( ) VR ( ) O ( ) F ( ) NA ( )

N = No; VR = very rarely; O = occasionally; F = frequently; NA = not applicable

estimates the nasal airway flow semiquantitatively by assessing the variation of the pressure obtained with the nasal catheters, which are connected to a pressure transducer, thereby detecting apneas, respiratory irregularities, snoring and airway flow limitation (flattening index). Studies comparing this system with conventional polysomnography for the diagnosis of obstructive sleep apnea and hypopnea syndrome reveal good concordance for cases with higher apnea-hypopnea index, generally > 20.[18]

Multiple Sleep Latency Test (MSLT)

This is considered the method of choice for the assessment and monitoring of excessive daytime sleepiness, quantifying this symptom and making it possible to identify REM sleep, which makes it extremely useful in the diagnosis of narcolepsy. It is the only scientifically validated test for the objective assessment of sleepiness.

This test is carried out in the sleep laboratory, beginning at 1.5 to 3 hours after the end of nocturnal sleep. The patient

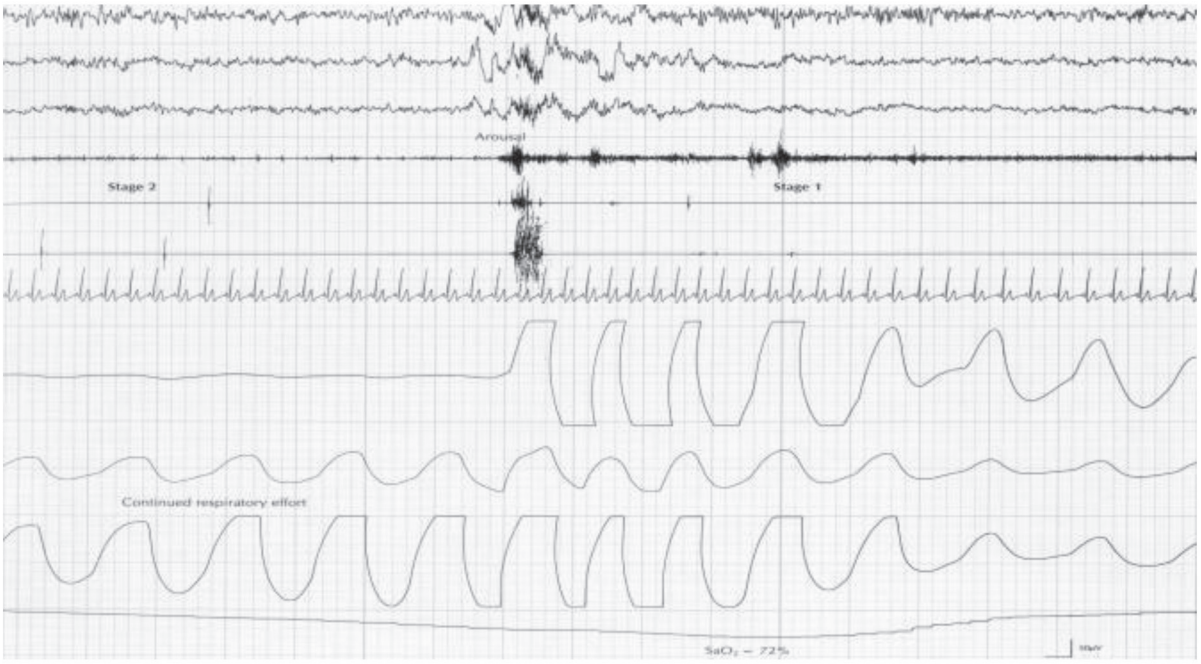


Figure 2 - Polysomnographic recording of obstructive sleep apnea. The recording channels correspond to, from top to bottom: 3 electroencephalogram channels, 1 submental electromyogram channel, 2 electro-oculogram channels, 1 electrocardiogram channel, 1 nasal flow channel, 1 thoracic belt channel, 1 abdominal belt channel, and 1 pulse oximetry channel.

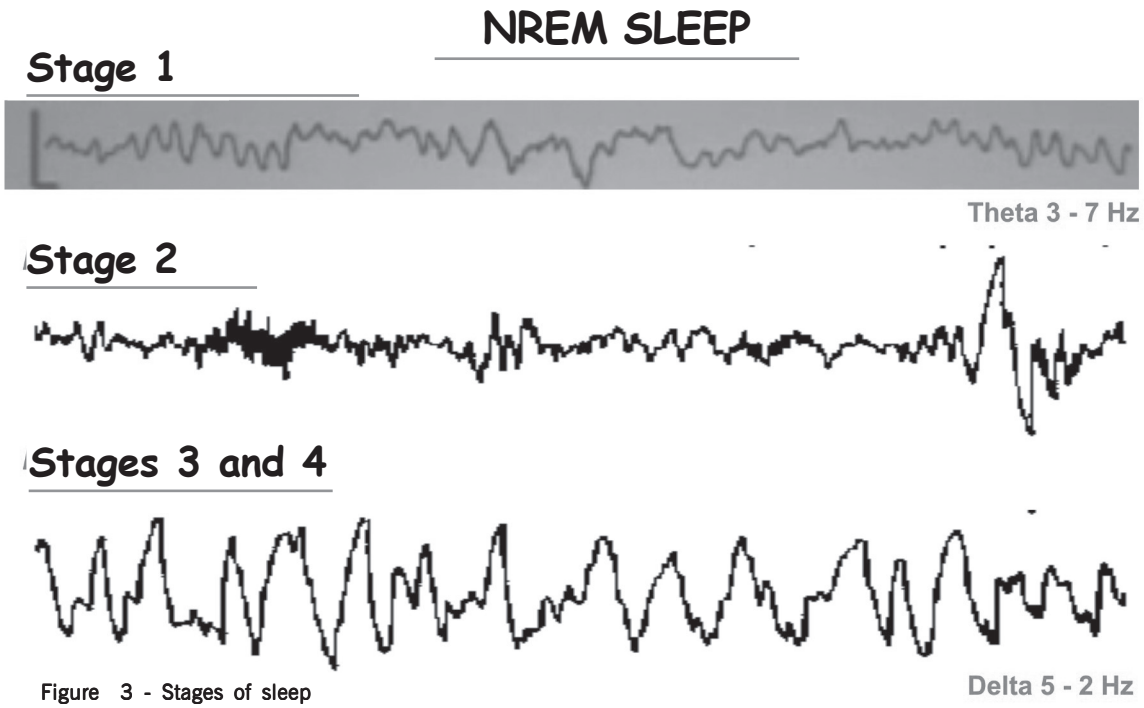


Figure 3 - Stages of sleep

Source: Mary A. Carskadon and William Dement: Normal Human Sleep. An Overview (chapter 2) in principles and practice of sleep medicine. M. H. Kryger, Thomas Roth, Willian A. C. Dement 2nd. Saunders Company; 1994.

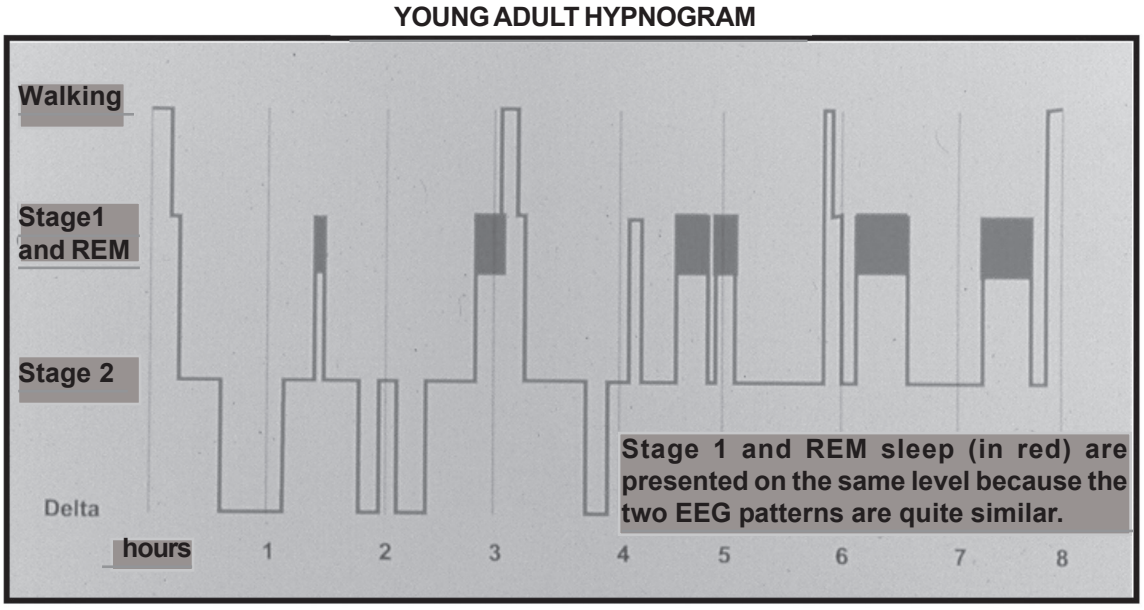
Table 4 – Reference values of sleep pattern in the adult[11]

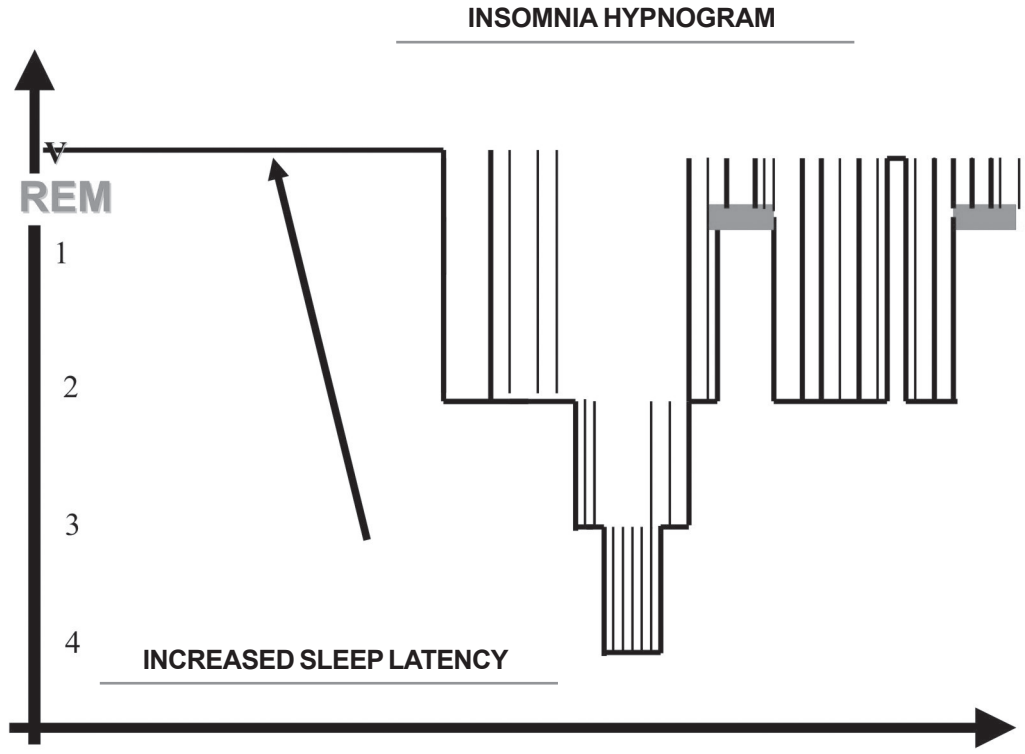
Latency for sleep onset: up to 30 min
Latency for REM sleep: 70 - 90 min
Sleep efficiency: > 85%
Stage 1: 2 - 5%
Stage 2: 45 - 55%
Stage 3: 3 - 8%
Stage 4: 10 - 15%
REM sleep: 20 - 25% (4 to 6 events)
NREM cycle - REM: mean interval of 90 min
Slow-wave sleep is predominant in the first half of the night
REM sleep is predominant in the second half of the night

remains in the laboratory for practically the entire day. The MSLT should ideally follow a night of polysomnography.

The MSLT calculates latency for sleep onset as the mean of four or five sleep recordings, each lasting 20 minutes and taken at four-hour intervals. During these periods, the patient is kept out of bed and under supervision to prevent them from dozing.[19]

The MSLT has high sensitivity and specificity in sleepiness due to narcolepsy. Over 80% of narcoleptic patients present mean sleep latency of less than 5 minutes on the MSLT.[20] Those whose latency is longer than 5 minutes may present lower values when retested.[21]





Source: Adapted of RW Mccarley. Sleep dream and states of consciousness. In: PM Conn, editor. Neuroscience in Medicine. Philadelphia: Linppincott; 1995. p. 537.

Two or more sleep onset recordings in REM are found in 80% of narcoleptics.[20] On occasion, patients who do not initially present this pattern will be able to demonstrate two or more REM stages when retested.[20]

Other conditions, as well as other sleep disorders, sleep deprivation, drugs, including alcohol, tricyclic antidepressants and monoamine oxidase inhibitors may or may not result in a mean sleep latency < 10 and REM 1.

Normality references for this test are shown in Table 6.

Other methods such as the maintenance of wakefulness test and systems for sleep recordings that are either very simplified or more elaborate contribute to improve the diagnosis of these disorders. However, it must be borne in mind that such recordings are costly and are unavailable to a great part of our population.

Therefore, the indication for sleep recording should be based on the presence of symptoms, clinical findings and risks that suggest such diagnoses.

Table 5 – Reference values of respiratory events[12]

AHI: 5 - 15/hour: Light apnea
AHI: 15 – 30/hour: Moderate apnea
AHI: > 30/hour: Severe apnea

Table 6 – Multiple Sleep Latency Test parameters of normality

Parameters	Normal	Inconclusive	Abnormal
Mean sleep latency	> 9 min	5 - 8 min	< 5
REM sleep	Absent	1*	> 2 (narcolepsy)

**May be accompanied by sleep deprivation and other sleep disorders*

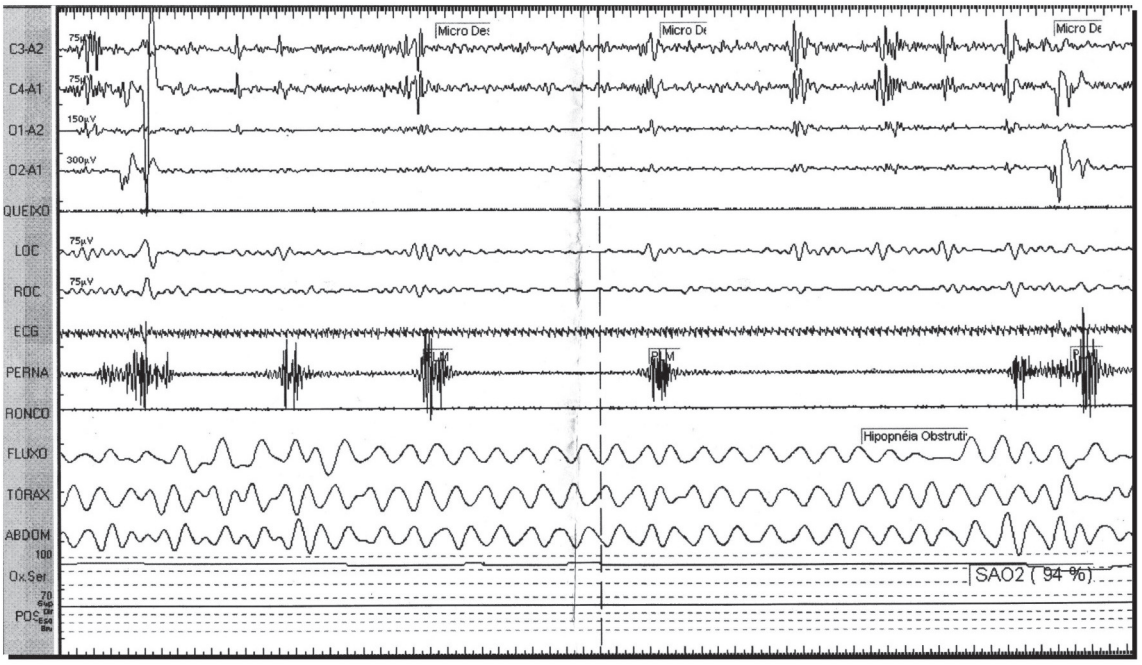


Figure 5 - Periodic Lower Limb Movements

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