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2024 Position Statement on the Use of Different Diagnostic Methods for Sleep Disorders in Adults – Brazilian Sleep Association

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Abstract

Introduction The current document represents the official position of Associação Brasileira do Sono (ABS; Brazilian Sleep Association) on the application of different sleep studies and provides specific recommendations for the use of different types of polysomnography (PSG) and respiratory polygraphy.

Materials and Methods The present document was based on existing guidelines. The steering committee discussed its findings and developed recommendations and contraindications, which were refined in discussions with the advisory committee. Adaptations were made based on professional experience, pathophysiological knowledge, and theoretical reasoning, especially to cover topics not discussed in previous guidelines or to adapt recommendations to the context and current practices in Brazil.

Results A total of 55 recommendations were made, covering the following domains: professional requirements for the requisition and interpretation of sleep studies ($n = 7$); eligibility for different sleep studies ($n = 9$); diagnosis of sleep-disordered breathing (SDB; $n = 5$); diagnosis of SDB in special conditions ($n = 3$); diagnosis of SDB in association with other sleep disorders and comorbidities ($n = 3$); sleep studies on the follow-up of patients with SDB ($n = 9$); sleep studies for positive air pressure titration ($n = 3$); diagnosis of other sleep disorders ($n = 10$); and sleep studies on other conditions ($n = 6$).

Keywords
- guidelines
- sleep apnea
- polysomnography
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Conclusion The selection of the type of sleep study should be made carefully, considering resource constraints, clinical suspicion of moderate or severe obstructive sleep apnea (OSA), and individual patient needs, among other factors. It is crucial that health professionals receive appropriate training and board certification in sleep science, thus being able to determine the most suitable diagnostic method, understand their indications and limitations, and assure an accurate diagnosis for each patient.

Introduction

The field of sleep medicine is witnessing a substantial increase in the global awareness of sleep disorders, along with the growing availability and implementation of new sleep-related technologies. In this scenario, it is essential to properly assess the quality of diagnostic tests, as well as to understand the indications and limitations of the different modalities of sleep studies.

Type-1 polysomnography (PSG), performed in a controlled environment (in a sleep laboratory), is considered the gold standard study for the diagnosis of most sleep disorders,[1–3] as it enables the continuous evaluation of physiological variables, monitored simultaneously with synchronized video and accompanied by a trained professional (PSG technician), who provides direct observation and immediate assistance to the patient. However, although it is considered the gold standard, it is subjected to important practical limitations,[3–7] which include high costs, long waiting lists, the need for specialized infrastructure, the inconvenience of overnight stays in the sleep laboratory, and the fact that it does not always reflect the patient's natural sleep patterns (►**Table 1**). Due to these limitations, other diagnostic tools have been developed for the diagnosis of sleep disorders, especially for the investigation of obstructive sleep apnea (OSA). Many of these diagnostic tools have been validated using type-1 PSG as a reference, and they are widely used in the routine clinical practice, but attention and caution in the indication and interpretation of results are required.

The aim of the present paper is to analyze the existing guidelines on the application of sleep studies and, through a discussion, provide recommendations on the appropriate use and limitations of the different types of PSG and respiratory polygraphy currently available.

Materials and Methods

The present document is based on a review of the most recent guidelines published by important researchers and

Table 1 Strengths and limitations of type-1 PSG.

Strengths
• Gold-standard tool for the objective assessment of sleep and diagnosis of most sleep disorders.
• Gold-standard tool for the diagnosis of sleep disordered breathing.
• Enables the evaluation of multiple physiological parameters during sleep.
• Appropriate for use in CPAP titration.
• Enables the evaluation of the results of the treatment of patients with sleep disorders (especially SDB).
• Performed under assistance and real-time monitoring by qualified personnel.
• Performed in a specialized medical setting, with advanced life support equipment usually available.
Limitations
• Might not be affordable to many patients due to its high costs.
• Might not be available in many locations, especially those far from large urban centers.
• Requires the patient to stay in a sleep laboratory.
• There may be long waiting lists (depending on the number of patients and the availability of PSG beds).
• May not reflect the patient's usual sleep pattern or habits, as they are sleeping in an unfamiliar setting.
• Does not account for night-to-night variability in sleep parameters, as it is usually only performed for a single night, raising the possibility of a "first-night effect."
• Poor patient experience, due to the discomfort caused by the equipment and sleeping in an unfamiliar setting.
• Not suitable for patients with reduced mobility or other disabling physical conditions.

Abbreviations: CPAP, continuous positive air pressure; PSG, polysomnography; SDB, sleep-disordered breathing.
Note: Based on Kim and Pires[4] and Pires et al.[5]

international professional sleep medicine societies on the applications of diagnostic sleep medicine, with a particular focus on the guidelines developed by the American Academy of Sleep Medicine (AASM).[1–3,8–12] Following a discussion of the results of the current review, the steering committee (LOP, LM, GNP, and RSS) made recommendations on the use of the different methods and described their possible limitations. This was subsequently discussed with the advisory committee (LFD, MA, and EZ). Whenever needed, adaptations were made to these recommendations based on professional experience, pathophysiological knowledge, and theoretical reasoning, especially to cover topics not discussed in previous guidelines, or to adapt them to the context and current practices in Brazil. All recommendations are specifically related to the use of diagnostic tests in adults.

The document produced following the discussions between the steering and advisory committees is organized into two main parts: first, a qualitative appraisal of the application of each type of sleep study is provided, followed by a list of recommendations divided into actionable and implementable items. These recommendations are focused on the application of sleep studies in a general sense, considering all sleep disorders and other possible applications. However, as they comprise the greatest part of the recommendations, sleep-disordered breathing (SDB) conditions are discussed in detail for three main reasons: 1) OSA is the most prevalent sleep disorder requiring objective sleep assessment for its diagnosis,[13,14] therefore representing the diagnostic hypothesis leading to the performance of PSG in most cases. Insomnia is the second most prevalent sleep disorder, but it does not require objective sleep assessment for a proper diagnosis, while all other sleep disorders are significantly less prevalent; 2) the number of guidelines related to OSA and SDB outnumber those for other sleep disorders requiring objective sleep assessment; and 3) type-3 and type-4 sleep studies, which correspond to the greater part of the recent innovations in diagnostic sleep medicine, are used exclusively for the diagnosis of SDB.

This document is based on the following definitions:

- **The distinction between PSG and polygraphy:** Polysomnography and polygraphy differ in terms of their ability to measure sleep-related variables and sleep architecture. Polysomnography provides information on sleep stages and breathing through the use of a range of sensors, which can include electroencephalogram (EEG), electro-oculogram (EOG) electromyogram (EMG), and electrocardiogram (ECG) sensors. The term *polysomnography* is restricted to exams that use these sensors to record multiple physiological signals, thus being able to measure sleep and its stages, and are referred to as type-1 or type-2 sleep studies. Equipment and exams that do not use these electrodes are not able to directly measure sleep, restricting the detection of events that may occur during sleep, and are mainly focused on measuring respiration and oxygen saturation. We suggest using the terms *polygraphy*, *portable monitors*, or *home sleep apnea test* (HSAT) whenever referring to these methods, which are known as type-3 and type-4 sleep studies.
- **Type-1 to type-4 sleep studies:** The current document adopts the categorization of PSG and polygraphy into four types, following the parameters adopted by the AASM:[2,15]
  - **Type 1:** Complete laboratory PSG performed under real-time supervision, using at least seven channels.
  - **Type 2:** Complete home-based PSG performed without real-time supervision, using at least seven channels.
  - **Type 3:** Cardiorespiratory polygraphy usually containing four to seven channels, without EEG.
  - **Type 4:** Polygraphy containing one or two channels, one of which dedicated to oximetry.
- **HSAT and ambulatory sleep studies:** The term *home sleep apnea test* has been used inconsistently in the literature and might lead to confusion. It usually refers to type-3 and -4 sleep studies,[2] but sometimes also encompasses type-2 PSG.[8] We consider that HSAT is not an appropriate nomenclature for type-2 sleep studies, as they are used to diagnose other sleep disorders, unlike type-3 and type-4 studies, which are more specifically related to SDB. Therefore, HSAT is used in the current document to refer specifically to type-3 and -4 studies. A better term to refer to sleep studies that are not performed in a sleep laboratory (types 2 to 4) is *ambulatory sleep studies*.
- **Diagnostic tests in sleep medicine:** This content is only relevant to PSG and polygraphy. Other diagnostic tests that are also used in sleep medicine (such as the multiple sleep latency test [MSLT], the maintenance of wakefulness test, and actigraphy) are not covered in the current document.

While the current document discusses the use and application of different types of sleep studies, it does not aim to discuss the technical details of these tests (such as assembly, signal acquisition, data processing, and event scoring) or the diagnostic criteria of the sleep disorders due to which these exams are performed. For these topics, we endorse the guidelines and manuals provided by the AASM.[16,17]

The present document represents the official position of Associação Brasileira do Sono (ABS; Brazilian Sleep Association) regarding the use of PSG and respiratory polygraphy in Brazil according to the literature current available. Therefore, it is expected to be enforced and widely implemented by all professionals involved in the diagnosis of sleep disorders in Brazil.

Type-1 PSG

The sleep monitoring test, performed in the laboratory, enables monitoring throughout the night by a trained technician. It is performed with multichannel recording and video monitoring, and is considered the gold-standard exam, as defined by the international literature.[1,2] Polysomnography includes the simultaneous recording of physiological variables, enabling a more comprehensive understanding of sleep. This sleep study is widely used for diagnosis and research on sleep disorders, and has proved to be a reliable and accurate method,

Table 2 Indications for type-1 PSG.

Indications	Explanation
First choice for the diagnosis of SDB.	Type-1 is the best practice for the diagnosis of SDB.[1]
PAP titration in patients with SDB.	Type-1 is the only sleep study recommended for PAP titration. Split-night studies are acceptable for this purpose.[1]
To assess the results of the SDB treatment.	The efficacy of SDB treatments may be evaluated through type-1 PSG, including PAP, intra-oral appliances, and surgical treatment, among others.[1]
Patients under CPAP treatment who presented substantial weight loss (at least 10% of body weight).	Type-1 PSG is required to evaluate if the CPAP treatment is still needed.[1]
Patients under CPAP treatment who presented substantial weigh gain (at least 10% of body weight).	Type-1 PSG is required to evaluate whether there is a need to adjust the therapeutic CPAP pressure.[1]
Patients with heart failure with reduced or preserved ejection fraction who present nocturnal symptoms suggestive of SDB.	These conditions increase the likelihood of comorbid central sleep apnea, which requires detailed investigation through type-1 PSG.
Patients with neuromuscular disorders and sleep-related symptoms.	Type 1 PSG is recommended in cases in which sleep disorders cannot be evaluated by means of subjective sleep assessment (sleep history, questionnaires, sleep diary, etc.).[1]
Used in association with MLST in the evaluation of suspected narcolepsy.	MLST is usually performed on the day after the PSG.[1]
Diagnosis of PLMD.	Type-1 PSG is recommended for the diagnosis of PLMD, especially when it is suspected due to reports of repetitive limb movements during sleep, frequent awakenings, fragmented sleep, difficulty maintaining sleep, or excessive daytime sleepiness.[1]
Diagnosis of RBD.	In this case, it is recommended that a PSG be performed with concomitant video recording, and, ideally, with additional EMG channels to the FDS muscles.[20,21]

Abbreviations: CPAP, continuous positive air pressure; EMG, electromyogram FDS, flexor digitorum superficialis; MLST, multiple sleep latencies test; OSA, obstructive sleep apnea; PAP, Positive air pressure; PLMD, periodic limb movement disorder; PSG, polysomnography; RBD, rapid eye movement sleep behavior disorders; SDB, sleep-disordered breathing.

being considered a reference for the validation of other diagnostic technologies.[1,8] Due to its degree of complexity, it is very important that it be performed and monitored by well-trained and certified technicians and analyzed by board-certified sleep technologists and medical doctors.[10,18] ►**Table 1** provides an overview of the main strengths and limitations of type-1 PSG.

Indications for Type-1 PSG

The recommendations for the use of type-1 PSG are included in the AASM guidelines, initially considering sleep disorders in general,[1] followed by specific guidelines for SDB, especially OSA.[8,9] The current document endorses most of the recommendations of the AASM guidelines. The indications for the use of type-1 PSG are shown in ►**Table 2**, and the contraindications, in ►**Table 3**, which mainly refers to cases in which PSG is not necessary, might not contribute to providing a diagnosis or determining a treatment, and might bias clinical decisions if not properly interpreted.

The recommendations reported in ►**Tables 2** and **3** represent the cases in which type-1 PSG is either clearly recommended for the diagnosis of sleep disorders (especially in comparison with sleep studies of types 3 and 4) or not necessary. However, there are conditions in which the recommendation is not clear, mainly because of the limited evidence available or the uncertain diagnostic value. In these cases, PSG may be requested, given its potential diagnostic meaningfulness, ability to establish a differential diagnosis, and the aggregate value the PSG might yield in terms of diagnosing and treating the patient. The conditions for which PSG presents uncertain diagnostic value include: paroxysmal arousals or other sleep disruptions considered to be related to seizures; suspected parasomnia; sleep-related seizures that do not respond to conventional therapy; sleep-related bruxism; and coronary artery disease, stroke or transient ischemic attacks, among others. In these cases, PSG might be requested only if the healthcare provider believes that it can provide additional information that is relevant to either the diagnosis or treatment of the primary condition or the associated sleep symptoms.

For the titration of continuous positive airway pressure (CPAP) devices, a "split-night" sleep exam may be indicated in some circumstances. This involves an initial basal or diagnostic PSG, followed by CPAP titration on the same night. This is especially useful for patients with a high clinical probability of OSA, facilitating and accelerating the evaluation by performing the diagnostic test and the CPAP titration on the same night, thus reducing the costs to the patient.[19] However, the split-night exam has some limitations, including the fact that the CPAP device is used in the second half of the night, a period in which respiratory events may be more frequent. In addition, waking the patient in the middle of the

Table 3 Contraindications for type-1 PSG.

Contraindications	Explanation
Diagnosis of uncomplicated and noninjurious parasomnias.	These conditions (including disorders of arousal, nightmares, enuresis etc.) can be diagnosed based on clinical evaluation only, not requiring a PSG.[1]
Diagnosis of RLS.	RLS can be diagnosed based on clinical evaluation only. However, PSG may be appropriate in the case of suspected comorbidity with PLMD, or to establish a differential diagnosis to other sleep disorders.[1]
Diagnosis of insomnia with no suspected comorbidities.	The diagnosis of insomnia is based on clinical evaluation only. However, PSG may be requested to establish a differential diagnosis to other sleep disorders, especially in the case of treatment-resistant insomnia.[22]
Diagnosis of circadian rhythm sleep disorders.	Appropriate tools should be used to assess circadian rhythm sleep disorders, such as actigraphy.
Diagnosis of depression.	Although alterations in REM sleep have been associated with depression (mainly reduced REM latency and increased REM sleep density), these findings are not pathognomonic.[1]

Abbreviations: OSA, obstructive sleep apnea; PLMD, periodic limb movement disorder; PSG, polysomnography; REM, rapid eye movement; RLS, restless legs syndrome.

night to set up the CPAP mask may fragment the sleep recording and trigger an insomnia episode.[20–22]

The split-night exam is more appropriate if the following requirements are met:[1] 1) the patient has an apnea-hypopnea index (AHI) $>$ 40 events per hour in the initial part of the split-night preparation, without the CPAP device (which shall be at least 2 hours long and include rapid eye movement [REM] sleep recording); 2) there is a CPAP titration period of at least 3 hours; and 3) there is an elimination (or near elimination) of respiratory events both in REM and non-REM (NREM) sleep, including in REM sleep while in the supine position. Full-night CPAP titration PSG may be required if any of these criteria are not met.

Assembly of Type 1-PSG

As type-1 PSG refers to the most complete sleep assessment method, several physiological variables are recommended for the measurement and recording during PSG performed in the sleep laboratory. The details of the methodology to carry out the PSG, the technical and digital specifications, data interpretation and the rules to score and interpret events are described in detail in the AASM manual[17] and the guidelines published by the ABS.[10] The minimum registration channels should include:

1- EEG – with at least three derivations (frontal, central, and occipital, with reference to the contralateral mastoid).
2- EOG – two channels.
3- EMG.
(a) Chin (one channel).
(b) Tibialis anterior muscles (two channels).
4- ECG – one channel (modified D2 derivation).
5- Pulse oximetry.
6- Airflow.
(a) Nasal pressure sensor/cannula.
(b) Oronasal temperature sensor (thermistor/thermocouple).
(c) Positive airway pressure (PAP) flow sensor (in titration studies).
7- Chest and abdominal movement (respiratory effort) sensors (inductance respiratory plethysmography).
8- Body position sensor.
9- Snore sensor (piezoelectric sensor, microphone, or derived from the nasal pressure sensor).
10- Digital video simultaneous to the tracing, to verify the position of the body and head, to evaluate sleep-related movement disorders, and enable the diagnosis or exclusion of parasomnias, seizures and dissociative behaviors.

Complementary variables can be included, such as:

1- Measurement of exhaled or transcutaneous CO_2 for the investigation of sleep hypoventilation.
2- Extended EEG mount for seizure evaluation.
3- EMG of the masseter muscle, for bruxism.
4- EMG of the flexor digitorum superficialis (FDS), for the evaluation of REM sleep without atonia (RWA), an electrophysiological marker of REM sleep behavior disorders (RBDs).

Ambulatory Sleep Studies

Ambulatory sleep studies refer to sleep diagnostic methods that do not require a sleep laboratory for their performance, and they encompass type-2 to type-4 sleep studies. They are used as an alternative to laboratory PSG for the diagnosis of sleep disorders in adult patients with less complicated conditions who meet the relevant clinical eligibility criteria. These types of unattended studies can be used to evaluate patients admitted to hospitals, other facilities, or in their own homes. Ambulatory sleep studies can also be used to monitor non-PAP treatments for sleep apnea, such as

intraoral appliance therapy. There is a large and growing number of technologies and equipment available for use in ambulatory sleep studies. In general, these devices are divided into 3 categories (types 2–4), according to the number and types of recording channels, that is, the number and characteristics of the physiological variables that are monitored during sleep.

Type-2 PSG

Type-2 recording includes a minimum of 7 channels (EEG, EOG, EMG, E|CG, nasal flow, thermistor, and oxygen saturation), therefore presenting the same basic assembly used for type-1 PSG, but without the need for the technician to be present during the night of the exam.[23] The technical requirements to monitor the variables, as well as for the analysis and interpretation of the data, should meet the standards described in the current version of the AASM Manual for the Scoring of Sleep and Associated Events.[17]

The preparation of a patient for type-2 PSG can be done in two different ways. In the first option, the patient goes to the sleep laboratory (or an equivalent health care center) where the PSG sensors and equipment are positioned and installed. The patient then goes home, where the actual exam will take place. All the equipment should be returned to the sleep laboratory on the following morning. In the second option, a PSG technician assembles the PSG in the patient's home.

The main advantage of type-2 PSG over other types of ambulatory sleep studies is the possibility of monitoring the EEG, EOG and chin EMG, which is required for the identification of sleep and its stages. Type-2 PSG includes the measurement of total sleep time (TST) to more accurately calculate indices related to sleep, sleep fragmentation, and the scoring of respiratory events associated with cortical arousals. However, small differences have been observed in the analysis of sleep efficiency and latency when compared with laboratory PSG. Such disagreements may be the result of differences in the technique to determine sleep onset, which can be given, for example: 1) manually by the patient, when pressing a start button, 2) automatically, when previously programmed in the recording software for a certain time, or 3) when the sleep time is estimated from the patient's report by motion or by position sensors.

The main difference between type-2 PSG and laboratory PSG is the impossibility of correcting failure or loss of signal at the time of sleep data collection, due to the lack of real-time monitoring by a sleep technician. This increases the risk of data loss during the exam. Studies with large samples[8] have demonstrated signal failure, with rates of data loss ranging from 5 to 10% in recordings made in the patient's home. It is estimated that this loss is greater when the test is set up in the laboratory and the patient goes home.[24] Other benefits and limitations of type-2 PSG in comparison to type-1 are shown in ►**Table 4**.

Indications for Type-2 PSG

As the assembly type-2 PSG resembles that of type-1, all the recommendations listed for type-1 are also valid for type-2. Therefore, the decision to undergo either a type-1 or a type-2 sleep study is primarily dependent on personal and logistic factors, which include the willingness of the patient to sleep in the sleep laboratory, the availability of a specialized sleep laboratory, and the costs involved. Whenever possible, the healthcare provider should inform the patient about both possibilities and discuss the benefits and possible limitations to each type of study.

However, there are specific cases in which type-2 PSG is not recommended. These contraindications are based on three main categories: 1) environmental or personal factors that prevent the proper acquisition of data in a sleep laboratory; 2) safety concerns, including cases in which an ambulatory sleep study might increase the risk of injury to the patient or others; and 3) severe cases in which in-laboratory monitoring is required. In some of these contraindications, type-1 PSG is the only possibility, while for others, type-3 or type-4 recordings might be appropriate (provided that there is a high pretest probability of SDB and no suspicion of non-respiratory sleep disorders). ►**Table 5** shows the cases in which type-2 PSG is contraindicated.

Table 4 Strengths and limitations to type-2 PSG in comparison to type-1 PSG.

Strengths	Limitations
Better patient experience (as the patient sleeps in their usual setting).	Subjected to potential data loss, due to loss of signal or failure of specific electrodes, sensors or equipment, leading to the need to repeat the exam.
Better management of bedtime and awakening time, which may follow habitual sleep patterns.	Not suitable for patients in whom a non-supervised sleep study might subject them or others to risk or harm.
More appropriate for patients with limited mobility.	Not suitable for manual CPAP titration studies.
	Not suitable for split-night preparation.
	More complicated logistics, due to the arrangements needed to set up the equipment and to return it the following morning

Abbreviations: CPAP, continuous positive air pressure; PSG, polysomnography.

Table 5 Contraindications for type-2 PSG.

Patients with uncontrolled psychiatric disorders.
Patients with any form of neuromuscular disease.
Patients with a lack of appropriate housing.
Patients with alcohol abuse disorders.
Patients with suspected CSA or Cheyne-Stokes respiration.
Patients with COPD and FEV1< 65%.
Patients with any form of cognitive dysfunction who cannot be assisted by a caregiver during the entire night.
Blind patients who cannot be assisted by a caregiver during the entire night.
Patients who have a history of stroke in the last 180 days.
Patients within 180 days of discharge from hospital due to myocardial infarction.
Patients with suspected obesity-related hypoventilation.
Patients with severe, known, or documented hypoxemia.

Abbreviations: CSA, central sleep apnea; COPD, chronic obstructive pulmonary disease; FEV1, forced expiratory volume in the first second.

Type-3 Sleep Study (Cardiorespiratory Polygraphy)

A technically-adequate type-3 recording device incorporates a minimum of the following sensors: nasal pressure, thoracic and abdominal respiratory inductance plethysmography, and oximetry[8] or peripheral arterial tonometry (PAT) with oximetry and actigraphy (although some sources[8] do not consider PAT a type-3 sleep study). The technical requirements for these types of channels must meet the standards outlined in the current version of the AASM manual.[17] A single type-3 recording must be conducted over at least 1 night.[8,19,25] Type-3 sleep studies are considered confirmatory exams, based on the clinical suspicion of SDB (most likely OSA) supported by signs, symptoms, medical history, and clinical examination. If a HSAT is negative, inconclusive, or technically inadequate, PSG should be performed to rule out a diagnosis of OSA.[8] The advantages of this type of recording include its reduced cost, greater portability, and convenience for the patient. Although there are different algorithms to analyze events, manual scoring is still recommended.[26]

A recent study[27] evaluating data from prospective cohorts indicated limitations associated with the use of unassisted type-3 recording equipment in the identification of OSA and central sleep apnea (CSA) in patients with chronic stable congestive heart failure. Although single-night studies with these devices may work well in individuals with moderate to severe OSA, patients with milder OSA may require further investigations in a sleep laboratory setting or with an outpatient record of several nights (at least two). The study sheds light on the usefulness of conducting more than 1 night of type-3 recordings to gain a better understanding of patient sleep, as variations such as the position in which the patient slept, exposure to alcohol, medications, or stress, can have profound effects on outcomes.

The assembly and setup of type-3 equipment subjects it to important limitations, and the most important are:

- **Inability to monitor sleep stages:** The absence of EEG, EOG and chin EMG does not enable reliable sleep scoring. Although some devices have sleep scoring functionalities, their algorithms are usually based on indirect measures (such as movement and heart rate variability). Such algorithms have resulted in inconstant results, with a remarkable reduced precision in cases of sleep disorders. Therefore, currently-available sleep-staging features embedded in type-3 sleep studies cannot be considered clinically reliable.
- **Inability to identify mild respiratory events:** The absence of EEG hinders the observation of events conditionally associated with arousals, which include hypopneas associated with arousals (but not with desaturation) and respiratory effort-related arousals (RERAs). Central sleep apnea might also not be properly observed in devices that do not evaluate respiratory effort due to the lack of thoracic and/or abdominal belts (as is the case of some PAT devices).
- **Inability to rule out OSA:** Due to the inability to score arousal-related respiratory events, and due to reduced sensitivity for other reasons, type-3 sleep studies might be subject to false negative results. Therefore, a negative result on a type-3 sleep study does not rule out OSA. Instead, a complete PSG assessment (type 1 or 2) is recommended.

Regarding the terminology used in type-3 recordings that do not assess sleep, the term *apnea-hypopnea index* (AHI) should not be used due to the absence of any EEG recording. The appropriate term to use is *respiratory event index* (REI), which is calculated by dividing the total number of respiratory events (apneas and hypopneas) by the total monitoring time. The monitoring time is calculated by subtracting from the total recording time the artifact periods and the time the patient was asleep, which is determined by actigraphy, body position sensors, breathing patterns or sleep diaries. The

Table 6 Strengths and limitations of type-3 sleep studies in comparison to complete PSG.

Strengths	Limitations
Better patient experience (due to the smaller size and reduced number of sensors).	Indications limited to SDB. Not suitable for other sleep disorders.
Easier setup (even enabling self-assembly).	Negative results are not considered definitive.
More affordable, due to its reduced costs.	Inability to monitor sleep stages, due to the lack of EEG and associated sensors.
Suitable for multi-night recording.	Unable to detect respiratory events associated with arousals (including arousal-associated hypopneas and RERAs).
Usually shorter waiting list.	Reduced accuracy regarding milder SDB conditions (such as mild OSA and UARS).
	Does not enable the calculation of the AHI (the REI should be calculated instead).
	May underestimate disease severity, especially in mild cases.

Abbreviations: AHI, apnea-hypopnea index; EEG, electroencephalogram; OSA, obstructive sleep apnea; REI, respiratory event index; RERA, respiratory effort-related arousal; SDB, Sseep-disordered breathing; UARS, upper airway resistance syndrome.
Note: Based on Kim and Pires[4] and Duarte et al.[12]

method used to determine the monitoring time must also be described in the study results.[17]

Based on the aforementioned concerns, multiple sources[2,8,12,28] have highlighted the likelihood of type-3 studies underestimating OSA severity metrics, especially in mild cases. This may happen for two main reasons: 1) the inability to score hypopneas not associated with desaturation, which goes unnoticed, thus decreasing the total severity index (in this case, the REI); and 2) the use of total recording time or total monitoring time as a denominator to calculate the REI, instead of the TST. The total recording time will always be longer than the TST, which means that the number of detected events will be divided by a larger denominator. Therefore, the lower the sleep efficiency, the higher the underestimation of the REI in comparison to the AHI.

Specifically, the PAT is a non-invasive method to assess vascular function using a sensor placed on the finger. This involves the sensor applying a uniform pressure field (such as 40 mm Hg) to the finger. Episodes of upper airway obstruction cause episodic vasoconstriction of the digital vascular beds due to activation of the sympathetic nervous system, which results in attenuation of the PAT signal. In other words, this type of equipment identifies respiratory events and sleep stages through algorithms based on an autonomic sympathetic tone indicator. Some studies[26,29] suggest that the PAT can lead to incorrect classification of OSA severity because it does not measure airflow directly, therefore being probably more useful in young patients with a high pretest probability of OSA and without significant comorbidities. A meta-analysis[30] concluded that there may be significant disagreement between PAT and PSG measurements of AHI, as well as incorrect classification of the degree of severity of OSA. Another meta-analysis[31] involving 18 studies with a total of 1,049 patients aged 8 to 70 years (with 74 children) evaluated the diagnostic accuracy of PAT devices compared with PSG, and the authors reported sensitivity ranging from 87% to 96% and specificity ranging from 66% to 80%.[31] Thus, the investigation of the patient with these types of equipment requires careful critical evaluation by a board-certified sleep professional. The benefits of and limitations to type-3 studies in comparison to type-1 studies are shown in ►**Table 6**.

Indications for Type-3 Sleep Studies

Type-3 sleep studies are confirmatory tests for patients with a high pretest probability of moderate to severe OSA. Specifically, type-3 recordings with a technically-appropriate device can be used for the diagnosis of OSA in uncomplicated adult patients who only present signs and symptoms that indicate an increased risk of moderate to severe OSA. They can be used as an alternative to laboratory PSG for the diagnosis of OSA in adult patients who meet the clinical eligibility criteria.[2,25] A technically-adequate diagnostic recording should include a minimum of 4 hours of oximetry and flow data, obtained during a recording attempt that covers the usual sleep period of the individual being monitored.[26,29]

The most likely candidates for type-3 ambulatory recordings are those that present the following characteristics:

1. **A high pretest probability of OSA:** Assessed through a detailed clinical examination and anamnesis, or by using OSA screening questionnaires, such as the snoring, tiredness, observed apnea, blood pressure, body mass index, age, neck size, gender (STOP-BANG),[32] the neck circumference, obesity, snoring, age, sex (NoSAS) score[33] or the Berlin questionnaire[34]).
2. **Absence of other sleep disorders:** Type-3 PSG shall be considered only in cases in which OSA is likely to be the only sleep disorder. Patients with other suspected sleep disorders that require evaluation through an objective sleep assessment (such as central hypersomnolence disorders, parasomnia, sleep-related movement disorders), either as a primary diagnostic hypothesis or as a comorbid condition, shall undergo a more appropriate diagnostic test (such as type-1 or -2 PSG, as well as other tests such as the MSLT when appropriate). Likewise, patients with

possible concurrent sleep disorders (such as severe insomnia) that might decrease the accuracy of type-3 PSG shall undergo a type-1 or type-2 study.

3. **Absence of significant complications or comorbidities:** Only patients without significant complications shall undergo a type-3 sleep study. Among the possible complications are conditions with an increased risk for non-obstructive SDB or significant comorbid medical conditions (such as significant cardiopulmonary disease, potential respiratory muscle weakness due to neuromuscular conditions, history of stroke, and chronic use of opioid medications).

Type-4 Sleep Study

Type-4 recordings usually involve 1 or 2 sensors, which can be for oximetry and/or airflow, heart rate, or tracheal sound. In general, such recordings are inexpensive, and the equipment is portable, durable, and simple to operate. Some have built-in automatic artifact detection software. Technically, they can also be monitored remotely. However, type-4 recordings should be used with caution due to the high level of training required of the professional to ensure appropriate patient selection and interpretation of the results.[26,29]

Data derived from pulse oximetry include the oxygen desaturation index (ODI), the time below a certain SpO2 level, as well as the minimum and mean SpO2 values. New measures have been described, such as hypoxic load indexes. The data collected through the type-4 recording must be downloaded and analyzed using the relevant software to make the data available in the form of graphs.[26,29] The benefits of and limitations to type-4 in comparison to type-1 studies are shown in ►**Table 7**.

Indications for Type-4 Sleep Studies

Oximetry alone can be used as a "screening" method for SDB.[26,29] However, this method should not be considered accurate as a diagnostic technique in isolation. According to an AASM clinical guidance statement on the follow-up of OSA patients, even if nocturnal pulse oximetry is used to measure SpO2, it is not recommended for the diagnosis of OSA and is, therefore, not considered an acceptable alternative to type-1, -2 or -3 PSG for the follow-up evaluation of patients with OSA.[9]

Limitations to Type-4 Sleep Studies

A type-4 sleep study uses a limited number of sensors, which reduces the ability to detect respiratory events. It presents the same limitations as those of type-3 studies in this regard, which are mostly rooted in the absence of EEG electrodes and the consequent inability to detect respiratory events associated with arousals (such as arousal-associated hypopneas and RERAS). But it has additional limitations in comparison with a type 3 sleep study, mainly related to the lack of sensors related to respiratory effort and airflow. The lack of respiratory effort analyses prevents a proper distinction of obstructive, central, and mixed respiratory events, therefore leading to a possible diagnosis of CSA to be mistaken for OSA. The lack of airflow analyses hinders its ability to make the distinction between apneas and hypopneas, therefore limiting the proper characterization and phenotyping of OSA.

Just as with type-3 studies, type-4 cannot reliably calculate the AHI. Calculating the AHI would depend on the ability to properly evaluate sleep and arousals (which would require an EEG) and differentiate apneas from hypopneas (which would require airflow analyses). In type-4 studies, respiratory events are recorded mostly based on desaturation. Therefore, the proper metric for OSA severity would be the ODI. This variable is available in most of the other sleep studies (types 1 to 3) as a complementary parameter, but it is the only metric available to estimate OSA in type-4 devices. The ODI might be presented considering SpO_2 desaturations of 3% and 4%.

Although some type-4 devices have sleep scoring functionalities, their algorithms are usually based on indirect measures (such as movement and heart rate variability).

Table 7 Strengths and limitations to type-4 sleep studies in comparison to types- 1 and -2.

Strengths	Limitations
Better patient experience (due to its reduced size and few sensors).	Indications limited to SDB. Not suitable for other sleep disorders.
Easier to use, requiring few instructions.	Negative results are not considered definitive.
More affordable, due to its reduced cost.	Inability to monitor sleep stages, due to the lack of EEG and associated sensors.
Suitable for multi-night recording.	Unable to detect respiratory events associated with arousals (including arousal-associated hypopneas and RERAs).
	Unable to differentiate apneas from hypopneas.
	Unable to differentiate central, obstructive and mixed respiratory events.
	Does not enable the calculation of the AHI (the ODI should be calculated instead).

Abbreviations: AHI, apnea-hypopnea index; EEG, electroencephalogram; ODI, oxygen desaturation index; RERA, respiratory effort-related arousal; SDB, sleep-disordered breathing.
Note: Based on Kim and Pires[4] and Duarte et al.[12]

Similarly to type-3 devices, algorithms embedded in type-4 sleep studies have yielded inconsistent results, with remarkably-reduced precision in cases of sleep disorders.[26] Therefore, metrics related to sleep staging in the type-4 devices currently available cannot be considered clinically reliable.

Type-4 studies can lead to many false positives and false negatives compared with type-3 studies, but they can be useful to "screen" for OSA in areas where access to type-1 and -2 devices is limited.[3] The sensitivity and specificity of oximetry alone for the diagnosis of OSA have been demonstrated to range from 48% to 97% and from 63% to 100% respectively, depending on the methodology used, the population tested, whether or not the test is supervised, and whether the technique combines additional forms of "screening".[35] The accuracy of the oximetry measurement can be impacted by different flow problem situations, such as low pulse volume, atrial fibrillation, hemoglobinopathies, peripheral vascular disease, dark skin, or nail disorders.[2]

Recommendations

The following recommendations are practical and actionable items to standardize the use and application of sleep studies (of types 1–4). Additional notes to the recommendations are provided whenever necessary. They are mostly based on previous guidelines,[1–3,8–12] but they were adapted when we needed to account for the current practice in Brazil, and for topics not covered in the available guidelines.

These recommendations can be used to choose which type of sleep study is most appropriate for each case, considering the sleep disorders under investigation and all other associated clinical, environmental and personal characteristics. A simplified algorithm to evaluate the suitability of each sleep study is provided in ►**Fig. 1**.

1. Professional requirements for the requisition and interpretation of sleep studies.
   This section contains recommendations about which practitioners should be able to request sleep studies, and under which circumstances, considering the professional prerogatives and practices of each health care profession. These recommendations have no legal value, but are based on the best practices considering the professional prerogatives and practices of each healthcare profession related to the diagnosis and treatment of sleep disorders.

   1.1. The decision for the most appropriate sleep study (including HSAT) for the diagnosis of sleep disorders depends on a detailed clinical examination and evaluation of medical history, to assess the risk of concurrent sleep disorders and medical comorbidities.
   - **Note:** The HSAT is not indicated in cases of comorbid sleep disorders or medical conditions. Therefore, the decision for the most appropriate sleep study is likely to be made by a physician, considering the need to assess and evaluate the possibility of such comorbidities.

   1.2. The requisition of sleep studies (including the HSAT) for the diagnosis of sleep disorders is restricted to physicians in most cases.
   - **Note 1:** The nosological diagnosis of most sleep disorders is a medical prerogative. Therefore, in most cases, the physician should be the only healthcare professional allowed to request a sleep study for diagnostic purposes (with exceptions for dentists, as in recommendation 1.3).
   - **Note 2:** Sleep-related healthcare professionals other than physicians and dentists (such as psychologists, physiotherapists, and speech therapists, for example) should not request sleep studies for diagnostic purposes, but rather refer their patients to a sleep physician when suspecting a sleep disorder. The benefits of a multidisciplinary approach to sleep medicine should be reinforced, so that this practice can be properly implemented.

   1.3. Sleep studies (including the HSAT) for the diagnosis of sleep disorders may be requested by sleep dentists in uncomplicated cases primarily related to dental sleep medicine (mostly non-comorbid OSA and sleep-related bruxism), provided that a thorough anamnesis is performed, and the risk of other sleep disorders or comorbid medical conditions are assessed.
   - **Note:** Whenever there is a risk or suspicion of significant comorbid sleep disorders or medical conditions, the patient should be referred to a sleep physician before the sleep study is requested.

   1.4. Sleep studies (including the HSAT) for the diagnosis of sleep disorders should NOT be requested by healthcare professionals other than physicians and dentists.
   - **Note:** Healthcare professionals not involved in the nosological diagnosis of sleep disorders (such as psychologists, physiotherapists, speech therapists, among others) should not request sleep studies for diagnostic purposes. However, they are entitled to request sleep studies for other purposes (check recommendation 1.5).

   1.5. Sleep studies (including the HSAT) to following-up on the results of a treatment or to adapt a treatment may be requested by any healthcare professional.
   - **Note 1:** When assessing the results of a treatment or adapting a treatment, a sleep study can be requested by any healthcare professional in charge of a patient, as long as it is clinically relevant.
   - **Note 2:** Examples of tests requested by other professionals include (but are not limited to): psychologists requesting PSG or actigraphy to monitor the results of cognitive-behavioral therapy for insomnia, physiotherapists requesting an HSAT to assess and improve patient adherence to CPAP, and speech therapists requesting an HSAT to evaluate the effectiveness of the myofunctional therapy for OSA.

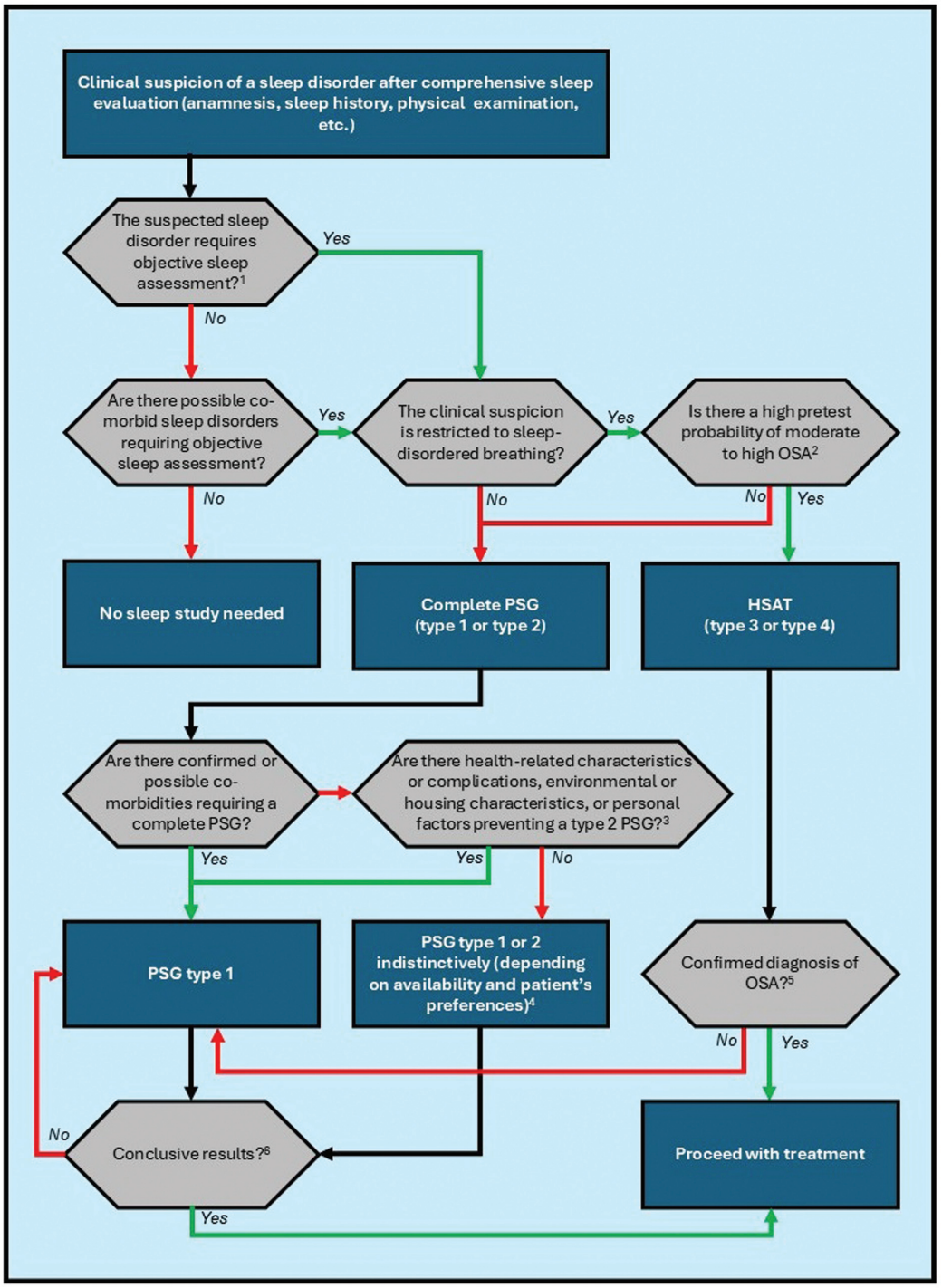

Fig. 1 Algorithm to evaluate the suitability of each type of sleep study for different cases. The rectangles indicate steps in the decision-making process; the hexagons indicate a yes/no decision point; the green arrows mean "yes"; the red arrows mean "no"; and the black arrows indicate sequential processes. 1) Some sleep disorders (such as insomnia or restless legs syndrome) do not require any objective sleep assessment. 2) High pretest probability of OSA can be assessed through a detailed clinical examination and anamnesis, or by using OSA screening questionnaires. 3) The list of characteristics and conditions that might prevent the use of type-2 PSG include (but it is not limited to) uncontrolled psychiatric diseases, neuromuscular diseases, lack of appropriate housing, alcohol abuse, suspected central sleep apnea or Cheyne-Stokes respiration, cognitive dysfunction requiring continuous assistance, blind patients who may not be assisted during the entire night, chronic obstructive pulmonary disease, recent history or hospitalization due to cardiovascular disease, obesity-related hypoventilation, hypoxemia, among others. 4) In the absence of conditions that determine a preference for a PSG of types 1 or 2, the decision shall be made based on clinical characteristics, patient preference, and service availability, and the patient shall be informed of the potential benefits of and limitations to each type of PSG. 5) The HSAT is considered a confirmatory study based on a high pretest probability of moderate to severe OSA. Negative results on the HSAT cannot be used to rule out OSA, and a type-1 or -2 sleep study is recommended instead. 6) If a complete PSG yields a negative result but the main diagnostic hypothesis is still a type of sleep disorder, the PSG might be repeated. **Abbreviations:** HSAT, home sleep apnea test; OSA, obstructive sleep apnea; PSG, polysomnography.

1.6. Raw data from HSAT devices must be reviewed and interpreted by a board-certified sleep medicine physician.

- **Note:** This recommendation refers specifically to how the results of a HSAT are released and disclosed to the patient, to the healthcare professional ordering the exam, or to a healthcare provider. A report must be analyzed and signed by a board-certified sleep medicine physician to be considered reliable.

1.7. Fully-automated HSAT results that will not undergo a review by a board-certified sleep medicine physician are NOT recommended.

- **Note 1:** This recommendation complements recommendation 1.6. Fully-automated reports may not be precise; therefore, they are not recommended for diagnostic purposes.
- **Note 2:** Sleep technologies sold to lay consumers are not recommended for the diagnosis of sleep disorders (especially SDB), as their results are usually fully-automated and analyzed by non-auditable algorithms.

2. Eligibility for different sleep studies

This section discusses the criteria to determine when a patient should be considered eligible for different types of sleep studies. These recommendations are mostly independent of the sleep disorder under analysis, although some are unavoidably related to SDB due to the specificities of the HSAT.

2.1. Complete PSG (of types 1 or 2) is the gold standard for the objective assessment of sleep disorders and for the diagnosis of most sleep disorders requiring an objective assessment.

- **Note 1:** This recommendation does not apply to sleep disorders for which the diagnostic criteria are based on clinical assessment only (such as insomnia and restless legs syndrome, RLS).
- **Note 2:** In specific cases, PSG may be associated with other tests not covered in this document (such as the MLST, for the diagnosis of narcolepsy).

2.2. A type-1 PSG is preferred over type-2 in cases of significant comorbidities or severe cases in which laboratory monitoring is required.

- **Note:** Conditions not suitable for type-2 monitoring include uncontrolled psychiatric disorders, neuromuscular disease, alcohol abuse disorder, chronic use of opioid medications, suspected CSA or Cheyne-Stokes respiration, chronic obstructive pulmonary disease (COPD) and forced expiratory volume in the first second (FEV1) $< 65\%$, a history of any significant cardiovascular event in the last 180 days, hypoventilation disorders, and any condition that requires CO_2 monitoring during the exam.

2.3. Type-2 PSG is preferred over type-1 in patients with limited mobility.

- **Note:** This recommendation is only valid if none of the conditions listed in recommendation 2.2 are present.

2.4. Type-2 PSG is NOT recommended in cases in which the device and sensors might increase the risk of harm or injury to the patient or others.

- **Note:** This recommendation is valid for patients with any form of cognitive dysfunction who cannot be assisted by a caregiver during the entire night, blind patients who cannot be assisted by a caregiver during the entire night, patients with a history or suspicion of violent parasomnia, and patients with psychiatric disorders with episodes of aggressiveness, agitation or disorientation during the night, among others. In such cases, a type-1 PSG study or an HSAT should be considered instead, depending on the diagnostic hypothesis and the safety of the patient.

2.5. In the absence of conditions that determine a preference for type-1 or 2 PSG, the decision shall be made based on clinical characteristics, the patient's preference, and service availability.

- **Note 1:** In these cases, the patient shall be informed of the potential benefits of and limitations to each type of PSG.
- **Note 2:** The informed decision should be made based on both clinical aspects and the patient's preferences. Important factors to be considered include cost, availability and the patient experience.

2.6. The HSAT is only suitable in cases of high pretest probability of moderate to severe OSA.

- **Note 1:** Considering the sensors and assembly of the HSAT (especially the lack of EEG sensors), it cannot detect hypopneas associated with arousals and RERAs, therefore reducing its accuracy in mild cases.
- **Note 2:** Specifically for type-4 studies, the lack of sensors to detect respiratory flow and respiratory effort hinders the differentiation of obstructive, central and mixed events, as well as between apneas and hypopneas.
- **Note 3:** High pretest probability of moderate to severe OSA can be assessed by means of a thorough clinical evaluation, medical history, reported signs and symptoms (either by the patient or others) or by using disease-risk tools (such as the STOP-BANG, the NoSAS score, or the Berlin Questionnaire).

2.7. The HSAT is NOT recommended in cases of suspected or possible sleep disorder that requires objective sleep assessment, other than SDB.

- **Note:** The HSAT does not have the sensors necessary to evaluate other sleep disorders requiring objective evaluation (such as central disorders of hypersomnolence, movement disorders or parasomnia). If the symptoms can be explained by other sleep disorders, PSG (of types 1 or 2) should be performed instead.

2.8. The HSAT is NOT recommended in cases of insomnia

- **Note 1:** As the HSAT does not enable the calculation of the TST, SDB-related severity indexes (such as the REI or the ODI) are calculated based on the total recording time or total monitoring time. These devices might underestimate SDB severity, especially in cases of moderate to severe insomnia with potential reduced objective sleep duration.
- **Note 2:** Prescribing hypnotics for the performance of the HSAT is not recommended as a first option, in patients not currently under pharmacological treatment for insomnia. There is no strong evidence suggesting that hypnotics significantly increase the AHI; however, a better practice would be to request a PSG examination instead, which would properly account for the TST in the calculation of the disease severity metrics.

2.9. The HSAT is NOT recommended for cases of significant comorbidity.

- **Note 1:** In cases of significant comorbidities, the HSAT is not recommended, as it cannot detect important events that would require the full assembly of a PSG study.
- **Note 2:** Significant comorbidities include (but are not limited to) moderate to severe pulmonary disease, neuromuscular disease, congestive heart failure and other major cardiovascular diseases, and chronic use of opioid medications, among others.

3. Sleep studies for the diagnosis of SDB

The previous section discussed the eligibility of patients for different types of sleep studies, regardless of the sleep disorder under analysis. This section addresses further recommendations on the application of sleep studies, specifically focusing on SDB.

3.1. PSG is recommended as the gold-standard for the diagnosis of SDB.

- **Note 1:** Polysomnography (ideally of type 1) should be preferred over other types of sleep studies whenever possible, as type-3 and -4 studies are associated with reduced diagnostic accuracy and important limitations regarding the detection of relevant respiratory events.
- **Note 2:** The HSAT is only suitable when the indications and contraindications are taken into consideration, and when the benefits of portable monitoring (including the patient's experience, costs, and availability, among others) surpass the risks associated with the limited diagnostic accuracy.

3.2. Clinical tools, questionnaires and predictive algorithms are NOT recommended for the diagnosis of OSA in the absence of PSG or the HSAT.

- **Note:** The diagnosis of SDB requires an objective sleep assessment. Any tool (including questionnaires and predictive algorithms) may be used to screen for risk for the risk of SDB, but not to establish a diagnosis.

3.3. Polysomnography should be performed if the result of the HSAT is negative, inconclusive or technically inadequate.

- **Note:** Home sleep apnea tests are considered confirmatory tests, and their applicability depends on a high pretest probability of SDB. Negative HSAT results are not sufficient to rule out OSA and other SDB conditions because of the inherent risk of false negatives. This risk is explained by the inability of the HSAT to score sleep and detect arousal-associated events (hypopneas and RERAs). Therefore, if the HSAT was performed based on symptoms suggestive of OSA and yielded in a negative result, a complete PSG (either of type 1 or 2) shall be performed.

3.4. The PSG should be repeated if a previous PSG is negative and the suspicion of OSA remains.

- **Note:** Repeating a PSG is not a mandatory procedure, but this should be the best practice in cases in which, after a first negative result, OSA remains the most probable diagnostic hypothesis.

3.5. A type-4 sleep study cannot be considered a definitive diagnostic tool due to its limited specificity and sensitivity; therefore, it cannot replace PSG (of types 1 or 2) or a type-3 sleep study in the diagnosis of SDB.

- **Note:** Type-4 sleep studies can be used to follow up patients under treatment, when appropriate.

4. Sleep studies for the diagnosis or to assess SDB in special conditions.

This section provides specific recommendations for the use of different sleep assessment methods for the diagnosis of SDB in special conditions.

4.1. Polysomnography or a type-3 sleep study is recommended as a preoperative procedure in patients before they undergo surgery for snoring or OSA.

- **Note 1:** A type-4 sleep study is NOT recommended to justify surgery for snoring or OSA, as it does not provide sufficient information about the characteristics of the disease.
- **Note 2:** The use of a type-3 study is only valid if the aforementioned requirements for this type of sleep study are met (recommendations 3.1 to 3.5).

4.2. Polysomnography or a type-3 sleep study is recommended as a preoperative procedure to evaluate the presence of OSA in patients undergoing bariatric surgery.

- **Note:** The use of a type-3 study is only valid if the aforementioned requirements for this type of sleep study are met (recommendation 3.1 to 3.5).

4.3. Polysomnography is recommended for assessment of patients with underlying medical conditions that

lead to sleep-related hypoxemia or sleep-related hypoventilation.

5. Sleep studies for the diagnosis of SDB in association with other sleep disorders and co-morbidities.

   5.1. Type-1 PSG is recommended for patients with systolic or diastolic heart failure if they have nocturnal symptoms suggestive of SDB, or if they remain symptomatic despite optimal medical management of congestive heart failure.

   5.2. Type-1 PSG is recommended for patients with coronary artery disease, a history of stroke or transient ischemic attacks, significant tachyarrhythmias or bradyarrhythmias, hypertension, or other relevant cardiovascular diseases, if there is suspicion of SDB.

   5.3. Patients with comorbid conditions associated with a high risk of OSA should undergo PSG, even if only minor sleep-related symptoms are present.

   - **Note:** This includes conditions like obesity (body mass index [BMI] $> 35\,kg/m^2$), atrial fibrillation, refractory hypertension, type-2 diabetes, nocturnal arrhythmias, stroke, pulmonary hypertension, high-risk driving populations, and preoperative for bariatric surgery.

6. Sleep studies to follow up SDB patients

   This section presents recommendations for the longitudinal assessment of SDB.

   6.1. The HSAT should not be used for general screening of asymptomatic populations.

   6.2. Follow-up PSG or HSAT is NOT recommended for routine reassessment of asymptomatic patients with OSA under PAP therapy.

   6.3. Follow-up PSG or HSAT is recommended to reassess patients with recurrent or persistent symptoms, regardless of compliance with PAP treatment.

   6.4. Follow-up PSG or HSAT is recommended to assess the response to non-PAP treatments for OSA.

   - **Note:** This recommendation includes (but is not limited to) treatments related to upper airway surgery, hypoglossal nerve stimulation, intraoral appliances, myofunctional therapy, and weight loss, among others.

   6.5. Follow-up PSG or a HSAT is recommended to assess the response to non-PAP treatments for OSA when symptoms return, despite a good initial response to treatment.

   - This recommendation includes (but is not limited to) treatments related to upper airway surgery, hypoglossal nerve stimulation, intraoral appliances, myofunctional therapy, and weight loss, among others.

   6.6. Follow-up PSG or HSAT is NOT routinely indicated in patients treated with CPAP whose symptoms continue to be resolved with the PAP treatment.

   6.7. Follow-up PSG is recommended in patients under PAP treatment with relevant findings obtained through the PAP's automated event detection tools.

   6.8. Follow-up PSG is recommended in patients under OSA treatment who developed or presented changes in cardiovascular disease.

   6.9. Follow-up PSG or HSAT is recommended for patients under CPAP treatment who presented substantial changes in body weight.

   - **Note 1**: In cases of substantial weight loss (10% or more of body weight), PSG or HSAT is necessary to evaluate if the CPAP treatment is still needed.
   - **Note 2:** In case of substantial weight gain (10% or more of body weight), PSG or HSAT is necessary to evaluate the need to adjust the therapeutic CPAP pressure.

7. Sleep studies for CPAP titration

   This section presents recommendations related to the application of sleep studies for CPAP titration.

   7.1. In the laboratory setting, titration with automated PAP (APAP) devices is allowed, according to specific indications in the guidelines for OSA therapy,[19] under technical supervision, and with the possibility to change to manual titration if necessary.

   7.2. In case of non-successful split-night PSG, full-night CPAP titration PSG is recommended.

8. Sleep studies for other sleep disorders

   This section presents recommendations for the implementation of sleep studies for other sleep disorders.

   8.1. Type-1 PSG is recommended on the night before an MSLT for the evaluation of suspected narcolepsy.

   8.2. Polysomnography is NOT recommended in cases of typical, uncomplicated, non-injurious parasomnias, such as typical disorders of arousal, nightmares, enuresis, and sleepwalking, as these conditions can usually be diagnosed by clinical evaluation alone.

   8.3. Polysomnography is recommended when evaluating patients with sleep behaviors suggestive of parasomnias that are unusual or atypical because of: the patient's age at onset; the time, duration, or frequency of the occurrence of the behavior; or the specifics of the particular motor patterns in question.

   - **Note:** Atypical behaviors during sleep may require additional investigation to exclude seizure disorders.

   8.4. PSG is recommended when the presumed parasomnia does not respond to conventional therapy.

   8.5. PSG is not mandatory for the diagnosis of sleep-related bruxism.

   - **Note 1:** Although PSG has been suggested as criteria for "definitive" bruxism,[36] the diagnosis might be established based on self-reported symptoms and dental examination.
   - **Note 2:** Polysomnography might be useful to phenotype bruxism or to refine a diagnosis.

   8.6. Polysomnography is recommended when a diagnosis of periodic limb movement disorder is considered.

   8.7. Polysomnography is not recommended to diagnose RLS.

- **Note:** Polysomnography may be appropriate in the case of suspected comorbidity with periodic limb movement disorder (PLMD) or for a differential diagnosis to other sleep disorders.

8.8. Polysomnography is not recommended for the diagnosis of circadian rhythm sleep disorders

- **Note:** appropriate tools should be used to assess circadian rhythm sleep disorders, such as actigraphy.

8.9. Type-1 PSG and video recording are recommended in the evaluation of sleep-related behaviors that are violent or otherwise potentially injurious to the patient or others.

8.10. Type-1 PSG with concomitant video recording is recommended for the diagnosis of REM sleep behavior disorder (RBD).

- **Note:** In cases of suspicion of RBD, additional EMG channels are recommended, ideally to monitor the activity of the FDS muscles.

9. **Sleep studies for other conditions**

This section presents recommendations for the application of sleep studies for conditions not primarily considered to be sleep disorders.

9.1. Neither PSG nor the HSAT are recommended to diagnose chronic lung disease.

- **Note:** Type-1 PSG is recommended whenever there is a possibility of co-occurrence of chronic lung disease and SDB.

9.2. Polysomnography is NOT recommended for patients with a seizure disorder who present no specific complaints consistent with a sleep disorder or otherwise related to sleep.

- **Note:** Standard EEG (that is, not as part of PSG) during sleep and wakefulness is sufficient in cases not primarily related to sleep.

9.3. Type-1 PSG with additional EEG derivations in an extended bilateral assembly and video recording are recommended to assist in the diagnosis of paroxysmal arousals or other sleep disruptions that are thought to be seizure-related when the initial clinical evaluation and results of a standard EEG are inconclusive.

9.4. Type-1 PSG is recommended when a presumed case of sleep-related seizure does not respond to conventional therapy.

9.5. Type-1 PSG is recommended in situations involving forensic or legal medicine considerations related to sleep.

9.6. PSG is NOT recommended for the diagnosis of depression.

- **Note:** Although alterations in REM sleep have been associated with depression (mainly reduced REM latency and increased REM sleep density), these findings are not pathognomonic.

New Technologies for The Diagnosis of Sleep Disorders

The rapid evolution of devices and smartphone applications to screen for sleep disorders has significantly reshaped the landscape of sleep technologies in recent years.[37] Many of these innovations are marketed directly to consumers, and enable autonomous use without the involvement of a certified sleep practitioner.[38] In addition, artificial intelligence (AI), which is commonly embedded in these new diagnostic consumer technologies, is generating great excitement in the field of sleep medicine, as demonstrated by the recent AASM position statement.[39,40] As the sleep community grapples with the clinical and research implications of this expanding field, advances in science and computer engineering, coupled with the emergence of *big data* and cloud storage capabilities, are accelerating the development of AI. Moreover, as sleep medicine moves toward more streamlined diagnoses, advanced platforms for home OSA testing and wearable sleep monitoring devices are gaining recognition among the general public.[41] Patients are increasingly bringing data collected by these devices to their doctors, and are more often observed actively participating in decisions about their health.[42] It is clear that the practice of sleep medicine is poised for significant changes in the near future. However, appropriate and independent validations of these new technologies are essential. Indeed, important concerns have already been raised in relation to their diagnostic accuracy and overall reliability.[38,43–45] The lack of clarity regarding the algorithms used to process physiological signals, the performance of these measurements compared with gold-standard methods, and concerns about privacy and information security are important issues that need to be critically addressed by healthcare professionals.[43,46]

Among the most notable recent innovations in diagnostic sleep medicine is the development of devices that use novel sensors, sensor placements and algorithms, particularly for the diagnosis of SDB. Examples include devices that screen for OSA using mandibular movements[47,48] or tracheal sounds,[49,50] as well as several snoring and sleep apnea smartphone applications.[51,52] However, these new technologies are not yet recognized by major sleep medicine societies as reliable tools. Therefore, the current document does not include specific recommendations about them. Another important advance has been made regarding the assembly of PSG, particularly the development of self-assembled somnography (SAS), which is essentially a reduced version of a type-2 PSG that can be set up and installed autonomously by the patient, without the assistance of a sleep technician.[53]

Although these new technologies are not yet part of current diagnostic guidelines, the ABS is closely monitoring their progress. These technologies are becoming more common in the Brazilian market, and more widely recognized in the international literature, with the number and quality of related validation studies steadily increasing. Future updates

to the current document will have to incorporate these technologies, as they are expected to become integral diagnostic tools in sleep medicine in the near future.

Conclusion

The most appropriate type of sleep study should be selected with care, taking into account resource limitations, the clinical suspicion of OSA, and individual patient needs, as well as the other criteria outlined in the present guidelines. It is crucial that health professionals have adequate training in sleep science, to enable them to determine the most appropriate diagnostic method, as well as to understand the indications and limitations to each type of test. This is essential to ensure accurate diagnoses and to determine the best treatment for each patient.

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Conflict of Interests
GNP is a shareholder at SleepUp Tecnologia em Saúde Ltda. (São Caetano do Sul, SP, Brazil). The other authors have no conflict of interests to declare.

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