The AASM Manual for the Scoring of Sleep and Associated Events

RULES, TERMINOLOGY AND TECHNICAL SPECIFICATIONS

AASM
American Academy of SLEEP MEDICINE™

VERSION 2.6

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Dedication

The Scoring Manual Committee acknowledges the invaluable service of our colleague and friend, Carole L. Marcus, MBBCh, who served on this Board from 2012–2016.

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I. User Guide

Organization of the Manual

The AASM Manual for the Scoring of Sleep and Associated Events is designed to guide users through the technical aspects of conducting routine polysomnography (PSG) testing as well as the analytic scoring and interpretation of PSG results. The rules for PSG testing and scoring are divided over seven chapters (II–VIII) of the manual. Chapter II specifies all of the parameters that should be reported in a routine PSG test. Chapter III details the digital and filter settings that are recommended for routine PSG recording. Chapters IV–VIII provide additional technical specifications as well as scoring rules for the major categories of testing: sleep staging, arousal, cardiac, movement, and respiratory. Chapter IX provides technical specifications and scoring rules for home sleep apnea testing including those utilizing respiratory flow and/or effort and those utilizing peripheral arterial tonometry (PAT). Chapter X (Development Process) details the process by which the rules were developed. An outline of the evidence level and decision-making process for each rule may be found in chapter XI (Procedural Notes). Lastly, chapter XII is a glossary of the terminology used throughout the manual.

While the rules in most chapters apply to patients of all ages, rules for adult and pediatric populations are separated in chapters IV (Sleep Staging Rules) and VIII (Respiratory Rules) due to critical age-specific differences in testing and scoring.

The rules within each chapter are organized into categories designated by an upper case letter. The rules themselves are numbered and may have several components that are identified by lower case letters.

IN EACH SECTION, ALONG WITH THE RULES, YOU WILL NOTICE:

The type of rule:

RECOMMENDED	These rules are recommended for the routine scoring of in-laboratory polysomnography or home sleep apnea testing.
ACCEPTABLE	These are rules that may be used as alternatives to the recommended rules at the discretion of the clinician or investigator.
OPTIONAL	These are suggested rules for uncommonly encountered events, events not known to have physiologic significance or events for which there was no consensus decision. Scoring may be performed at the discretion of the clinician or investigator.

Notes: If applicable, notes are positioned at the end of a category in order to provide additional information that is critical for carrying out the rules. Rules are followed by superscripts that signify the corresponding note (ex.[N1,N2]).

Sleep Facility Accreditation

AASM sleep facility accreditation requires compliance with all of the rules, definitions, and notes in this manual. According to the AASM, rules specified to be recommended, acceptable, or optional are all acceptable methods for scoring. Based on the discretion of the clinician or investigator, a specific center or laboratory may use the acceptable rule in place of the recommended rule without any risk to accreditation. Optional rules may be followed in addition to the recommended and acceptable rules without any risk to accreditation. For further information please contact the accreditation department at the AASM (accreditation@aasm.org).

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II. Parameters to be Reported for Polysomnography

Recommended parameters must be reported. Optional parameters may be monitored at the discretion of the clinician or investigator and if monitored, should be reported.

A. General Parameters

1. Electroencephalogram (EEG) derivations	RECOMMENDED
2. Electrooculogram (EOG) derivations	RECOMMENDED
3. Chin electromyogram (EMG)	RECOMMENDED
4. Leg electromyogram (EMG)	RECOMMENDED
5. Airflow signals	RECOMMENDED
6. Respiratory effort signals	RECOMMENDED
7. Oxygen saturation	RECOMMENDED
8. Body position	RECOMMENDED
9. Electrocardiogram (ECG)	RECOMMENDED
10. Synchronized PSG video	RECOMMENDED

B. Sleep Scoring Data

1. Lights out clock time (hr:min)	RECOMMENDED
2. Lights on clock time (hr:min)	RECOMMENDED
3. Total sleep time (TST; time spent in N1 + N2 + N3 + R, in min)	RECOMMENDED
4. Total recording time (TRT; "lights out" to "lights on" in min)	RECOMMENDED
5. Sleep latency (SL; lights out to first epoch of any sleep in min)	RECOMMENDED
6. Stage R latency (sleep onset to first epoch of stage R in min)	RECOMMENDED
7. Wake after sleep onset (WASO; TRT − SL − TST, in min)[N1]	RECOMMENDED
8. Percent sleep efficiency (TST / TRT × 100)	RECOMMENDED
9. Time in each stage (in min)	RECOMMENDED
10. Percent of TST in each stage (time in each stage / TST) × 100	RECOMMENDED

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Note 1. Wake after sleep onset includes all wake activity, including time out of bed. Time with the patient disconnected from the recording equipment should be scored as stage W. Brief episodes of sleep during this time, if they occur, are not considered significant for the stage scoring summary.

C. Arousal Events

1. Number of arousals	RECOMMENDED
2. Arousal index (ArI; number of arousals × 60 / TST)	RECOMMENDED

D. Cardiac Events

1. Average heart rate during sleep	RECOMMENDED
2. Highest heart rate during sleep	RECOMMENDED
3. Highest heart rate during recording	RECOMMENDED
4. Occurrence of bradycardia (if observed); report lowest heart rate	RECOMMENDED
5. Occurrence of asystole (if observed); report longest pause	RECOMMENDED
6. Occurrence of sinus tachycardia during sleep (if observed); report highest heart rate	RECOMMENDED
7. Occurrence of narrow complex tachycardia (if observed); report highest heart rate	RECOMMENDED
8. Occurrence of wide complex tachycardia (if observed); report highest heart rate	RECOMMENDED
9. Occurrence of atrial fibrillation (if observed); report average heart rate	RECOMMENDED
10. Occurrence of other arrhythmias (if observed); list arrhythmia	RECOMMENDED

E. Movement Events

1. Number of periodic limb movements of sleep (PLMS)	RECOMMENDED
2. Number of periodic limb movements of sleep (PLMS) with arousals	RECOMMENDED
3. PLMS index (PLMSI; PLMS × 60 / TST)	RECOMMENDED
4. PLMS arousal index (PLMSArI; PLMS with arousals × 60 / TST)	RECOMMENDED
5. REM without atonia (RWA) [N1]	OPTIONAL

Note 1. If electing to measure RWA, the leads used to determine the presence of RWA should be included in the PSG report (e.g., chin, chin and lower limbs, chin and upper limbs).

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F. Respiratory Events[N1]

1. Number of obstructive apneas	RECOMMENDED
2. Number of mixed apneas	RECOMMENDED
3. Number of central apneas	RECOMMENDED
4. Number of hypopneas	RECOMMENDED
5. Number of obstructive hypopneas	OPTIONAL
6. Number of central hypopneas	OPTIONAL
7. Number of apneas + hypopneas	RECOMMENDED
8. Apnea index (AI; (# obstructive apneas + # central apneas + # mixed apneas) × 60 / TST)	RECOMMENDED
9. Hypopnea index (HI; # hypopneas × 60 / TST)	RECOMMENDED
10. Apnea-hypopnea index (AHI; (# apneas + # hypopneas) × 60 / TST)	RECOMMENDED
11. Obstructive apnea-hypopnea index (OAHI; (# obstructive apneas + # mixed apneas + # obstructive hypopneas) × 60 / TST)	OPTIONAL
12. Central apnea-hypopnea index (CAHI; (# central apneas + # central hypopneas) × 60 / TST)	OPTIONAL
13. Number of respiratory effort-related arousals (RERAs)	OPTIONAL
14. Respiratory effort-related arousal index (RERA index; # of RERAs × 60 / TST)	OPTIONAL
15. Respiratory disturbance index (RDI; (# apneas + # hypopneas + # RERAs) × 60 / TST)	OPTIONAL
16. Number of oxygen desaturations ≥3% or ≥4%[N2]	OPTIONAL
17. Oxygen desaturation index ≥3% or ≥4% (ODI; # oxygen desaturations ≥3% or ≥4% × 60 / TST)	OPTIONAL
18. Arterial oxygen saturation, mean value	RECOMMENDED
19. Minimum oxygen saturation during sleep[N3]	RECOMMENDED
20. Occurrence of hypoventilation during diagnostic study[N4]	
Adults	OPTIONAL
Children	RECOMMENDED
21. Occurrence of hypoventilation during PAP titration[N4]	
Adults	OPTIONAL
Children	OPTIONAL
22. Occurrence of Cheyne-Stokes breathing in adults[N5]	RECOMMENDED

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23. Duration of Cheyne-Stokes breathing (absolute or as a percentage of total sleep time) or the number of Cheyne-Stokes breathing events.	RECOMMENDED
24. Occurrence of periodic breathing in children	RECOMMENDED
25. Occurrence of snoring	OPTIONAL

Note 1. Using supplemental oxygen may cause an underestimation of respiratory events which should be taken into consideration by the interpreting physician.

Note 2. The criteria used to score a respiratory event as a hypopnea (either rule 1A or 1B) should be specified in the PSG report.

Note 3. Percent time spent below a given threshold of oxygen desaturation may be reported at the discretion of the clinician.

Note 4. If electing to measure the arterial PCO_2 or surrogate during sleep in cases where it is optional to do so, the occurrence/absence of hypoventilation must be included in the PSG report.

Note 5. Reporting the occurrence of Cheyne-Stokes breathing in the PSG report is required only if central apneas and/or central hypopneas are present.

G. Summary Statements

1. Findings related to sleep diagnoses	RECOMMENDED
2. EEG abnormalities	RECOMMENDED
3. ECG abnormalities	RECOMMENDED
4. Behavioral observations	RECOMMENDED
5. Sleep hypnogram	OPTIONAL

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III. Technical and Digital Specifications

A. Digital Specifications for Routine PSG Recordings[N1]

1. Maximum Electrode Impedances: 5 K Ω[N2] RECOMMENDED

2. Minimum Digital Resolution: 12 bits per sample RECOMMENDED

3. Sampling Rates

	Desirable	Minimal	
EEG[N3,N4]	500 Hz	200 Hz	RECOMMENDED
EOG[N5]	500 Hz	200 Hz	RECOMMENDED
EMG[N6]	500 Hz	200 Hz	RECOMMENDED
ECG[N7]	500 Hz	200 Hz	RECOMMENDED
Airflow	100 Hz	25 Hz	RECOMMENDED
Oximetry, Transcutaneous PCO_2[N8]	25 Hz	10 Hz	RECOMMENDED
Nasal Pressure, End-Tidal PCO_2, PAP Device Flow[N9]	100 Hz	25 Hz	RECOMMENDED
Esophageal Pressure	100 Hz	25 Hz	RECOMMENDED
Body Position[N10]	1 Hz	1 Hz	RECOMMENDED
Snoring Sounds[N11]	500 Hz	200 Hz	RECOMMENDED
Rib Cage and Abdominal Movements[N12]	100 Hz	25 Hz	RECOMMENDED

4. Routinely Recorded Filter Settings

	Low-Frequency Filter	High-Frequency Filter	
EEG[N4,N13]	0.3 Hz	35 Hz	RECOMMENDED
EOG[N13]	0.3 Hz	35 Hz	RECOMMENDED
EMG[N6]	10 Hz	100 Hz	RECOMMENDED
ECG[N14]	0.3 Hz	70 Hz	RECOMMENDED
Oronasal Thermal Flow, Thoracoabdominal Belt Signals	0.1 Hz	15 Hz	RECOMMENDED
Nasal Pressure	Direct current (DC) or ≤0.03 Hz	100 Hz	RECOMMENDED
PAP Device Flow	DC	DC	RECOMMENDED
Snoring	10 Hz	100 Hz	RECOMMENDED

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Note 1. In the absence of clear preferences, use similar settings among leads to simplify technical implementation.

Note 2. This applies to measured EEG and EOG electrode impedance. Electrode impedances should be rechecked during a recording when any pattern that might be artifactual appears. The AASM Scoring Manual currently does not specify maximum impedances for ECG or for EMG of the legs. However, it is suggested that the impedance be adjusted so that the baseline amplitude is minimized.

Note 3. For EEG, 500 Hz sampling rate could improve resolution of spikes in the EEG and better maintain details of the waveform.

Note 4. For more detailed EEG analysis, sampling rate and high-frequency filter settings may be increased. In these circumstances, the sampling rate should be at least 3 times the highest frequency of interest.

Note 5. For EOG, using the 500 Hz desirable EEG sampling rate also allows the reflection of the EEG in this lead as an EEG backup and may better define some artifacts in these leads.

Note 6. This applies to submental and leg EMG. Higher sampling rates better define waveforms; while the waveform itself is not an issue, a better-defined waveform can help avoid amplitude attenuation as the envelope of the rapidly oscillating signal is interpreted.

Note 7. For ECG, 500 Hz sampling rate can better define pacemaker spikes and ECG waveforms, however, pacemaker spikes can be seen at 200 Hz, and the evaluation of cardiac ischemia by ECG waveform is not a common PSG issue. Higher frequencies may be required for complex waveform analysis and research applications.

Note 8. For oximetry, 25 Hz sampling is desirable to assist with artifact evaluation.

Note 9. For nasal pressure transducer technology (especially with settings which identify snoring occurring on top of the airflow waveform), this higher frequency may be of benefit for better definition of vibration and snoring.

Note 10. The body position channel is exempt from the digital resolution standard. However, the recommended sampling rate of 1 Hz remains in effect.

Note 11. For snoring sound, 500 Hz sampling rate can better define amplitude variation by clearer waveforms with more accurate amplitude determination as the envelope of the rapidly oscillating signal is interpreted, (as for EMG). If a preprocessing of snoring results in a continuous sound loudness level or in a sound intensity level, then a much lower sampling rate is acceptable. That sampling rate is not specified because it depends on the preprocessing of the sound in order to produce loudness.

Note 12. For rib cage and abdominal movements using inductance plethysmography, cardiogenic oscillations can be better seen and may result in better artifact assessment at a higher sampling rate.

Note 13. To accommodate older equipment, filter settings in the range of 30–35 Hz may be used to comply with the recommendations of 35 Hz. This applies most specifically in the context of EEG and EOG high filter settings.

Note 14. For ECG, low-frequency settings and wide bandwidth minimizes distortion in a 12 lead ECG; however, in PSG recording with single-channel modified lead II used for identifying basic heart rates and dysrhythmias, it may not be as necessary. Advanced cardiac assessment may be more optimal using a low-frequency filter of 0.3 Hz for slower parts of the cardiac cycle. The channel is susceptible to artifacts at this setting due to patient movement, perspiration, muscle activity and electrode displacement. Artifact is less likely at these settings when standard ECG leads are used for cardiac monitoring.

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B. PSG Recording Features

1. A toggle switch permitting visual (on-screen), standard, negative 50 μV DC calibration signal for all channels to demonstrate polarity, amplitude and time constant settings for each recorded parameter	RECOMMENDED
2. A separate 50/60 Hz filter control for each channel	RECOMMENDED
3. The capability of providing the minimal recommended sampling rate (or higher) for all signals as specified in III.A.3	RECOMMENDED
4. A method of measuring actual individual electrode impedance against a reference (the latter may be the sum of all other applied electrodes)	RECOMMENDED
5. The capability of retaining and viewing the data in the exact manner in which it was recorded by the attending technologist (i.e., retain and display all derivation changes, sensitivity adjustments, filter settings, temporal resolution)	RECOMMENDED
6. The capability of retaining and viewing the data in the exact manner it appeared when it was scored by the scoring technologist (i.e., retain and display all derivation changes, sensitivity adjustments, filter settings, temporal resolution)	RECOMMENDED
7. A filter design for data collection which functionally simulates or replicates conventional (analog-style) frequency response curves rather than removing all activity and harmonics within the specified bandwidth	RECOMMENDED
8. An electrode selector process with the flexibility for choosing and/or changing electrode input signal derivations without relying on a common reference electrode	OPTIONAL

C. Use Systems with the Following PSG Display and Display Manipulation Features

1. The display for scoring and review of sleep study data must meet or exceed the following criteria: 15-inch screen size, 1,600 pixels horizontal and 1,050 pixels vertical	RECOMMENDED
2. Histogram with stage, respiratory events, leg movement events, O2 saturation, body position (e.g., supine, prone, lateral) and arousals, with cursor positioning on histogram and ability to jump to the page	RECOMMENDED
3. Ability to view a screen on a time scale ranging from the entire night to windows as small as 5 seconds	RECOMMENDED
4. Recorded video data must be synchronized with PSG data and have an accuracy of at least one video frame per second	RECOMMENDED
5. Page automatic turning and automatic scrolling	OPTIONAL
6. Channel-off control key or toggle	OPTIONAL
7. Channel-invert control key or toggle	OPTIONAL
8. Change order of channel by click and drag	OPTIONAL
9. Display setup profiles (including colors) which may be activated at any time	OPTIONAL
10. Fast Fourier Transformation or spectral analysis on specifiable interval (omitting segments marked as data artifact)	OPTIONAL

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D. Perform the Following Digital Analyses of PSG

1. Ability to display whether sleep stage scoring was performed visually or computed by the system	RECOMMENDED
2. Ability to turn off and on, as demanded, highlighting of EEG patterns used to make sleep stage decisions (for example sleep spindle, K complex, alpha activity)	OPTIONAL
3. Ability to turn off and on, as demanded, highlighting of patterns identifying respiratory events (for example apneas, hypopneas, desaturations)	OPTIONAL
4. Ability to turn off and on, as demanded, highlighting of patterns identifying the movement analysis (for example PLMs)	OPTIONAL

E. Perform the Following Calibrations to Document Appropriate System Response[N1,N2]

1. Perform and document an impedance check of the EEG, EOG and EMG electrodes[N3]	RECOMMENDED
2. Record a minimum of 30 seconds of EEG with patient awake lying quietly with eyes open[N4]	RECOMMENDED
3. Record a minimum of 30 seconds of EEG with patient lying quietly with eyes closed[N4]	RECOMMENDED
4. Ask the patient to look up and down without moving head (×5)	RECOMMENDED
5. Ask the patient to look left and right without moving head (×5)	RECOMMENDED
6. Ask the patient to blink (×5)	RECOMMENDED
7. Ask the patient to grit teeth and/or chew (5 seconds)[N5]	RECOMMENDED
8. Ask the patient to simulate a snore or hum (5 seconds)[N6]	RECOMMENDED
9. Ask the patient to breathe normally and assure that airflow and effort channel signals are synchronized	RECOMMENDED
10. Ask the patient to perform a breath hold (10 seconds)[N7]	RECOMMENDED
11. Ask the patient to breathe normally and upon instruction to take a breath in and out—check polarity and mark the record IN and OUT accordingly[N7]	OPTIONAL
12. Ask the patient to breathe through the nose only (10 seconds)[N7]	RECOMMENDED
13. Ask the patient to breathe through the mouth only (10 seconds)[N7]	RECOMMENDED
14. Ask the patient to take a deep breath and exhale slowly (prolonged expiration—10 seconds)[N7]	OPTIONAL
15. Ask the patient to flex the left foot/raise toes on left foot (×5)[N8]	RECOMMENDED
16. Ask the patient to flex the right foot/raise toes on right foot (×5)[N8]	RECOMMENDED
17. Ask the patient to flex/extend the fingers on the left hand, as appropriate, if upper extremity EMG is recorded[N8,N9]	OPTIONAL

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18. Ask the patient to flex/extend the fingers on the right hand, as appropriate, if upper extremity EMG is recorded[N8,N9]	OPTIONAL
19. Adjust EKG signal to provide a clear waveform—the R wave should deflect upward[N10]	OPTIONAL
20. Perform and document a repeat impedance check of the EEG, EOG and EMG electrodes at the end of the PSG recording[N11]	RECOMMENDED
21. Repeat physiological calibrations at the end of the PSG recording[N11]	RECOMMENDED

Note 1. Perform physiological calibrations for all patients to the extent that the patient is able to cooperate and complete the requested maneuvers.

Note 2. Document all calibrations. Verify that the signal appropriately responds to the requested patient maneuvers. Repeat calibrations as needed to document a working signal for all recording parameters.

Note 3. Measured EEG, EOG and EMG channel impedances should be 5 K Ω or less and relatively equal. Limb EMG impedances of 10 K Ω or less are acceptable, but impedances of 5 K Ω or less are preferred. Recheck impedances during the recording when any pattern that might be artifact appears.

Note 4. Check EEG channels for blocking, 60 Hz, EKG, and sweat or respiratory artifact and make any necessary adjustments to assure a readable EEG recording.

Note 5. Adjust chin EMG to an adequate sensitivity while patient is awake. In an awake relaxed patient the chin EMG signal should be visible (at least 1–2 mm amplitude). During chewing or teeth gritting maneuvers the chin EMG signal should be at least double the size of the baseline signal.

Note 6. Check the integrity of the snore microphone or sensor by asking the patient to simulate a snore and hum. Adjust as necessary to provide a clear signal with activity. Activity should be negligible with quiet breathing.

Note 7. Adjust all respiratory channels to provide a large clean signal with each respiration. Observe and document the signal direction during inhalation and exhalation. Airflow and effort and signals should be in phase with respect to each other. Adjust belt position to attain a readable signal on all airflow and effort channels. Assure that airflow and effort signals respond appropriately to a 10 second breath hold.

Note 8. Adjust limb EMG signal to reflect a low background; check signal with bilateral limb movements to verify a noticeable deflection with movement.

Note 9. If recording the flexor digitorum superficialis, the patient should flex the fingers at the base (avoid bending at the distal two joints). If recording the extensor digitorum communis, the patient should extend their fingers back without moving their wrist.

Note 10. Compare heart rate (HR) to EKG signal (heart rate is collected from pulse oximetry) to assure HR accuracy.

Note 11. Repeat the impedance check and physiological calibrations after lights on in the morning.

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IV. Sleep Staging Rules Part 1: Rules for Adults

A. Technical Specifications for Electroencephalogram (EEG)

1. The recommended EEG derivations are:[N1,N2] RECOMMENDED

a. F4-M1
b. C4-M1
c. O2-M1
Backup electrodes should be placed at F3, C3, O1 and M2 to allow display of F3-M2, C3-M2 and O1-M2 if electrodes malfunction during the study. (see Figure 1A)

2. Acceptable EEG derivations are:[N1,N2,N3] ACCEPTABLE

a. Fz-Cz
b. Cz-Oz
c. C4-M1
Backup electrodes should be placed at Fpz, C3, O1, and M2 to allow substitution of Fpz for Fz, C3 for Cz or C4, O1 for Oz and M2 for M1 if electrodes malfunction during the study. (see Figure 1B)

3. EEG electrode position is determined by the International 10-20 System. (see Figure 1) RECOMMENDED

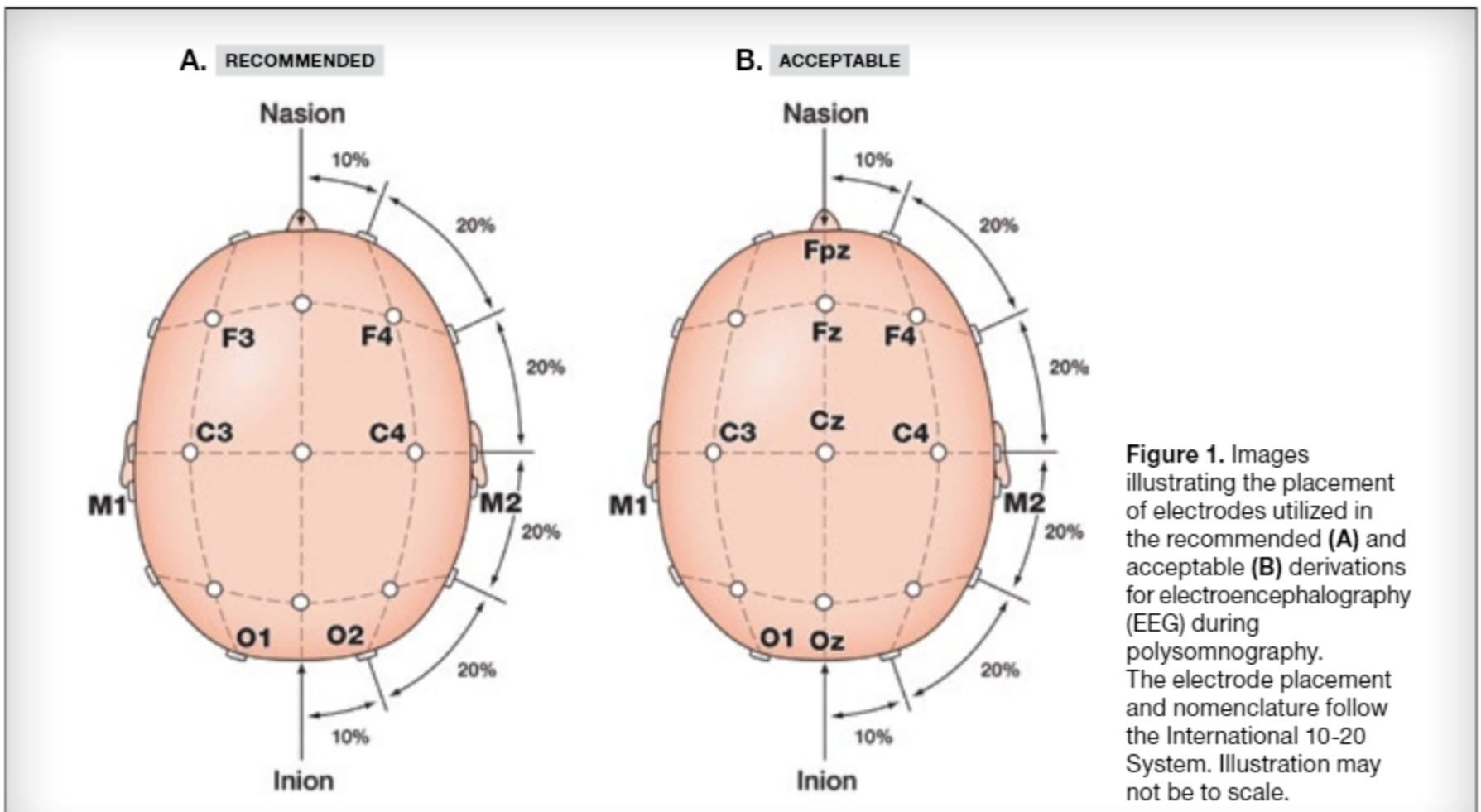


Figure 1. Images illustrating the placement of electrodes utilized in the recommended **(A)** and acceptable **(B)** derivations for electroencephalography (EEG) during polysomnography. The electrode placement and nomenclature follow the International 10-20 System. Illustration may not be to scale.

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Note 1. At a minimum, frontal, central, and occipital derivations (3 EEG channels) are required to stage sleep.

Note 2. M1 and M2 refer to the left and right mastoid processes. M1 is the standard reference electrode for recording EEG. If M1 fails during the recording, backup electrodes should be used and referenced to M2.

Note 3. Fz-Cz is not appropriate for measuring the amplitude of frontal activity for determination of slow wave activity. When using the **acceptable** EEG derivations and the **acceptable** EOG derivations (Figure 2), the E1-Fpz derivation should be used to measure frontal slow wave amplitude. Used in this way, Fpz will be the active electrode recording frontal activity and E1 the reference electrode in a referential derivation. When using the **acceptable** EEG derivations and the **recommended** EOG derivations, EEG amplitude to determine slow wave activity should be measured using the C4-M1 derivation (C3-M2 if either C4 or M1 electrodes malfunction). When using the **recommended** EEG derivations and **recommended** EOG derivations, the EEG amplitude is measured using the derivation F4-M1.

B. Technical Specifications for Electrooculogram (EOG)

1. The recommended EOG derivations and electrode positions are:[N1] (see Figure 2A) RECOMMENDED

a. Derivations: E1-M2 and E2-M2

b. Electrode positions: E1 is placed 1 cm below and 1 cm lateral to the left outer canthus and E2 is placed 1 cm above and 1 cm lateral to the right outer canthus

2. Acceptable EOG derivations and electrode positions are:[N2] (see Figure 2B) ACCEPTABLE

a. Derivations: E1-Fpz and E2-Fpz

b. Electrode positions: E1 is placed 1 cm below and 1 cm lateral to the outer canthus of the left eye and E2 is placed 1 cm below and 1 cm lateral to the outer canthus of the right eye

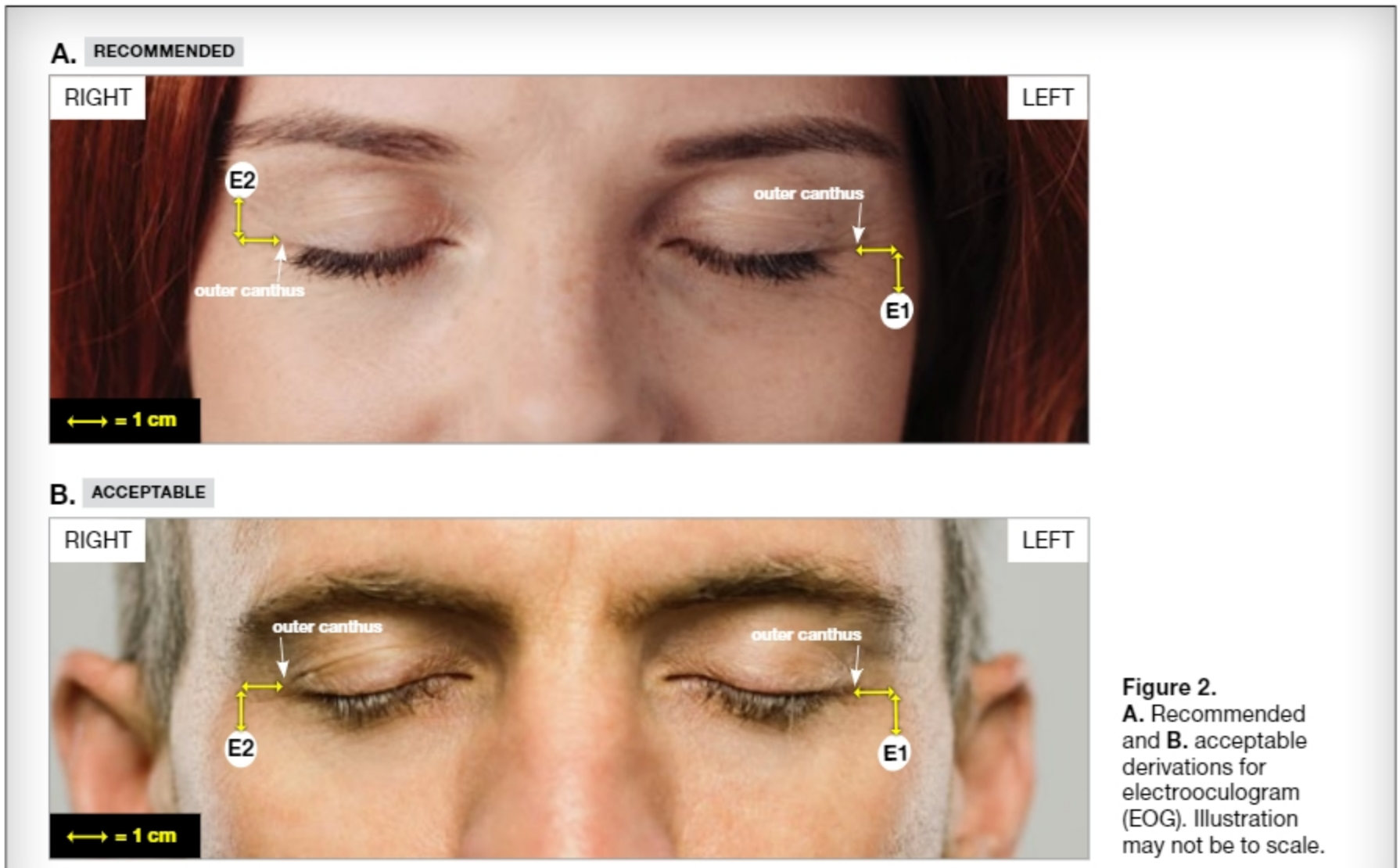


Figure 2.
A. Recommended and **B.** acceptable derivations for electrooculogram (EOG). Illustration may not be to scale.

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Note 1. When using the recommended EOG derivations, if the M2 reference electrode fails, E1 and E2 should be referenced to M1.

Note 2. When using the recommended electrode derivations, conjugate eye movements result in out-of-phase deflections. The acceptable derivations allow determination of the direction of eye movements (i.e., vertical movements will show in-phase deflections and horizontal eye movements, out-of-phase deflections).

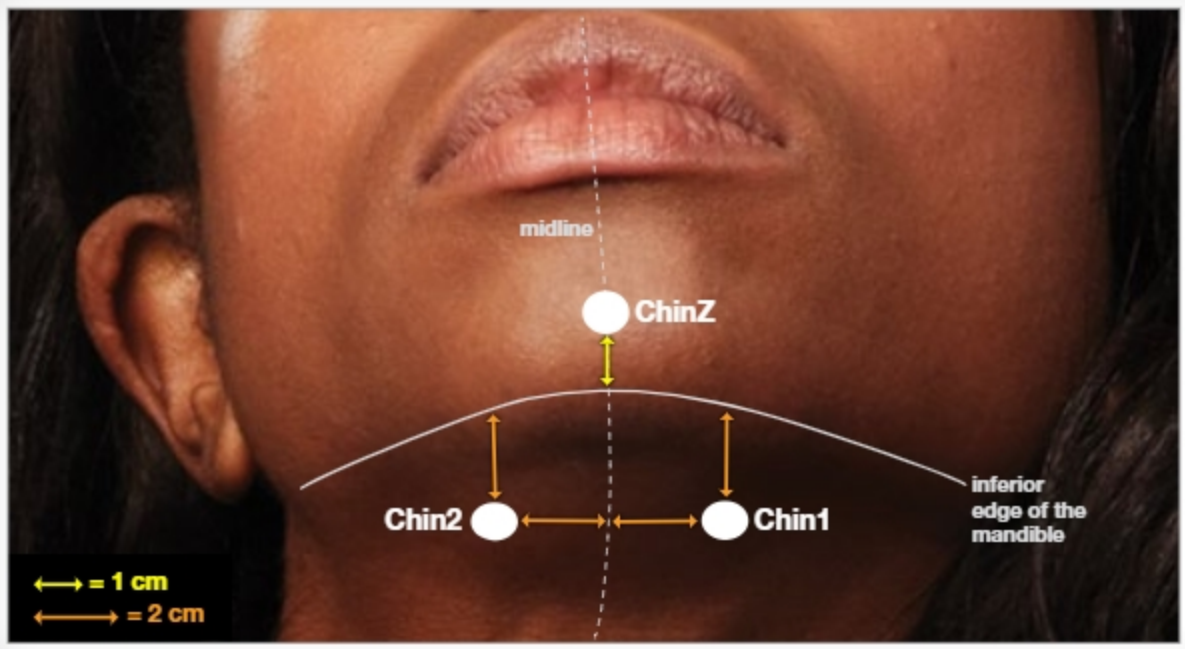
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C. Technical Specifications for Electromyogram (EMG)

1. Three electrodes should be placed to record chin EMG: RECOMMENDED

a. One in the midline 1 cm above the inferior edge of the mandible (see ChinZ in Figure 3)
b. One 2 cm below the inferior edge of the mandible and 2 cm to the right of the midline (see Chin2 in Figure 3)
c. One 2 cm below the inferior edge of the mandible and 2 cm to the left of the midline (see Chin1 in Figure 3)

2. The standard chin EMG derivation consists of either of the electrodes below the mandible referred to the electrode above the mandible. The other inferior electrode is a backup electrode to allow for continued display of EMG activity if one of the primary electrodes malfunctions.[N1] RECOMMENDED



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Figure 3. Placement of electrodes on the chin for electromyogram (EMG) recording. Illustration may not be to scale.

Note 1. If EMG electrode ChinZ (above the mandible) fails during the recording, it should be replaced, if possible. Otherwise, reference electrodes Chin2 and Chin1 (below the mandible) to each other.

D. General Scoring of Sleep Stages

1. The following terminology should be used for the stages of sleep in adults: RECOMMENDED

a. Stage W (Wakefulness)
b. Stage N1 (NREM 1)
c. Stage N2 (NREM 2)
d. Stage N3 (NREM 3)
e. Stage R (REM)[N1]

2. Score epochs using the following parameters: RECOMMENDED

a. Score sleep stages in 30-second, sequential epochs commencing at the start of the study.
b. Assign a stage to each epoch.
c. If two or more stages coexist during a single epoch, assign the stage comprising the greatest portion of the epoch.
d. When three or more segments of an epoch meet criteria for different stages (stage W, N1, N2, N3, R):
    i. Score the epoch as sleep if the majority of the epoch meets criteria for stage N1, N2, N3, or R.
    ii. Assign the sleep stage that occurs for the majority of sleep within the epoch. (see Figure 4)

3. Score in accordance with the following definitions for EEG frequencies: RECOMMENDED

a. Slow wave activity: frequency of 0.5–2.0 Hz and peak-to-peak amplitude of >75 μV, measured over the frontal regions
b. Delta waves are 0–3.99 Hz
c. Theta waves are 4–7.99 Hz
d. Alpha waves are 8–13 Hz
e. Beta waves are greater than 13 Hz

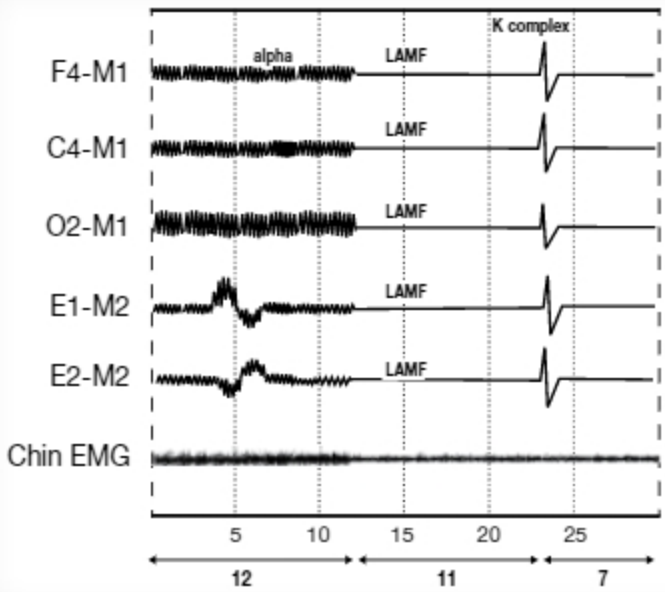


Figure 4. In this epoch, there is an initial segment meeting criteria for stage W (12 seconds), a second segment meeting criteria for stage N1 (11 seconds) and a final segment meeting criteria for stage N2 (7 seconds). The epoch is scored as sleep as the majority of the epoch is sleep. The epoch is scored as stage N1 as the majority of sleep is stage N1. The following epoch would be scored as stage N2 unless there was evidence of a shift to another sleep stage. (See subsequent sections in this chapter for definitions of alpha rhythm, LAMF, and K complex.)

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Note 1. When referring to scoring, use the term "stage R," and when referring to the physiological state, use the term "REM sleep" (e.g., REM Sleep Behavior Disorder)..

E. Scoring Stage W[N1,N2,N3,N4,N5]

1. Score in accordance with the following definitions: RECOMMENDED

Alpha rhythm (posterior dominant rhythm in adults and older children): An EEG pattern consisting of trains of sinusoidal 8–13 Hz activity recorded over the occipital region with eye closure and attenuating with eye opening.

Eye blinks: Conjugate vertical eye movements at a frequency of 0.5–2 Hz present in wakefulness with the eyes open or closed.

Reading eye movements: Trains of conjugate eye movements consisting of a slow phase followed by a rapid phase in the opposite direction as the individual reads.

Rapid eye movements (REMs): Eye movements recorded in the EOG derivations consisting of conjugate, irregular, sharply peaked eye movements with an initial deflection usually lasting <500 msec. While rapid eye movements are characteristic of stage R sleep, they may also be seen in wakefulness with eyes open when individuals visually scan the environment. (see Figure 5)

Slow eye movements (SEM): Conjugate, reasonably regular, sinusoidal eye movements with an initial deflection that usually lasts >500 msec. Slow eye movements may be seen during eyes closed wake and stage N1.

2. Score epochs as stage W when more than 50% of the epoch contains EITHER 2a or 2b or BOTH:
(see Figure 6) RECOMMENDED

a. Alpha rhythm (posterior dominant rhythm) over the occipital region (individuals generating alpha rhythm with eye closure)
b. Other findings consistent with stage W (all individuals)
    i. Eye blinks (0.5 to 2 Hz)
    ii. Rapid eye movements associated with normal or high chin muscle tone
    iii. Reading eye movements

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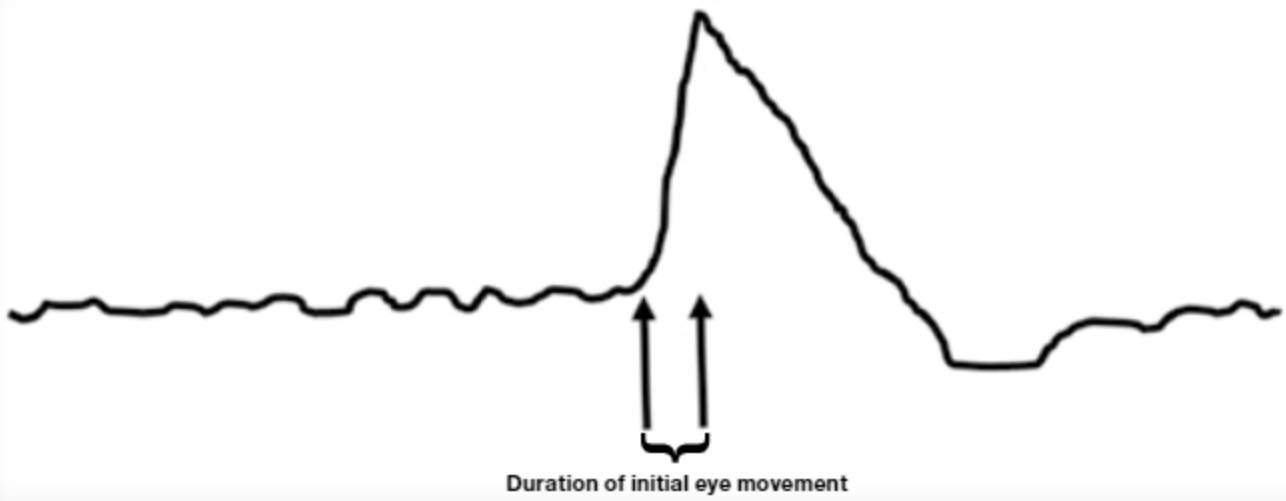


Figure 5. Measurement of initial eye movement deflection.

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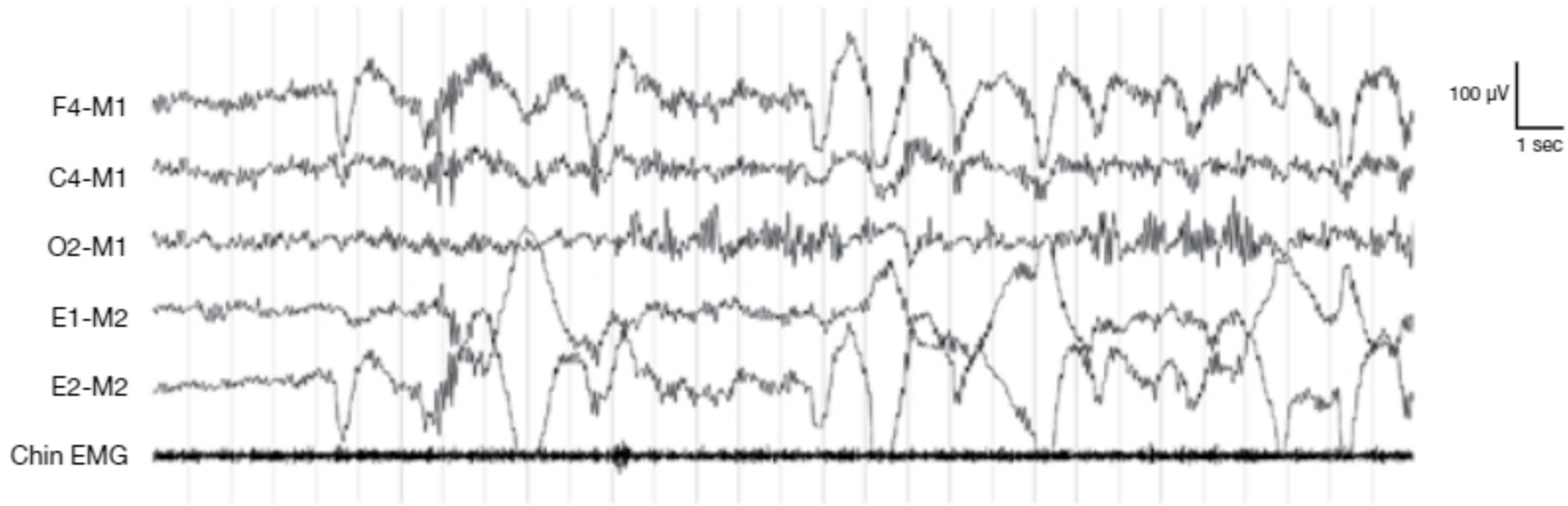


Figure 6. An epoch of stage W with both alpha rhythm (posterior dominant rhythm) and REMs. Note the EMG activity in the chin channel.

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Note 1. Stage W represents the waking state, ranging from full alertness through early stages of drowsiness. Electrophysiological and psychophysiological markers of drowsiness may be present during stage W and may persist into stage N1.

Note 2. In stage W, the majority of individuals with eyes closed will demonstrate alpha rhythm (posterior dominant rhythm). The EEG pattern with eyes open consists of low-amplitude activity (chiefly beta and alpha frequencies) without the rhythmicity of alpha rhythm. About 10% of individuals do not generate an alpha rhythm upon eye closure, and a further 10% may generate a limited alpha rhythm. In these individuals, the occipital EEG activity is similar during eye opening and eye closure.

Note 3. The EOG during wakefulness may demonstrate rapid eye blinks at a frequency of about 0.5–2 Hz. The earliest sign of drowsiness is the absence of eye blinks. As drowsiness develops, slow eye movements may develop, even in the presence of continued posterior dominant rhythm. If the eyes are open, voluntary rapid eye movements or reading eye movements may be seen.

Note 4. The chin EMG during stage W is of variable amplitude but is usually higher than during sleep stages.

Note 5. Time with the patient disconnected from the recording equipment should be scored as stage W. Brief episodes of sleep during this time, if they occur, are not considered significant for the stage scoring summary.

F. Scoring Stage N1

1. Score in accordance with the following definitions: RECOMMENDED

Slow eye movements (SEM): Conjugate, reasonably regular, sinusoidal eye movements with an initial deflection that usually lasts >500 msec. Slow eye movements may be seen during eyes closed wake and stage N1.

Low-amplitude, mixed-frequency (LAMF) EEG activity: Low-amplitude, predominantly 4–7 Hz activity.

Vertex sharp waves (V waves): Sharply contoured waves with duration <0.5 seconds (as measured at the base of the wave), maximal over the central region and distinguishable from the background activity. They are most often seen during transition to stage N1 sleep but can occur in either stage N1 or N2 sleep. These waveforms typically first appear at 4-6 months post-term.

Sleep onset: The start of the first epoch scored as any stage other than stage W. (In most individuals this will usually be the first epoch of stage N1.)

2. In individuals who generate alpha rhythm, score stage N1 if the alpha rhythm is attenuated and replaced by low-amplitude, mixed-frequency activity for more than 50% of the epoch.[N1,N2,N3] RECOMMENDED

3. In individuals who do not generate alpha rhythm, score stage N1 commencing with the earliest of ANY of the following phenomena:[N1,N2,N3,N4,N5] RECOMMENDED

a. EEG activity in range of 4–7 Hz with slowing of background frequencies by ≥1 Hz from those of stage W
b. Vertex sharp waves
c. Slow eye movements

4. An epoch is scored as stage N1 if the *majority* of the epoch meets the criteria for stage N1 (EEG showing LAMF EEG activity) in the absence of evidence for another sleep stage. Subsequent epochs with an EEG showing LAMF EEG activity are scored as stage N1 until there is evidence for another sleep stage (usually stage W, stage N2 or stage R). (see Figure 7) RECOMMENDED

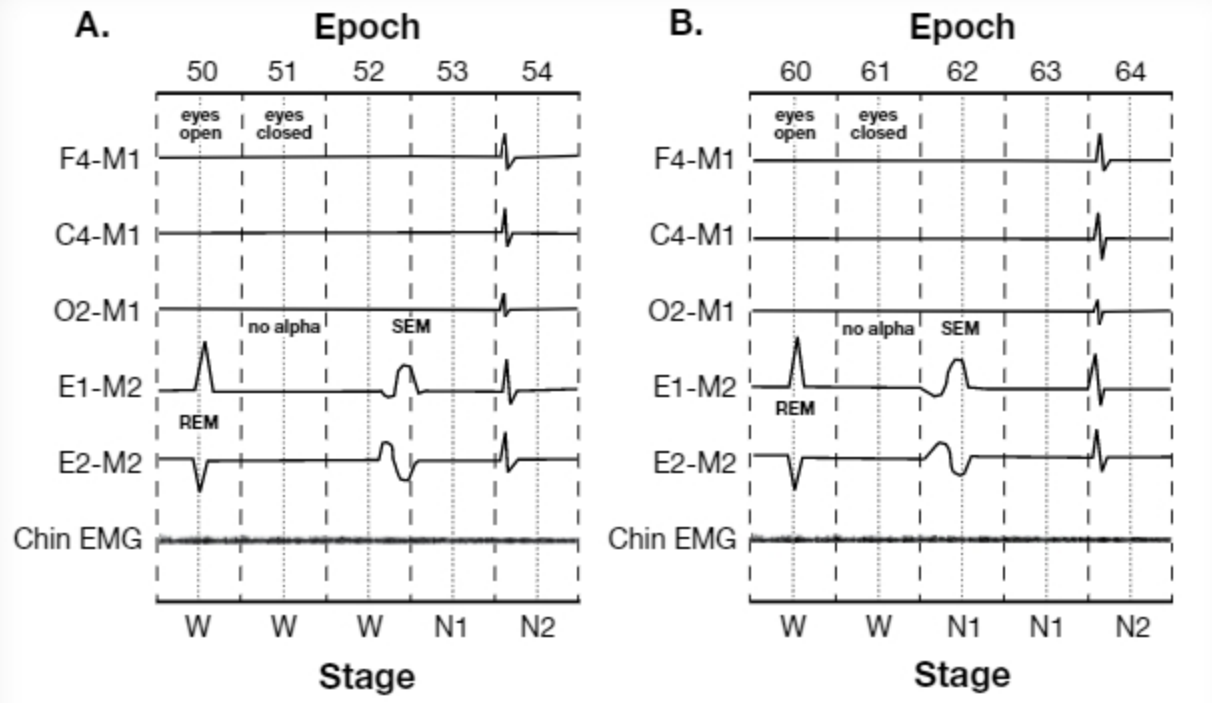


Figure 7. Transition from stage W to stage N1 in a patient who does not generate alpha rhythm (posterior dominant rhythm) with eye closure. It is assumed the EEG in epochs 52 and 62 do not meet criteria F.3.a. (that is, stage N1 cannot be scored based on the EEG criteria).
A. Epoch 52 continues to be scored as stage W since the slow eye movement occurs in the latter part of the epoch. Stage N1 is considered to start with the occurrence of the slow eye movement. Therefore, epoch 53 is scored as stage N1.
B. Epoch 62 is scored as stage N1 since the slow eye movement occurs in the first half of this epoch. Epoch 63 continues as stage N1 until there is evidence of stage N2 with the appearance of a K complex in the first half of epoch 64.

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5. **When an arousal interrupts stage N2 sleep, score subsequent segments of the recording as stage N1 if the EEG exhibits low-amplitude, mixed-frequency activity without one or more K complexes and/or sleep spindles until there is evidence for another stage of sleep (see G. Scoring Stage N2).** RECOMMENDED

6. **When an arousal interrupts stage R sleep and is followed by a low-amplitude, mixed-frequency EEG without posterior dominant rhythm AND with slow eye movements, score the portion of the record containing the eye movements as stage N1 even if the chin EMG activity remains low (at the stage R level). Continue to score stage N1 until there is evidence for another sleep stage (see G.2 for scoring stage N2 and I.3 for scoring stage R).** RECOMMENDED

Note 1. Vertex sharp waves may be present but are not required for scoring stage N1.

Note 2. The EOG will often show slow eye movements in stage N1, but these are not required for scoring.

Note 3. During stage N1, the chin EMG amplitude is variable, but often lower than in stage W.

Note 4. As slow eye movements often commence before attenuation of alpha rhythm, sleep latency may be slightly shorter for some individuals who do not generate alpha rhythm compared to those who do.

Note 5. Theta frequency (4–7.99 Hz) waveforms that are of pathological origin (such as those resulting from neurological impairment, encephalopathy or epilepsy) should not be considered toward the determination of stage N1 sleep. In a person with a slow background EEG in the awake state, further non-pathological slowing of the background activity of >1 Hz from that seen in the wake state would be considered evidence of stage N1 sleep.

G. Scoring Stage N2

1. **Score in accordance with the following definitions:** RECOMMENDED

K complex: A well-delineated, negative, sharp wave immediately followed by a positive component standing out from the background EEG, with total duration ≥0.5 seconds, usually maximal in amplitude when recorded using frontal derivations. For an arousal to be associated with a K complex, the arousal must either be concurrent with the K complex or commence no more than 1 second after termination of the K complex. (see V. Arousal Rule)

Sleep spindle: A train of distinct sinusoidal waves with frequency 11–16 Hz (most commonly 12–14 Hz) with a duration ≥0.5 seconds, usually maximal in amplitude in the central derivations.

2. **Begin scoring stage N2 (in absence of criteria for N3) if EITHER OR BOTH of the following occur during the first half of that epoch or the last half of the previous epoch:** [N1,N2,N3] RECOMMENDED
   a. One or more K complexes unassociated with arousals
   b. One or more sleep spindles

3. **Score a given epoch as stage N2 if the majority of the epoch meets criteria for stage N2. If the waveforms in rule G.2.a or G.2.b are followed by an arousal in the same or subsequent epoch** (see Figure 8)**, the segment of the recording preceding the arousal is considered stage N2 (see rule G.6.b).** [N1,N4] RECOMMENDED

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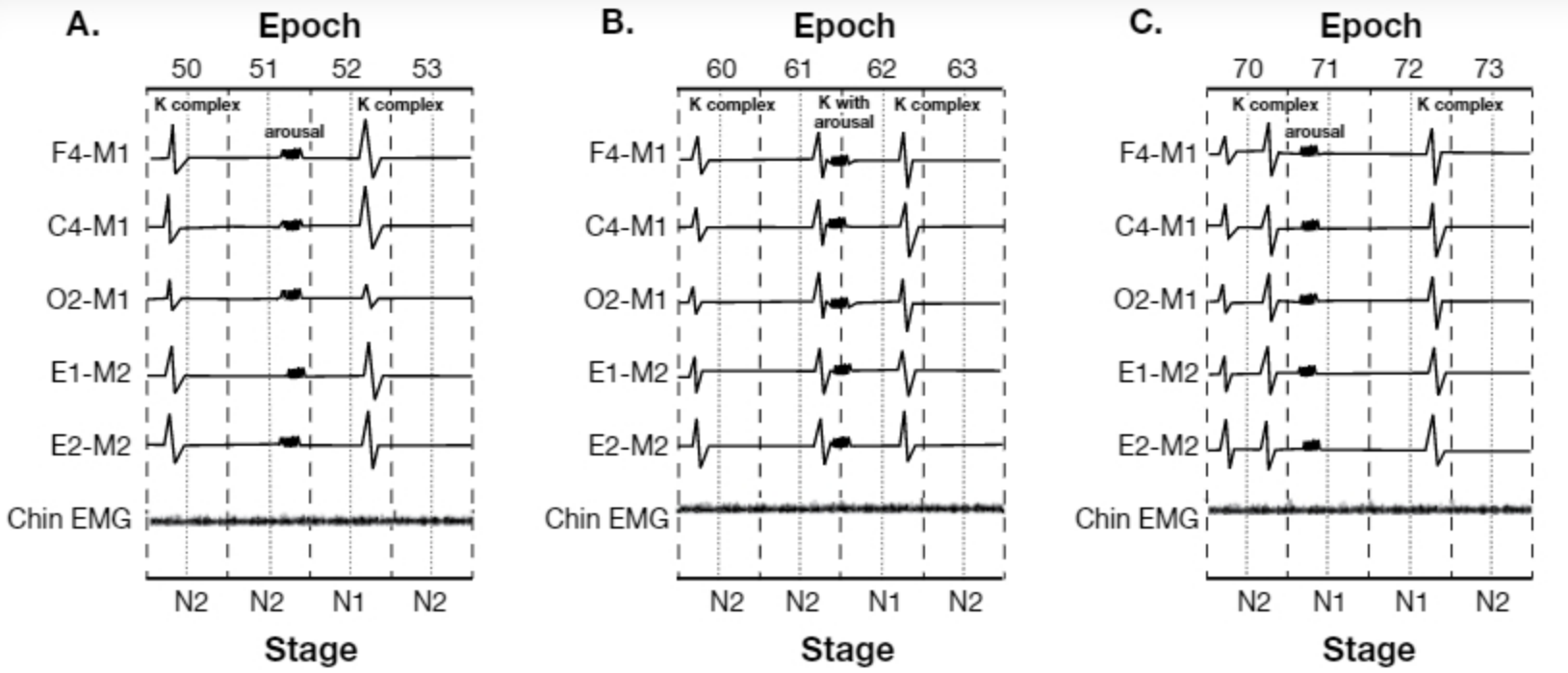


Figure 8. Start and continuation of stage N2. The EEG is assumed to show LAMF unless otherwise depicted.
A. Start of N2. Epoch 50 is scored as stage N2 as there is a K complex (unassociated with an arousal) in the first half of the epoch (rule G.2). Epoch 51 is stage N2 as this stage continues for the majority of the epoch (rule G.3). Following an arousal, epoch 52 is scored as stage N1 (rule G.6.b) until there is evidence for another stage of sleep. A K complex is noted in the last half of epoch 52 and epoch 53 is scored as stage N2 (rule G.2).
B. At the end of epoch 61, there is a K complex associated with an arousal. Epoch 62 is scored as stage N1 (rule G.6.b). A K complex associated with an arousal is not considered evidence for stage N2. Epoch 63 is scored as stage N2 by rule G.2.
C. A K complex occurs in the last half of epoch 70 but stage N2 is considered to be present only up to the arousal in epoch 71. Epoch 71 is scored as stage N1 as the majority of the epoch follows the arousal. Epoch 72 is scored as stage N1 as the K complex does not occur until the second half of the epoch.

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4. Continue to score epochs with low-amplitude, mixed-frequency EEG activity without K complexes or sleep spindles as stage N2 if they are preceded by epochs containing EITHER of the following and there is no intervening arousal: RECOMMENDED

a. K complexes unassociated with arousals
b. Sleep spindles

5. Epochs following an epoch of stage N3 that do not meet criteria for stage N3 are scored as stage N2 if there is no intervening arousal and the epoch does not meet criteria for stage W or stage R. (see Figure 9) RECOMMENDED

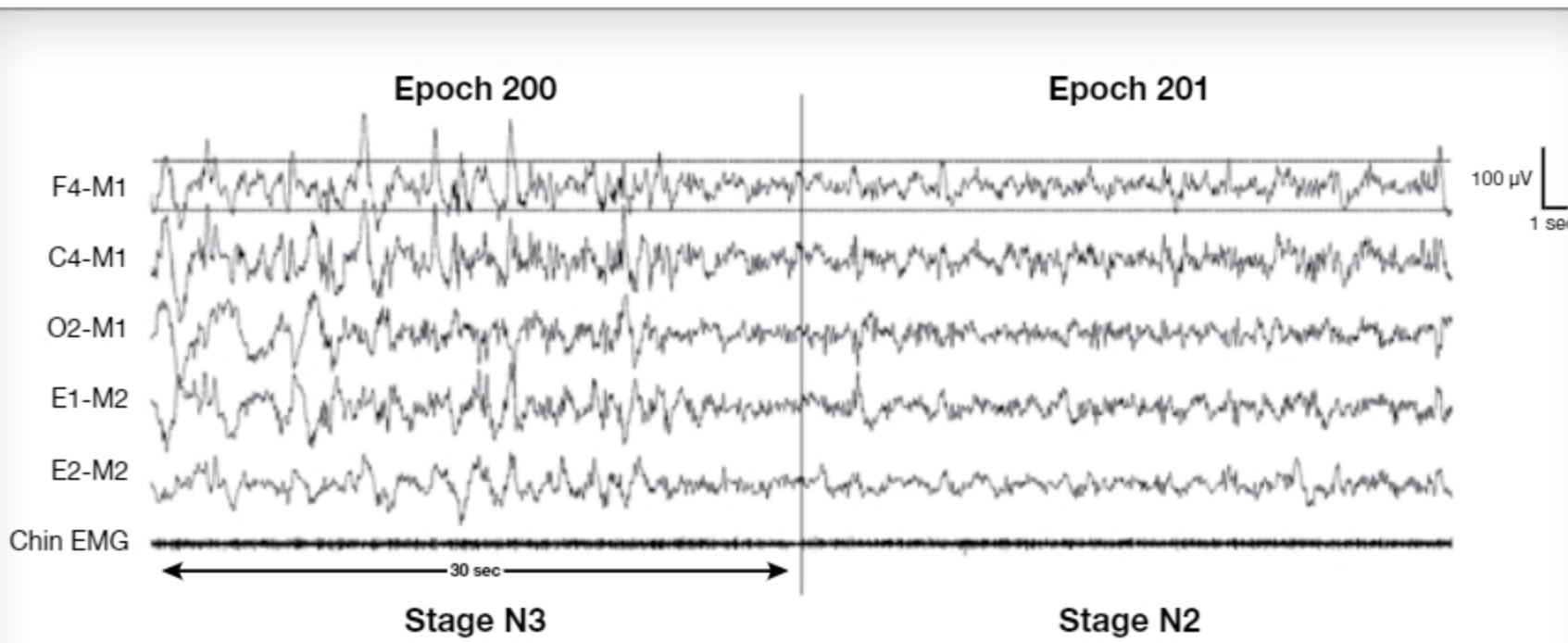


Figure 9. Transition from stage N3 to stage N2. The vertical distance between the lines in F4-M1 is 75 µV. Epoch 201 does not have sufficient slow wave activity to meet criteria for stage N3. There is no intervening arousal. Epoch 201 is scored as stage N2.

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6. End scoring stage N2 sleep when ONE of the following events occurs: [N5,N6] **RECOMMENDED**

a. Transition to stage W
b. An arousal followed by low-amplitude, mixed-frequency EEG (change to stage N1 until a K complex unassociated with an arousal or a sleep spindle occurs) (see Figure 8). This assumes that the epoch does not meet criteria for stage R (rule I.3) (see Figure 12C).
c. A major body movement followed by slow eye movements and low-amplitude, mixed-frequency EEG without non-arousal associated K complexes or sleep spindles (score the epoch following the major body movement as stage N1; score the epoch as stage N2 if there are no slow eye movements; the epoch containing the body movement is scored using the major body movement rules under section J) (see Figure 10)
d. Transition to stage N3
e. Transition to stage R

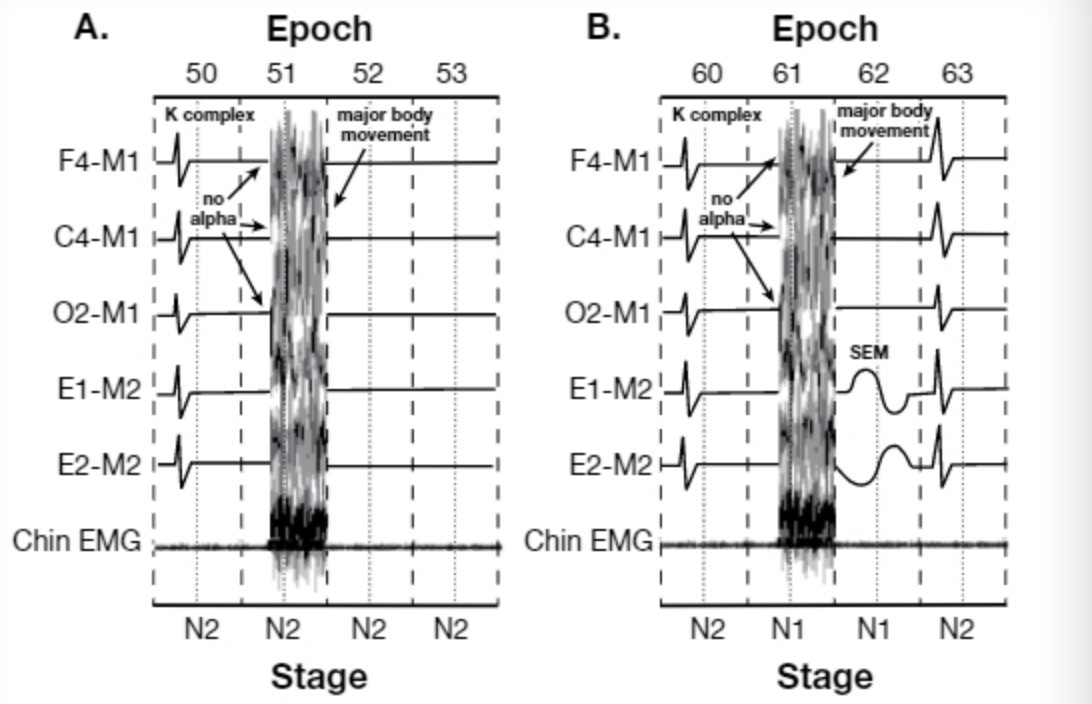


Figure 10. End of stage N2 due to a major body movement. The EEG is assumed to contain low-amplitude, mixed-frequency activity unless otherwise depicted. **A.** Epoch 52 continues to be scored as stage N2 as the major body movement is NOT followed by slow eye movements. Epoch 51 is scored according to the major body movement rules (section J). As epoch 51 does not contain alpha activity and an epoch of stage W does not precede or follow the epoch, the major body movement is scored the same as the epoch that follows it (stage N2; rule J.4). **B.** Epoch 62 is scored as stage N1 (stage N2 ends following the major body movement) as the body movement is followed by slow eye movements and low-amplitude, mixed-frequency EEG (rule G.6.c). Epoch 63 is scored as stage N2 as a K complex unassociated with an arousal occurs in the first half of the epoch.

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Note 1. An epoch of stage N2 meeting criteria in rule G.2 is termed **definite stage N2**. If there is a conflict between a stage N2 and stage R scoring rule, the stage R rule takes precedence (see I.4).

Note 2. Continue to score stage N1 for epochs with arousal-associated K complexes unless they contain sleep spindles or K complexes not associated with arousals.

Note 3. For the purposes of scoring N2 sleep, arousals are defined according to the arousal rule in chapter V. (V.A.1).

Note 4. For scoring epochs with a mixture of K complexes and/or sleep spindles and REMs, see rule I.7.

Note 5. The EOG usually shows no eye movement activity during stage N2 sleep, but slow eye movements may persist in some individuals.

Note 6. In stage N2, the chin EMG is of variable amplitude, but is usually lower than in stage W, and may be as low as in stage R sleep.

H. Scoring Stage N3[N1]

1. Score in accordance with the following definition:[N2,N3] RECOMMENDED

Slow wave activity: Waves of frequency 0.5 Hz–2 Hz and peak-to-peak amplitude >75 μV, measured over the frontal regions referenced to the contralateral ear or mastoid (F4-M1, F3-M2).

2. Score stage N3 when ≥20% of an epoch consists of slow wave activity, irrespective of age.[N4,N5,N6] RECOMMENDED

Note 1. Stage N3 represents slow wave sleep and replaces the Rechtschatten and Kales nomenclature of stage 3 and stage 4 sleep.

Note 2. K complexes would be considered slow waves if they meet the definition of slow wave activity.

Note 3. Pathological wave forms that meet the slow wave activity criteria, such as those generated by metabolic encephalopathies, epileptic, or epileptiform activity, are not counted as slow wave activity of sleep. Similarly, waveforms produced by artifact or those of non-cerebral origin should not be included in the scoring of slow waves.

Note 4. Sleep spindles may persist in stage N3 sleep.

Note 5. Eye movements are not typically seen during stage N3 sleep.

Note 6. In stage N3, the chin EMG is of variable amplitude, often lower than in stage N2 sleep and sometimes as low as in stage R sleep.

I. Scoring Stage R

1. Score in accordance with the following definitions: RECOMMENDED

Rapid eye movements (REMs): Eye movements recorded in the EOG derivations consisting of conjugate, irregular, sharply peaked eye movements with an initial deflection usually lasting <500 msec. While rapid eye movements are characteristic of stage R sleep, they may also be seen in wakefulness with eyes open when individuals visually scan the environment.

Low chin EMG tone: Baseline EMG activity in the chin derivation no higher than in any other sleep stage and usually at the lowest level of the entire recording.

Sawtooth waves: An EEG pattern consisting of trains of sharply contoured or triangular, often serrated, 2–6 Hz waves maximal in amplitude over the central head regions and often, but not always, preceding a burst of rapid eye movements.

Transient muscle activity: Short irregular bursts of EMG activity usually with duration <0.25 seconds superimposed on low EMG tone. The activity may be seen in the chin or anterior tibial EMG derivations, as well as in EEG or EOG deviations, the latter indicating activity of cranial nerve innervated muscles (facial and scalp muscles). The activity is often maximal when associated with rapid eye movements.

2. Score stage R sleep in epochs with ALL of the following phenomena (definite stage R):[N1,N2,N3,N4,N5,N6] RECOMMENDED

a. Low-amplitude, mixed-frequency (LAMF) EEG activity without K complexes or sleep spindles
b. Low chin EMG tone for the majority of the epoch and concurrent with REMs
c. REMs at any position within the epoch

3. Score segments of sleep preceding and contiguous with an epoch of definite stage R (as defined in I.2), in the *absence of rapid eye movements*, as stage R if ALL of the following are present: (see Figures 11, 12 and 13) RECOMMENDED

a. The EEG shows low-amplitude, mixed-frequency activity without K complexes or sleep spindles[N4]
b. The chin EMG tone is low (at the stage R level)
c. There is no intervening arousal (see Figure 12C)
d. Slow eye movements following an arousal or stage W are absent[N5]

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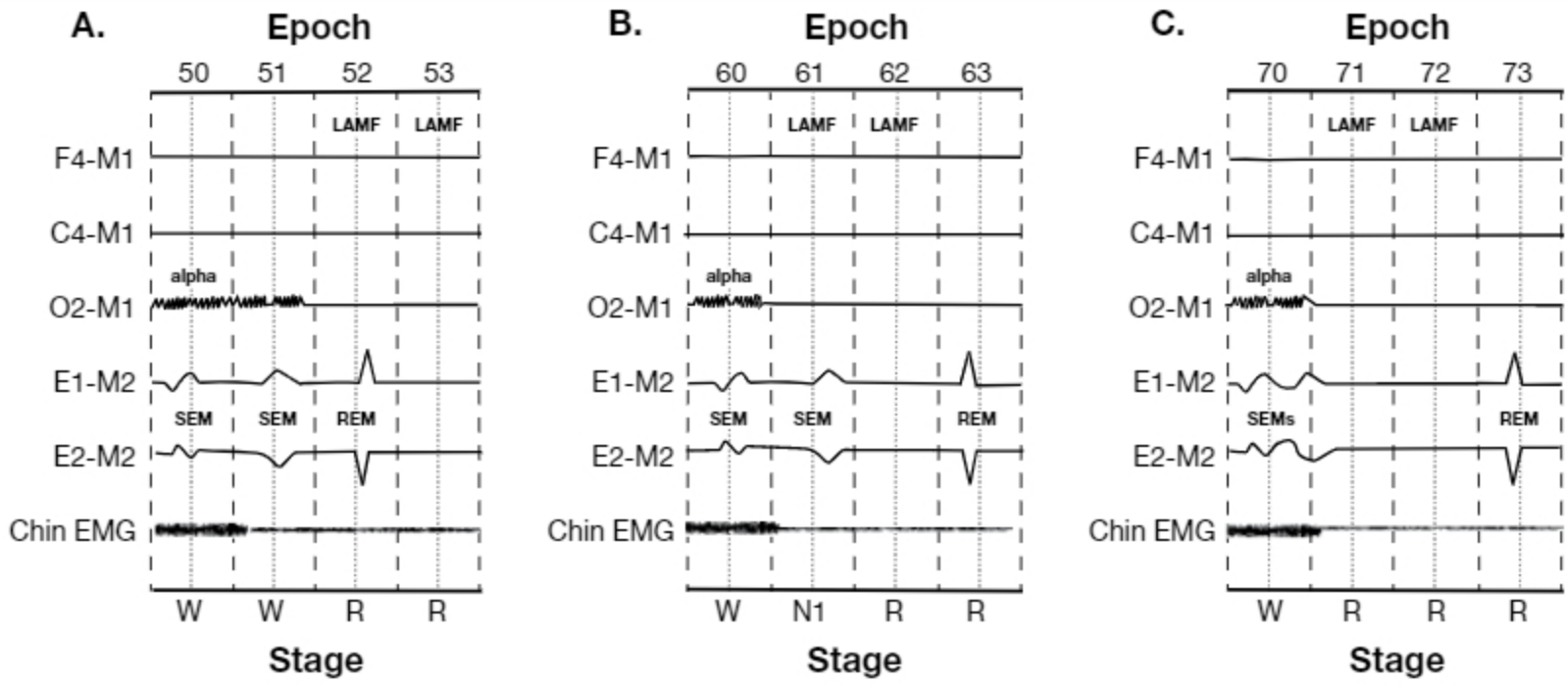


Figure 11. Start of stage R.
A. Epoch 52 is an epoch of definite stage R. Epoch 53 is scored as stage R by rule I.5 (REM continuation rule).
B. Epoch 61 is scored as stage N1 as alpha is replaced by low-amplitude, mixed-frequency (LAMF) EEG activity. A SEM is present in the second half of the epoch. While not required for scoring stage N1, the presence of the SEM prevents the epoch from being scored as stage R (rule I.3.d). Epoch 62 is scored as stage R by rule I.3.
C. Epoch 71 is scored as stage R as the majority of the epoch meets the criteria of rule I.3.

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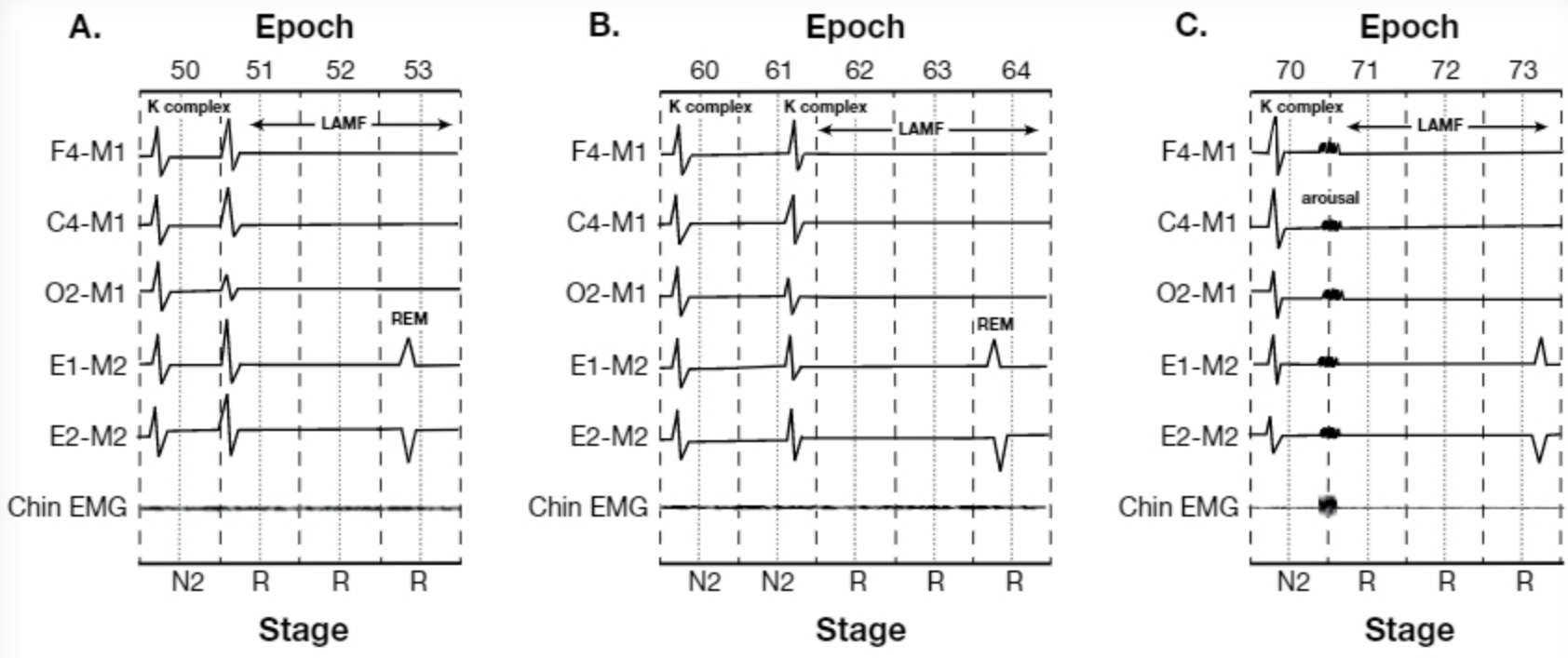


Figure 12. Start of stage R.
A. Transition from definite stage N2 (epoch 50) to definite stage R (epoch 53). The EEG of the majority of epoch 51 and all of epoch 52 has low-amplitude, mixed-frequency (LAMF) EEG without sleep spindles or K complexes and chin EMG is at the stage R level. As the epochs 51 and 52 are contiguous with definite stage R (Epoch 53), they are scored as stage R.
B. Epoch 60 is an epoch of definite stage N2. Epoch 61 is scored as stage N2 by the stage N2 continuation rule. Epochs 62 and 63 are scored as stage R as the EEG has LAMF activity without K complexes or sleep spindles, the chin EMG is at the stage R level, and the epochs are contiguous with an epoch of definite stage R (epoch 64). Note that, using rule G.2, epoch 62 would be scored as stage N2. However, the stage R rule (I.3) takes precedence.
C. Using rule G.6.b, epoch 71 would be scored as stage N1 (arousal ends stage N2). However, REM rule I.3 takes precedence and epochs 72 and 73 are scored as stage R.

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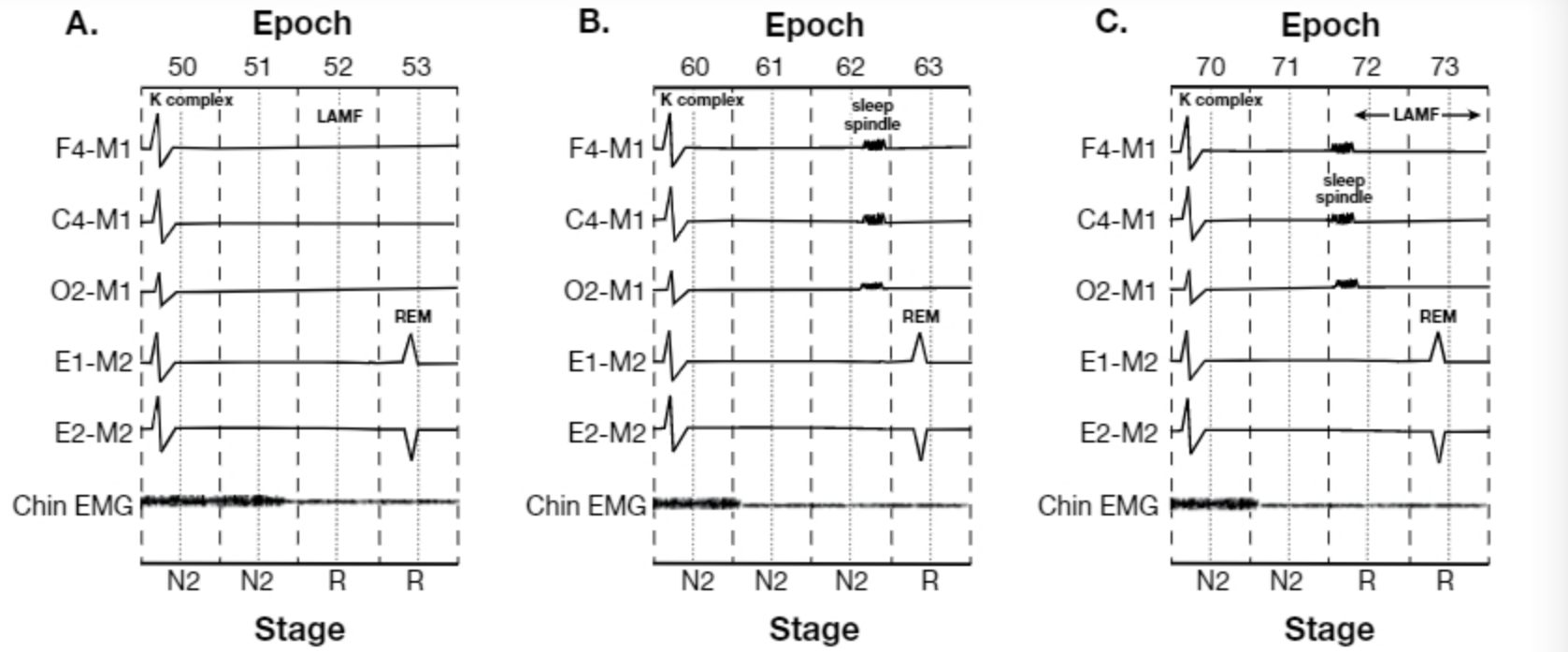


Figure 13. Scoring stage R.
A. A transition between definite stage N2 (epoch 50) and definite stage R (epoch 53). Epoch 52 is scored as stage R as the EEG shows low-amplitude, mixed-frequency (LAMF) without K complexes or sleep spindles and the chin EMG falls to the stage R level at the end of epoch 51.
B. A transition between definite stage N2 (epoch 60) and definite stage R (epoch 63). Stage N2 is considered to continue until the last K complex or sleep spindle.
C. Epoch 72 is scored as stage R as the majority of epoch 72 (following the sleep spindle in the first half of the epoch) has an EEG with LAMF activity without K complexes or sleep spindles, the chin EMG is at the stage R level, and this portion of the record is contiguous with definite stage R (epoch 73). Note that, by rule G.2, epoch 72 would be scored as stage N2. However, rule I.3 takes precedence over rule G.2. As the majority of epoch 72 meets rule I.3 criteria, the epoch is scored as stage R.

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4. **If the *majority* of an epoch contains a segment of the recording meeting criteria for stage R (I.2, I.3, I.5), the epoch is scored as stage R. Stage R rules take precedence over stage N2 rules.** (see Figure 12, epoch 62 and Figure 13, epoch 72) **RECOMMENDED**

5. **Continue to score segments of sleep that follow one or more epochs of definite stage R (as defined in I.2), in the absence of rapid eye movements, as stage R if ALL of the following are present:** (see Figures 14–18) **RECOMMENDED**
   a. The EEG shows LAMF EEG activity without K complexes or sleep spindles
   b. The chin EMG tone is low (at the stage R level) for the majority of the epoch
   c. There is no intervening arousal

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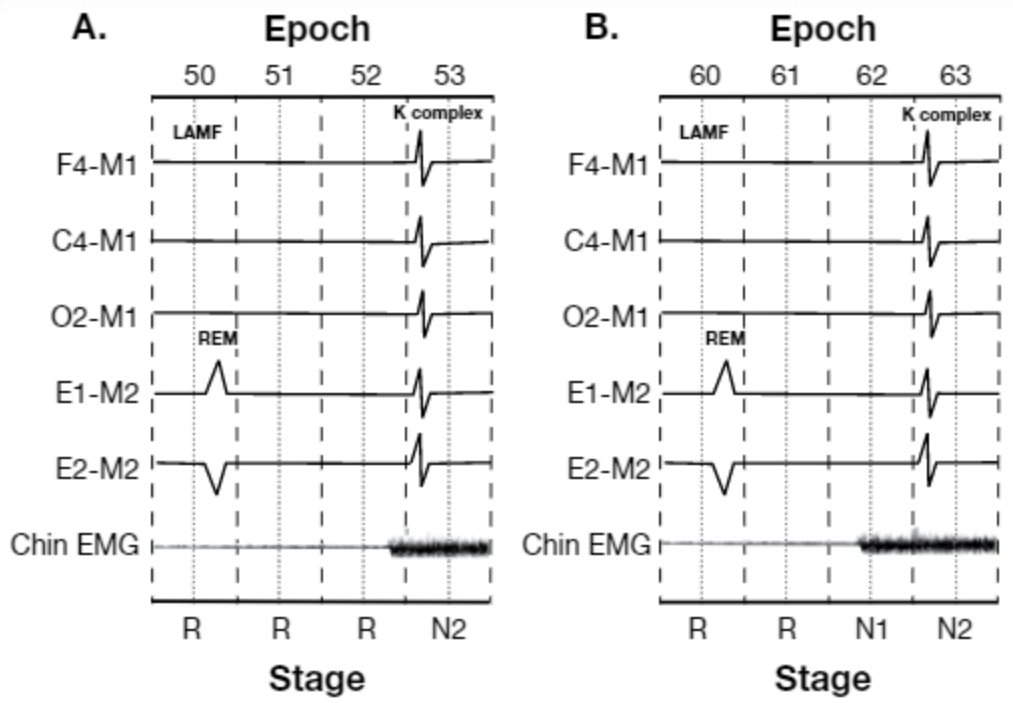


Figure 14. Continuation and end of stage R. The EEG is assumed to contain low-amplitude, mixed-frequency activity unless otherwise depicted.
A. Epoch 50 is definite stage R (rule I.2). Epochs 51 and 52 continue to be scored as stage R as the chin EMG remains low and the EEG does not contain K complexes or sleep spindles. Epoch 52 is scored as stage R as the chin EMG tone does not increase until the last half of the epoch. Epoch 53 is scored as stage N2 given that the K complex is unassociated with an arousal in the first half of the epoch.
B. Epoch 60 is definite stage R and Epoch 61 continues to be scored as stage R as the chin tone remains low and the EEG contains low-amplitude, mixed-frequency activity. Epoch 62 is not scored as stage R as the chin tone is not low for the majority of the epoch. Epoch 62 is scored as stage N1 given the low-amplitude mixed-frequency EEG pattern and the absence of K complexes or sleep spindles in the first half of the epoch.

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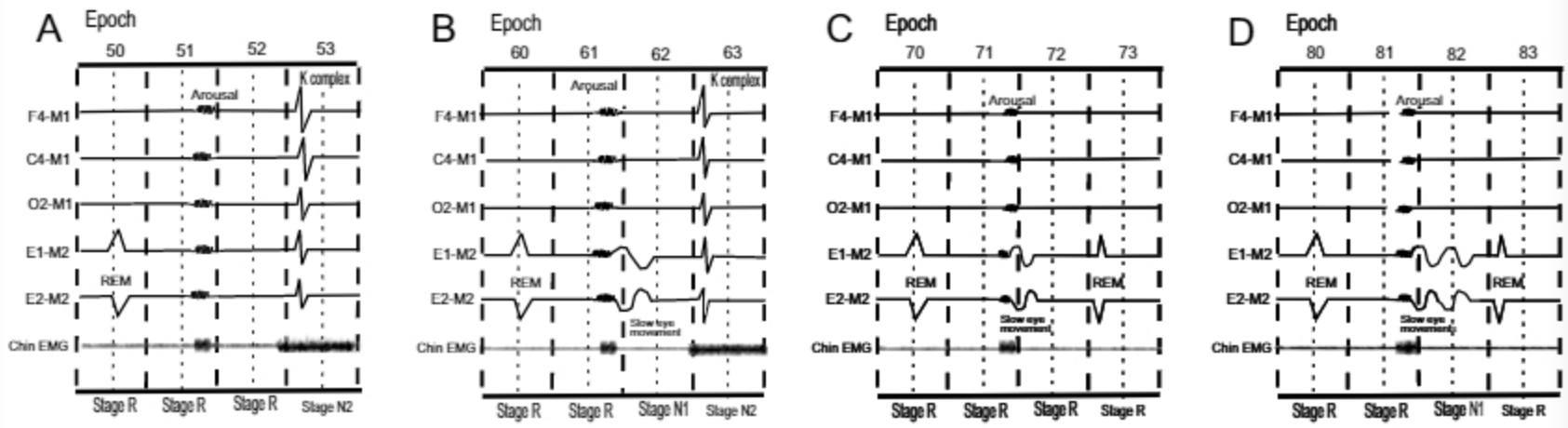


Figure 15. End of Stage R when an arousal is followed by slow eye movements. The EEG is assumed to contain low-amplitude, mixed-frequency activity unless otherwise depicted.
A. Stage R is interrupted by an arousal followed by low-amplitude, mixed-frequency EEG **without slow eye movements.** Epoch 52 continues to be scored as stage R as the EEG shows a low-amplitude, mixed-frequency pattern, and the majority of the epoch contains low chin EMG tone (at the stage R level). Compare the effects of an arousal interrupting stage R with one interrupting N2 (Figure 8).
B. Stage R is interrupted by an arousal **followed by slow eye movements** and low amplitude, mixed-frequency. Because slow eye movements are present following the arousal, Epoch 62 is scored as stage N1 even though chin activity is at the stage R level. Stage N1 continues until there is evidence for another sleep stage (here stage N2 in epoch 63).
C. Stage R is interrupted by an arousal **followed by slow eye movements** and low amplitude, mixed-frequency EEG. However, the majority of epoch 72 does not contain slow eye movements and is scored as stage R based on rule I.3 as epoch 73 is definite stage R.
D. Stage R is interrupted by an arousal **followed by slow eye movements** and low amplitude, mixed-frequency EEG with chin activity at the stage R level. Epoch 82 is scored as stage N1 even if the chin activity is at the stage R level as the majority of the epoch contains slow eye movements. Stage N1 continues until there is evidence of another sleep stage (here definite stage R in epoch 83).

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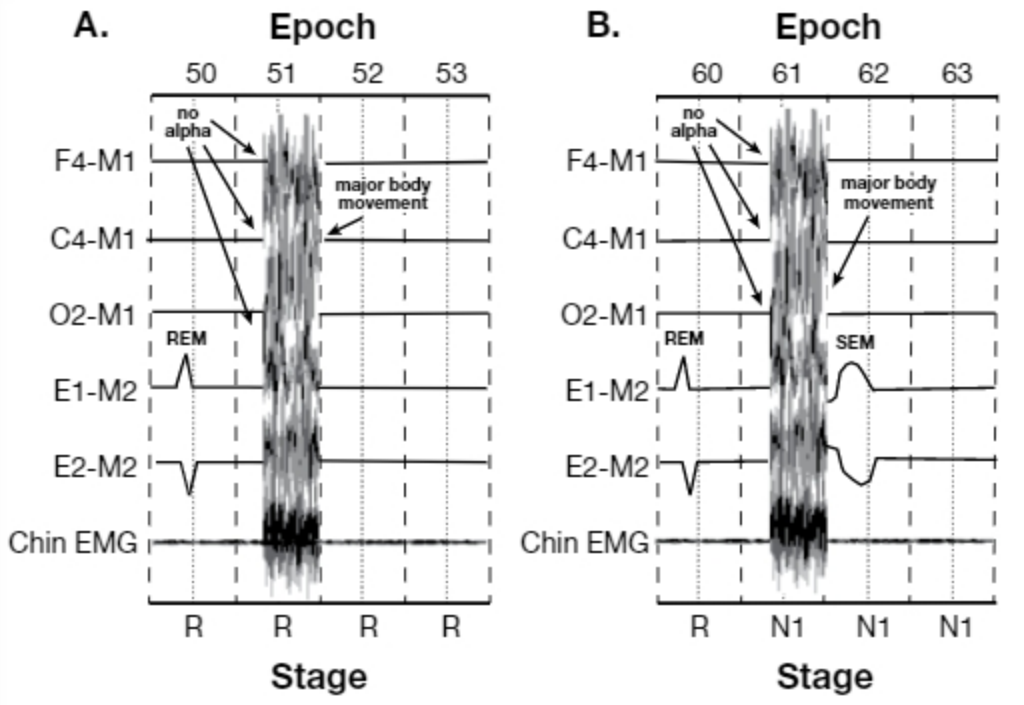


Figure 16. End of stage R due to a major body movement. The EEG is assumed to contain low-amplitude mixed-frequency activity unless otherwise depicted.
A. Epoch 52 continues as stage R as the EEG contains low-amplitude mixed-frequency activity, the chin EMG tone is low, and slow eye movements do NOT follow the major body movement. Note that if Epoch 51 was scored as stage W based on the appearance of alpha activity, stage R would end (movement rules in J).
B. Epoch 62 is not scored as stage R even if the EEG exhibits low-amplitude mixed-frequency activity and the chin tone remains low because slow eye movements follow the major body movement.

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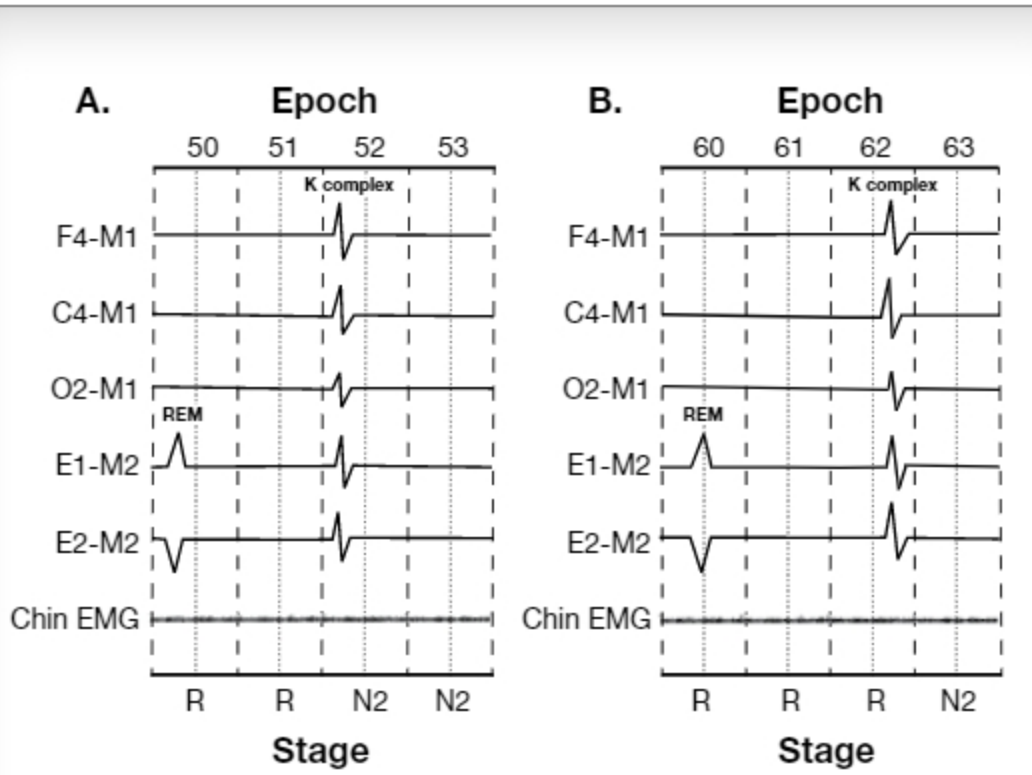


Figure 17. Transition from stage R to stage N2. The EEG is assumed to contain low-amplitude, mixed-frequency activity unless otherwise depicted.
A. Epoch 50 is definite stage R. Epoch 51 is scored as stage R by rule I.5 (continuation of stage R rule). Epoch 52 is an epoch of definite stage N2 given the K complex in the first half of the epoch.
B. Epoch 62 is scored as stage R as the K complex does not occur until the second part of the epoch.

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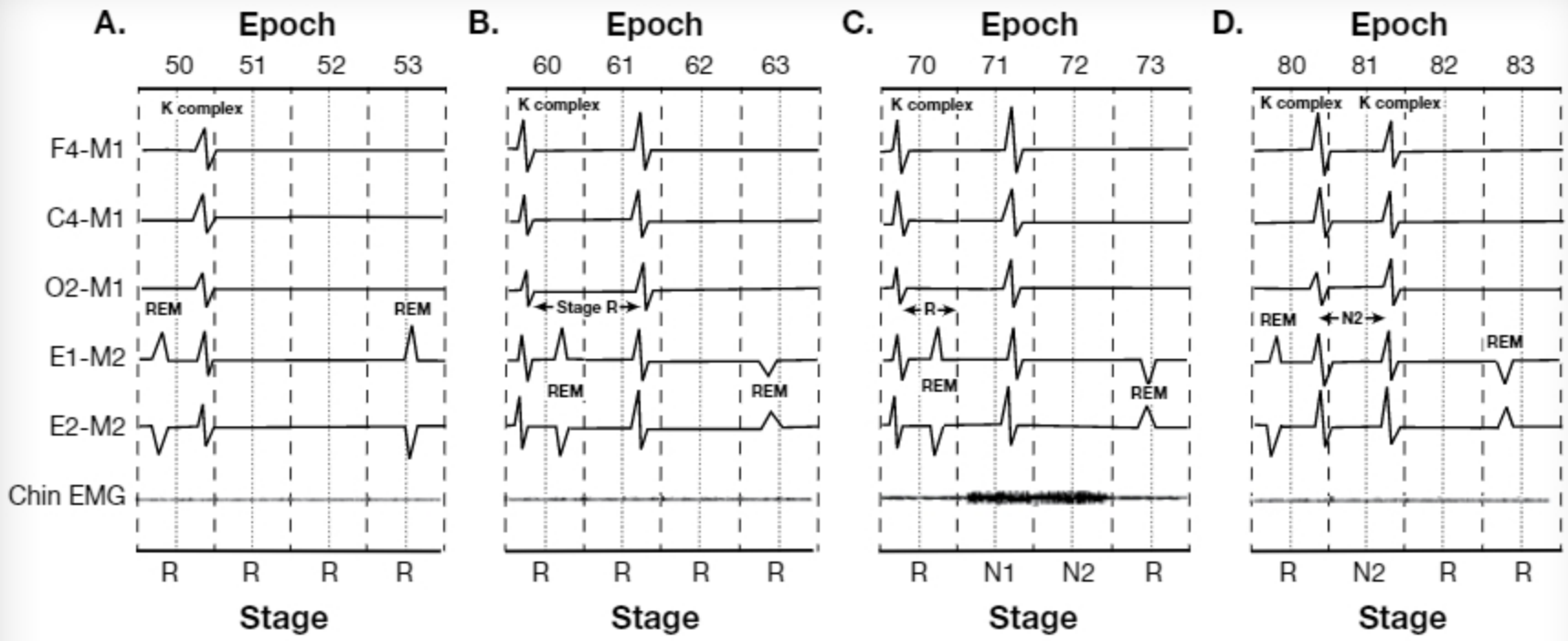


Figure 18. Mixture of REMs and K complexes.
A. Epoch 51 is scored as stage R as the majority of the epoch is considered stage R (rule I.7.b). Epochs 51 and 52 are scored as stage R by rule I.3.
B. Epochs 60 and 61 are scored as stage R as the majority of the epochs are considered stage R (rule I.7.b).
C. Epoch 71 is scored as N1 as the chin EMG is not at the stage R level for the majority of the epoch. Epoch 72 is an epoch of definite stage N2. Note that rule I.3 does not apply for epoch 72 as the chin EMG is not at the stage R level.
D. The majority of epoch 80 is considered stage R (rule I.7.b) so the epoch is scored as stage R. Most of epoch 81 is considered stage N2 (rule I.7.a) so the epoch is scored as stage N2. Epoch 82 is scored as stage R by rule I.3. Rule I.3 takes precedence over the stage N2 rule G.2. Epoch 83 is an epoch of definite stage R.

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6. End scoring stage R sleep when ONE OR MORE of the following occur: RECOMMENDED

a. There is a transition to stage W or N3
b. An increase in chin EMG tone above the level of stage R is seen for the majority of the epoch and criteria for stage N1 are met (see Figure 14, epoch 62)
c. When an arousal interrupts Stage R and is followed by a low-amplitude mixed-frequency EEG without posterior dominant rhythm **AND slow eye movements**, score the portion of the record containing the slow eye movements as Stage N1 even if the chin EMG activity remains low (at stage R level). Continue to score stage N1 until there is evidence for another stage, usually stage N2 (see G.2) or Stage R (see I.2 and I.3). If there are no slow eye movements and chin EMG tone remains low, continue to score as stage R. (see Figure 15)
d. A major body movement followed by **slow eye movements** and low-amplitude, mixed-frequency EEG without non-arousal associated K complexes or sleep spindles (Score the epoch following the major body movement as stage N1; if no **slow eye movements** are present and the EMG tone remains low, continue to score as stage R; the epoch containing the body movement is scored using the criteria under heading J) (see Figure 16)
e. One or more non-arousal associated K complexes or sleep spindles are present in the first half of the epoch in the absence of rapid eye movements, even if chin EMG tone remains low (Score the epoch as stage N2) (see Figure 17)

7. Score segments of the record with low chin EMG activity and a mixture of REMs and sleep spindles and/or K complexes as follows: N1,N2,N3,N4,N5,N6 RECOMMENDED

a. Segments between two K complexes, two sleep spindles, or a K complex and sleep spindle without intervening REMs are considered to be stage N2.
b. Segments of the record containing REMs without K complexes or sleep spindles and chin tone at the REM level are considered to be stage R.
c. If the majority of an epoch contains a segment considered to be stage N2, it is scored as stage N2. If the majority of an epoch contains a segment considered to be stage R, it is scored as stage R. (see Figure 18)

Note 1. Epochs defined by rule I.2 are called epochs of definite stage R.

Note 2. Low-amplitude, mixed-frequency activity in stage R resembles that seen in stage N1. In some individuals, a greater amount of alpha activity can be seen in stage R than in stage N1. The alpha frequency in stage R often is 1–2 Hz slower than during wakefulness.

Note 3. Sawtooth waves or transient muscle activity are strongly supportive of the presence of stage R sleep and may be helpful when the stage is in doubt, however, they are not required for scoring stage R.

Note 4. For scoring epochs with low chin EMG tone and a mixture of REMs and K complexes or sleep spindles see I.7.

Note 5. Slow eye movements can occur during stage R but slow eye movements following an arousal in combination with an EEG showing LAMF activity suggests a transition to stage N1 even if the chin tone remains low.

Note 6. Segments of the record with low chin EMG activity and a mixture of REM and sleep spindles and/or K complexes usually occur during the first REM period of the night.

J. Scoring Epochs with Major Body Movements

1. Score in accordance with the following definition: RECOMMENDED

Major body movement: Movement and muscle artifact obscuring the EEG for more than half an epoch to the extent that the sleep stage cannot be determined.

2. If alpha rhythm is present for part of the epoch (even <15 seconds duration), score as stage W. RECOMMENDED

3. If no alpha rhythm is discernible, but an epoch scoreable as stage W either precedes or follows the epoch with a major body movement, score as stage W. RECOMMENDED

4. Otherwise, score the epoch as the same stage as the epoch that follows it. RECOMMENDED

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IV. Sleep Staging Rules Part 2: Rules for Children

A. Ages for Which Pediatric Sleep Staging Rules Apply

1. Pediatric sleep staging rules can be used to score sleep and wakefulness in children 2 months post-term or older.[N1,N2] RECOMMENDED

> Note 1. For infants less than 2 months post-term, refer to IV. Sleep Staging Rules Part 3: Rules for Infants.
>
> Note 2. There is no precise upper age boundary for pediatric sleep staging rules; refer to discussion in the Pediatric Task Force review paper.[1]

Reference

1. Grigg-Damberger M, Gozal D, Marcus CL, et al. The visual scoring of sleep and arousal in infants and children. *J Clin Sleep Med*. 2007;3(2):201–240.

B. Technical Specifications

1. See IV. Sleep Staging Rules Part 1: Rules for Adults and III. Technical and Digital Specifications for technical considerations other than those in the note below.[N1] RECOMMENDED

> Note 1. Adult electrode derivations for EEG, EOG and chin EMG are acceptable for recording sleep except that the distance between the chin EMG electrodes often needs to be reduced from 2 cm to 1 cm and the distance from the eyes in EOG electrodes often need to be reduced from 1 cm to 0.5 cm in children and infants with small head size.

C. General Scoring of Sleep Stages

1. The following terminology should be used when scoring sleep in children 2 months post-term or older: RECOMMENDED

a. Stage W (Wakefulness)
b. Stage N1 (NREM 1)
c. Stage N2 (NREM 2)
d. Stage N3 (NREM 3)
e. Stage N (NREM)
f. Stage R (REM)

Not all sleep waveforms are well developed by 2 months post-term, therefore, the following possible scenarios may apply:[N1,N2,N3,N4,N5]

2. If all epochs of NREM sleep contain no recognizable sleep spindles, K complexes or high-amplitude 0.5–2 Hz slow wave activity, score all epochs as stage N (NREM). RECOMMENDED

3. If some epochs of NREM sleep contain sleep spindles or K complexes, score those as stage N2 (NREM 2). If in the remaining NREM epochs, there is no slow wave activity comprising more than 20% of the duration of epochs, score as stage N (NREM). RECOMMENDED

4. If some epochs of NREM sleep contain greater than 20% slow wave activity, score these as stage N3 (NREM 3). If in the remaining NREM epochs, there are no K complexes or spindles then score as stage N (NREM). RECOMMENDED

5. If NREM is sufficiently developed that some epochs contain sleep spindles or K complexes and other epochs contain sufficient amounts of slow wave activity, then score NREM sleep in this infant as either stage N1, N2 or N3 as in an older child or adult. RECOMMENDED

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Note 1. Sleep spindles may be seen by age 6 weeks – 3 months post-term and are present in all normal infants by age 2–3 months post-term. At this age the spindles are asynchronous between the hemispheres but become more synchronous over the first year of life.

Note 2. K complexes are usually present by age 3–6 months post-term.

Note 3. EEG activity of 0.5–2 Hz with a typical amplitude of 100–400 μV in the frontal regions may first appear by 2 months of age and is usually present by age 4–5 months post-term. The criteria for slow wave activity are the same as for adults (amplitude >75 μV of 0.5–2 Hz).

Note 4. NREM sleep can be scored as stage N1, N2 or N3 in most infants by age 5–6 months post-term and occasionally in infants as young as 4 months post-term.

Note 5. In infants younger than 6 months post-term, non-EEG parameters are helpful in distinguishing NREM sleep from REM sleep. In REM sleep these parameters include the presence of irregular respiration, loss of chin muscle tone, transient muscle activity (muscle twitches), and rapid eye movements. In NREM sleep, they consist of regular respiration, absence of eye movements, and preserved chin muscle tone.

D. Scoring Stage W

1. Score in accordance with the following definitions: [N1,N2,N3] RECOMMENDED

Eye blinks: Conjugate vertical eye movements at a frequency of 0.5–2 Hz present in wakefulness with eyes open or closed.

Reading eye movements: Trains of conjugate eye movements consisting of a slow phase followed by a rapid phase in the opposite direction as the child reads or visually scans the environment.

Rapid eye movements (REMs): Eye movements recorded in the EOG derivations consisting of conjugate, irregular, sharply peaked eye movements with an initial deflection usually lasting <500 msec. While rapid eye movements are characteristic of stage R sleep, they may also be seen in wakefulness with eyes open when individuals visually scan the environment.

Posterior dominant rhythm (PDR): The dominant reactive EEG rhythm over the occipital regions in relaxed wakefulness with eyes closed which is slower in infants and young children and attenuates with eye opening or attention. Frequency is 3.5–4.5 Hz when first seen in infants 3–4 months post-term, 5–6 Hz by 5–6 months, and 7.5–9.5 Hz by 3 years of age and amplitude is usually >50 μV. In older children and adults, posterior dominant rhythm is often referred to as alpha rhythm.[N1,N2] (see Table 1)

Table 1. Initial age of waveform appearance.

Waveform	Age of Initial Appearance
Sleep spindles	6 weeks – 3 months post-term
K complexes	3–6 months post-term
Slow wave activity	2–5 months post-term
Posterior dominant rhythm	
Frequency of 3.5–4.5 Hz	3–4 months post-term
Frequency of 5–6 Hz	5–6 months post-term
Frequency of 7.5–9.5 Hz	3 years
Mean frequency of 9 Hz	9 years
Mean frequency of 10 Hz	15 years
Vertex sharp waves	4–6 months post-term
Hypnagogic hypersynchrony (HH)	3–6 months post-term

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2. Score epochs as stage W when more than 50% of the epoch contains EITHER or BOTH: RECOMMENDED

a. Age-appropriate posterior dominant rhythm over the occipital region (individuals generating alpha rhythm with eye closure)

b. Other findings consistent with stage W (all individuals)

i. Eye blinks (0.5–2 Hz)

ii. Rapid eye movements associated with normal or high chin muscle tone

iii. Reading eye movements

Note 1. The PDR in infants and children typically contains intermixed slower EEG rhythms including:

a. Posterior slow waves of youth (PSW) which are intermittent runs of bilateral but often asymmetric 2.5–4.5 Hz slow waves superimposed, riding upon, or fused with the PDR, are usually <120% of PDR voltage, block with eye opening and disappear with drowsiness and sleep. PSW are uncommon in children <2 years of age, have a maximal incidence between ages 8–14 years, and are uncommon after age 21 years.

b. Random or semi-rhythmic occipital slowing: <100 μV, 2.5–4.5 Hz rhythmic or arrhythmic activity lasting <3 seconds; a normal finding in EEGs of children ages 1–15 years, especially prominent in ages 5–7 years; the amount of intermixed slowing decreases and its frequency increases with increasing age.

Note 2. Spontaneous eye closure in infants signals drowsiness.

Note 3. The highest amplitude and sharpest component of reading eye movements in children is usually surface-negative in the occipital derivations, typically lasting 150–250 msec, and having amplitudes up to 65 μV.

E. Scoring Stage N1

1. Score in accordance with the following definitions: RECOMMENDED

Slow eye movements (SEM): Conjugate, reasonably regular, sinusoidal eye movements with an initial deflection that usually lasts >500 msec. Slow eye movements may be seen during eyes closed wake and stage N1.

Low-amplitude, mixed-frequency (LAMF) activity: Low amplitude, predominantly 4–7 Hz activity.

Vertex sharp waves (V waves): Sharply contoured waves with duration <0.5 seconds (as measured at the base of the wave), maximal over the central region and distinguishable from the background activity. They are most often seen during transition to stage N1 sleep but can occur in either stage N1 or N2 sleep. These waveforms typically first appear at 4–6 months post-term.

Sleep onset: The start of the first epoch scored as any stage other than stage W. (In most subjects this will usually be the first epoch of stage N1.)

Hypnagogic hypersynchrony (HH): Paroxysmal bursts or runs of diffuse, high-amplitude, sinusoidal, 75–350 μV, 3–4.5 Hz waves which begin abruptly, are usually widely distributed but often are maximal over the central, frontal, or frontocentral scalp regions. These waveforms can occur in stage N1 and N2.

2. In individuals who generate a posterior dominant rhythm (PDR), score stage N1 if the PDR is attenuated or replaced by low-amplitude, mixed-frequency activity for more than 50% of the epoch.[N1,N2,N3,N4] RECOMMENDED

3. In individuals who do not generate a posterior dominant rhythm, score stage N1 commencing with the earliest of ANY of the following phenomena:[N5] RECOMMENDED

a. Activity in the range of 4–7 Hz with slowing of background frequencies by ≥1–2 Hz from those of stage W

b. Slow eye movements

c. Vertex sharp waves

d. Hypnagogic hypersynchrony

e. Diffuse or occipital-predominant, high-amplitude, rhythmic 3–5 Hz activity

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Note 1. In most individuals sleep onset will be the first epoch of stage N1, but in infants younger than 2 months post-term, this is often stage R.

Note 2. Drowsiness in infants up to 6–8 months of age is characterized by the gradual appearance of diffuse, high-amplitude (often 75–200 μV) 3–5 Hz activity which is typically of higher amplitude, more diffuse, and 1–2 Hz slower than the waking EEG background activity.

Note 3. Drowsiness in children 8 months to 3 years is characterized by either diffuse runs or bursts of rhythmic or semi-rhythmic bisynchronous 75–200 μV, 3–4 Hz activity often maximal over the occipital regions and/or higher amplitude (>200 μV) 4–6 Hz theta activity maximal over the frontocentral or central regions.

Note 4. Sleep onset from 3 years on is often characterized by a 1–2 Hz slowing of the PDR frequency and/or the PDR often becomes diffusely distributed then is gradually replaced by relatively low-voltage, mixed-frequency EEG activity.

Note 5. Hypnagogic hypersynchrony is a distinctive EEG pattern of drowsiness and stage N1 that often disappears with deeper stages of NREM sleep. HH is seen in approximately 30% of infants at 3 months post-term, 95% of all normal children ages 6–8 months, and is less prevalent after age 4–5 years; it is seen in only 10% of healthy children by age 11 and is rarely seen after age 12 years.

F. Scoring Stage N2

1. Same as the adult rules found under the adult sleep staging rules heading G. [N1,N2,N3] RECOMMENDED

Note 1. Sleep spindles are usually are first seen in infants 4–6 weeks post-term as brief bursts of low-amplitude, less-sinusoidal 12–14 Hz activity maximal over the vertex region, are usually well-developed and are present in all normal infants 8–9 weeks.

Note 2. Eighty percent of children <13 years of age have two independent scalp locations and frequency ranges for sleep spindles: 10.0–12.75 Hz over the frontal and 12.5–14.75 Hz maximal over the central or centroparietal region.

Note 3. K complexes are usually present 5–6 months post-term and are maximal over the pre-frontal and frontal regions, as they are in adults.

G. Scoring Stage N3

1. Same as the adult rules found under the adult sleep staging rules heading H. [N1] RECOMMENDED

Note 1. Slow wave activity in pediatric populations is often of high amplitude (100–400 μV), 0.5–2.0 Hz activity, maximal over the recommended derivations in the frontal scalp regions and first appears as early as 2 months, more often 3–4.5 months post-term.

H. Scoring Stage R

1. Same as the adult rules found under the adult sleep staging rules heading I. [N1] RECOMMENDED

Note 1. The continuous, low-amplitude, mixed-frequency EEG activity of stage R in infants and children resembles adults although the dominant frequencies increase with age: approximately 3 Hz activity at 7 weeks post-term, 4–5 Hz activity with bursts of sawtooth waves at 5 months, 4–6 Hz at 9 months, and prolonged runs or bursts of notched 5–7 Hz theta activity at 1–5 years of age may populate the background activity. By 5–10 years of age, the low-amplitude, mixed-frequency activity in stage R is similar to that of adults.

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IV. Sleep Staging Rules Part 3: Rules for Infants

A. Ages for Which Infant Sleep Staging Rules Apply

1. Infant sleep staging rules should be used to score sleep and wakefulness in infants 0–2 months post-term (37–48 weeks conceptional age). [N1,N2,N3,N4] RECOMMENDED

Note 1. Conceptional age (CA) is gestational age (GA) at birth plus the number of weeks postpartum. GA is the time elapsed between the first day of the mother's last menstrual period and the day of delivery expressed in completed weeks. If the pregnancy was achieved using assisted reproductive technology, GA is calculated by adding 2 weeks to the CA. Chronological age (or postnatal or legal age) is the time elapsed since birth (can be expressed in days, months, or years).

Note 2. At birth, an infant is classified as one of the following: premature (<37 weeks gestation); full-term (37–42 weeks); or post-term (born after 42 weeks). A neonate is a child during the first 28 days after birth; an infant is a child age 1 to 12 months.[1]

Note 3. Knowing an infant's CA is crucial for interpreting the normalcy, immaturity or abnormality of an EEG or PSG because the brain and the EEG continue to develop and mature at a similar rate independent of whether the infant is in utero or post-delivery.

Note 4. For premature infants (<37 weeks CA) refer to discussion in the Pediatric and Infant Scoring Task Force review paper.[2]

References

1. Engle WA; American Academy of Pediatrics Committee on Fetus and Newborn. Age terminology during the perinatal period. *Pediatrics*. 2004;114(5):1362–1364.
2. Grigg-Damberger M, Gozal D, Marcus CL, et al. The visual scoring of sleep and arousal in infants and children. *J Clin Sleep Med.* 2007;3(2):201–240.

B. Technical Specifications

1. See IV. Sleep Staging Rules Part 1: Rules for Adults and III. Technical and Digital Specifications for technical considerations other than those below. RECOMMENDED

2. Adult electrode derivations for EEG, EOG and chin EMG are acceptable when recording sleep except that the distance between the chin EMG electrodes often needs to be reduced from 2 cm to 1 cm and the distance from the eyes in EOG electrodes often need to be reduced from 1 to 0.5 cm because of small infant head sizes. RECOMMENDED

3. Since sleep spindles are often asynchronous in children until 2 years of age, and may be more prominent in the midline central (C3-Cz, C4-Cz) and central derivations (C3-M2, C4-M1), simultaneous display of the recommended and backup electrodes and Cz (midline central) may be considered (e.g., montage to consider: F4-M1, C4-M1, O2-M1, F3-M2, C3-M2, O1-M2, C4-Cz, C3-Cz). [N1] OPTIONAL

4. Since behavioral patterns are extremely useful, synchronized video and audio recording is highly desirable. RECOMMENDED

Note 1. Since rudimentary sleep spindles first appear at 43 to 48 weeks CA at the midline central (Cz, vertex) region and are often asynchronous, simultaneous display of left, right and midline central EEG channels may be considered (e.g., C3-Cz, Cz-C4). In infants this age, sleep spindles are often low voltage 12–14 Hz, not the wider range of 11–16 Hz seen at later ages.

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C. General Scoring of Sleep Stages

1. The following terminology should be used when scoring sleep in infants 0–2 months post-term (37–48 weeks CA):[N1,N2] RECOMMENDED

a. Stage W (Wakefulness)
b. Stage N (NREM)
c. Stage R (REM)
d. Stage T (Transitional)

2. Score epochs using the following rules: RECOMMENDED

a. Score sleep stages in 30-second, sequential epochs commencing at the start of the study
b. Assign a stage to each epoch
c. If two or more stages coexist, assign the stage comprising the greatest portion of the epoch
d. If two or more PSG characteristics are discordant for stage R or stage N sleep, score the epoch as stage T (Transitional) sleep
e. Score sleep onset as the first epoch of sleep[N3]

3. Sleep and wakefulness in infants 38 to 48 weeks CA are scored based on behavioral observation; regularity or irregularity of respiration; and EEG, EOG, and chin EMG patterns defined in Tables 1–6. RECOMMENDED

4. Score sleep based on *behavioral* characteristics as defined in Table 1.[N4] RECOMMENDED

Table 1. Behavioral characteristics of sleep stages.

Stage	Behavioral Characteristics
Wake	Calm or active with eyes open, scanning eye movements; Brief eye closure can occur with crying
N	Eyes closed, few movements, sucking can occur
R	Eyes closed, REM seen under closed eyelids, squirming, sucking, grimacing, small movements of the face or limbs

5. Score sleep based on the *respiration* characteristics as defined in Table 2.[N5,N6] RECOMMENDED

Table 2. Respiration characteristics of sleep stages.

Stage	Respiration Characteristics
Wake	Irregular, rapid, and shallow
N	Regular
R	Irregular, some central pauses (may or may not meet criteria for apnea)

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6. Score sleep based on the *EEG* characteristics as defined in Table 3. (see also Figure 1) **RECOMMENDED**

Table 3. EEG characteristics of sleep stages.[N7,N8]

Patterns	EEG Characteristics	Stage(s)
Discontinuous		
Trace alternant (TA)[N9,N10]	This EEG pattern in full-term infants is generally only seen in stage N sleep. It is characterized by at least 3 alternating runs of bilaterally symmetrical synchronous high voltage (50–150 µV) bursts of 1–3 Hz delta activity lasting 5–6 seconds (range 3–8 seconds) alternating with periods of lower amplitude (25–50 µV) 4–7 Hz theta activity (range 4–12 seconds).	N
Continuous		
Low voltage irregular (LVI)	Continuous low voltage mixed-frequency activity with delta and predominantly theta activity.	R, Wake
High voltage slow (HVS)[N11]	Continuous synchronous symmetrical predominantly high voltage 1–3 Hz delta activity.	N, rarely R
Mixed (M)	Both high voltage slow and low voltage polyrhythmic components; these are intermingled with little periodicity. The amplitude is lower than seen in the HVS pattern.	Wake, R, rarely N
Waveforms of interest		
Sleep spindles[N12,N13]	12 to 14 Hz, asynchronous, most prominent in midline central (CZ) and central derivations. Occur only in stage N sleep.	N

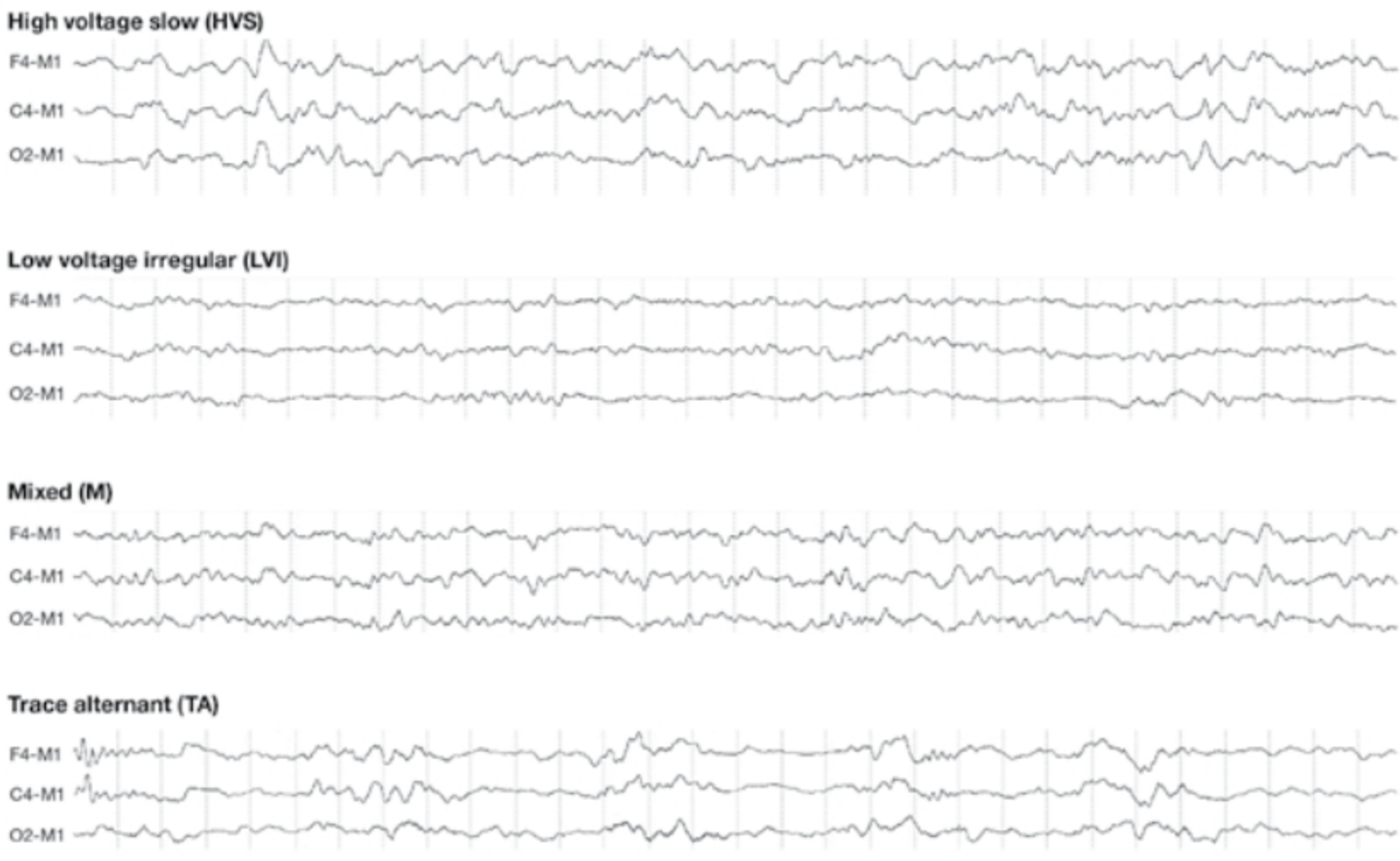


Figure 1. Sample 30 second tracings of EEG characteristics of sleep stages.

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7. Score sleep in accordance with the following definitions and based on the *EOG* characteristics as defined in Table 4. **RECOMMENDED**

Eye blinks: Conjugate vertical eye movements at a frequency of 0.5–2 Hz present in wakefulness with eyes open or closed.

Scanning eye movements: Trains of conjugate eye movements with eyes open consisting of a slow phase followed by a rapid phase in the opposite direction as the infant visually scans the environment or follows objects.[N14]

Rapid eye movements (REMs): Eye movements recorded in the EOG derivations consisting of conjugate, irregular, sharply peaked eye movements with an initial deflection usually lasting <500 msec. While rapid eye movements are characteristic of stage R sleep, they may also be seen in wakefulness with eyes open when individuals visually scan the environment.

Table 4. EOG characteristics of sleep stages.

Stage	EOG Characteristics
Wake	Eye blinks, REMs, scanning eye movements; transient eye closures may be seen in wakefulness especially when the infant is crying
N	Eyes closed, not moving
R	Eyes closed with REMs

8. Score sleep in accordance with the following definitions and based on the chin *EMG* patterns as defined in Table 5. RECOMMENDED

Low chin EMG tone: Baseline EMG activity in the chin derivation no higher than in any other sleep stage and usually at the lowest level of the entire recording.

Transient muscle activity: Short irregular bursts of EMG activity usually with duration <0.25 seconds superimposed on low EMG tone. The activity may be seen in the chin or anterior tibial EMG derivations, as well as in EEG or EOG deviations, the latter indicating activity of cranial nerve innervated muscles (facial and scalp muscles). The activity is often maximal when associated with rapid eye movements.

Table 5. Chin EMG patterns of sleep stages.

Stage	Chin EMG Patterns
Wake	Present, movement artifact
N	Present; could be lower than wake
R	Low, TMA may occur

Table 6 provides a summary of Tables 1 to 5.

Table 6. Summary of state characteristics.[N15]

Stage	Behavioral	Respiration	EEG	EOG	Chin EMG
Wake	Eyes open, crying, feeding	Irregular	LVI or M	REMs, blinks, scanning eye movements	Present
N	Reduced movement relative to wake (Eyes closed, periodic sucking, occasional startle)	Regular	TA, HVS, sleep spindles, or M	Eyes closed with no EMs	Present or low
R	Eyes closed Small movements	Irregular	LVI or M (rarely HVS)	REMs or Eyes closed with no EMs[N16]	Low, TMA may occur

LVI = low voltage irregular, M = mixed, TA = trace alternant, HVS = high voltage slow, REMs = rapid eye movements.

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Note 1. If NREM is sufficiently developed so that some epochs contain sleep spindles or K complexes and other epochs contain sufficient amounts of slow wave activity, then score NREM sleep in this infant as either stage N1, N2 or N3 as in IV. Sleep Staging Rules Part 2: Rules for Children, C.5.

Note 2. Stage N is analogous to the previously used terminology of "quiet sleep," stage R is analogous to the previously used terminology of "active sleep," and stage T is analogous to the previously used terminology of "indeterminate sleep."

Note 3. Up until 2 to 3 months post-term, the first epoch of sleep in infants is often stage R.

Note 4. The transition to sleep in an infant is characterized by relative immobility, absence of focused attention, and intermittent eye closure. If an infant's eyes are closed for more than 3 minutes, the infant is considered asleep. Theta and delta activity, especially over the frontal derivations, may increase in amplitude in transitions between W and sleep onset.

Note 5. Regularity or irregularity of respiration during sleep is the most reliable PSG characteristic in differentiating stage N and stage R sleep, respectively.

Note 6. Periodic breathing is common during stage R sleep and may rarely occur during stage N sleep in normal infants.

Note 7. The EEG patterns of transitional sleep may contain any of the EEG characteristics outlined in Table 3.

Note 8. Pathological EEG waveforms, such as those from spike and slow wave, projected rhythms or those generated due to underlying pathology, should not be included in defining stage or state as noted in Table 3.

Note 9. It is permissible to look at preceding and following epochs to identify the trace alternant (TA) pattern.

Note 10. Trace alternant (TA) first appears at 37 weeks conceptional age (CA), is the predominant EEG pattern in stage N sleep at 40 weeks CA and unlikely to be seen after 44 weeks CA. After 42 weeks CA, interburst intervals (IBIs) of TA last only 1–2 seconds and the IBI is of higher amplitude. TA after 44 weeks CA is replaced by high voltage slow (HVS) activity.

Note 11. High voltage slow (HVS) activity is the more mature EEG pattern of stage N sleep at term. It is characterized by continuous synchronous symmetrical 100–150 μV 1–3 Hz delta activity which often has an occipital or central predominance.

Note 12. Since rudimentary sleep spindles first appear at 43 to 48 weeks CA at the midline central (Cz, vertex) region and are often asynchronous, simultaneous display of left, right and midline central EEG channels may be considered (e.g., C3-Cz, Cz-C4). In infants this age, sleep spindles are often low voltage 12–14 Hz, not the wider range of 11–16 Hz seen at later ages.

Note 13. Since sleep spindles are often asynchronous in children until 2 years of age, simultaneous display of the recommended and backup electrodes may be considered (e.g., montage to consider: F3-M2, F4-M1, C3-M2, C4-M1, O1-M2, O2-M1, C3-Cz, Cz-C4).

Note 14. Scanning eye movements can be seen as early as 2 weeks post-term.

Note 15. Stage T (Transitional) is scored when 3 NREM and 2 REM or 2 NREM and 3 REM characteristics are present.

Note 16. In epoch(s) contiguous and following an epoch of definite stage R (e.g., containing REMs).

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D. Scoring Stage W

1. Score epochs as stage W if either a, b, or c is present for the majority of the epoch: [N1,N2] (Figure 2) **RECOMMENDED**

a. Eyes are wide open (for the majority of the epoch)
b. Vocalization (whimpering, crying, etc.) or actively feeding
c. All of the following are met:
    i. Eyes are open intermittently
    ii. REMs or scanning eye movements
    iii. Sustained chin EMG tone with bursts of muscle activity
    iv. Irregular respiration
    v. EEG: LVI or M[N3]

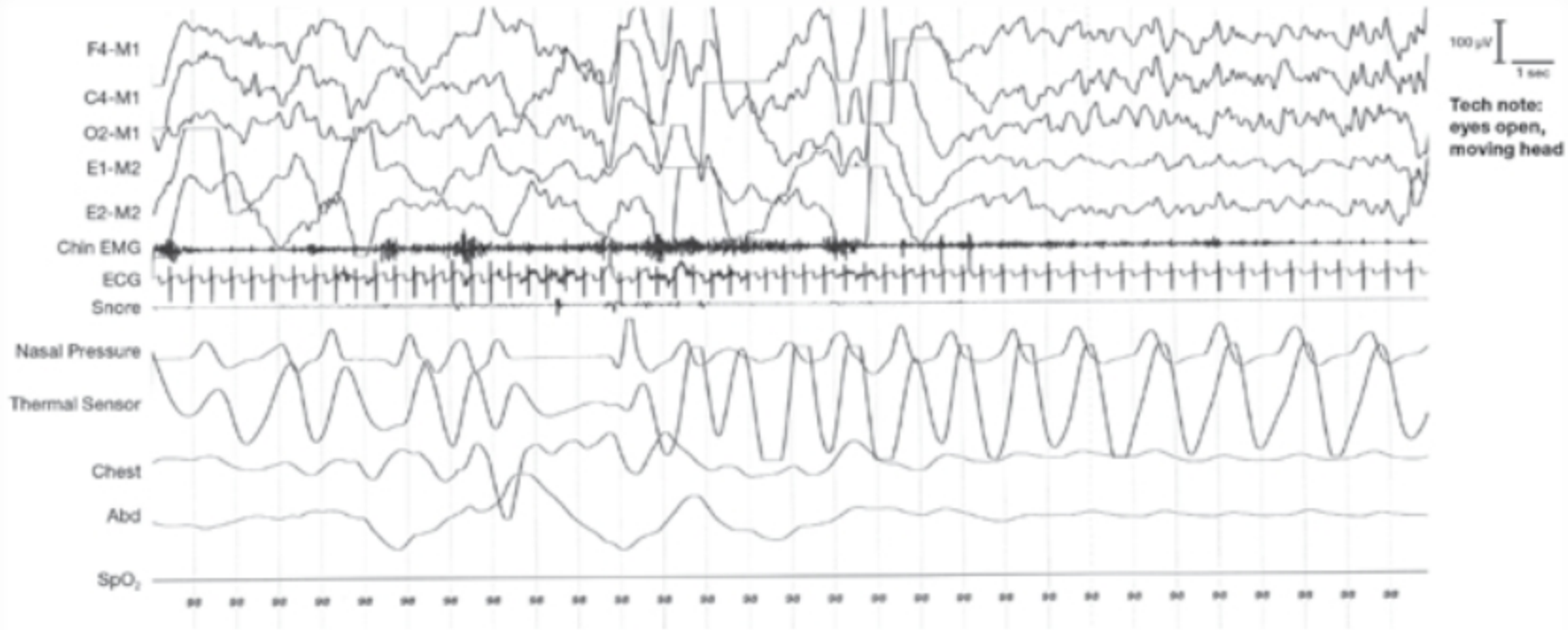


Figure 2. A 30 second tracing of stage W in an infant. EEG: mixed frequency pattern; EOG: REMs present; Chin EMG: present (high); Respiration: irregular; Behavior: eyes open, moving head. The thermal sensor is an oronasal flow sensor.

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Note 1. Wake is most reliably scored by behavioral observations, because many of the distinctive EEG features of wakefulness are not seen until after 2 months post-term.

Note 2. W (Wakefulness) is characterized by an EEG background of continuous, symmetrical, irregular, low-to-medium amplitude mixed-frequencies which may include: (a) irregular theta and delta activity (to 100 µV) maximal in O1, O2; (b) diffuse irregular alpha and beta activity (to 30 µV); (c) rhythmic theta activity (to 50 µV), often maximal in C3, Cz, C4; or (d) artifacts from body movements, and eye movements.

Note 3. This may have superimposed frequent movement artifacts.

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E. Scoring Stage N (NREM)

1. Score stage N if four or more of the following are present, including regular respiration, for the majority of the epoch:[N1,N2] (Figures 3 and 4) **RECOMMENDED**

a. Eyes closed with no eye movements
b. Chin EMG tone present
c. Regular respiration (post sigh respiratory pauses may occur)
d. Trace alternant (TA), high voltage slow (HVS), or sleep spindles present
e. Reduced movement relative to wake

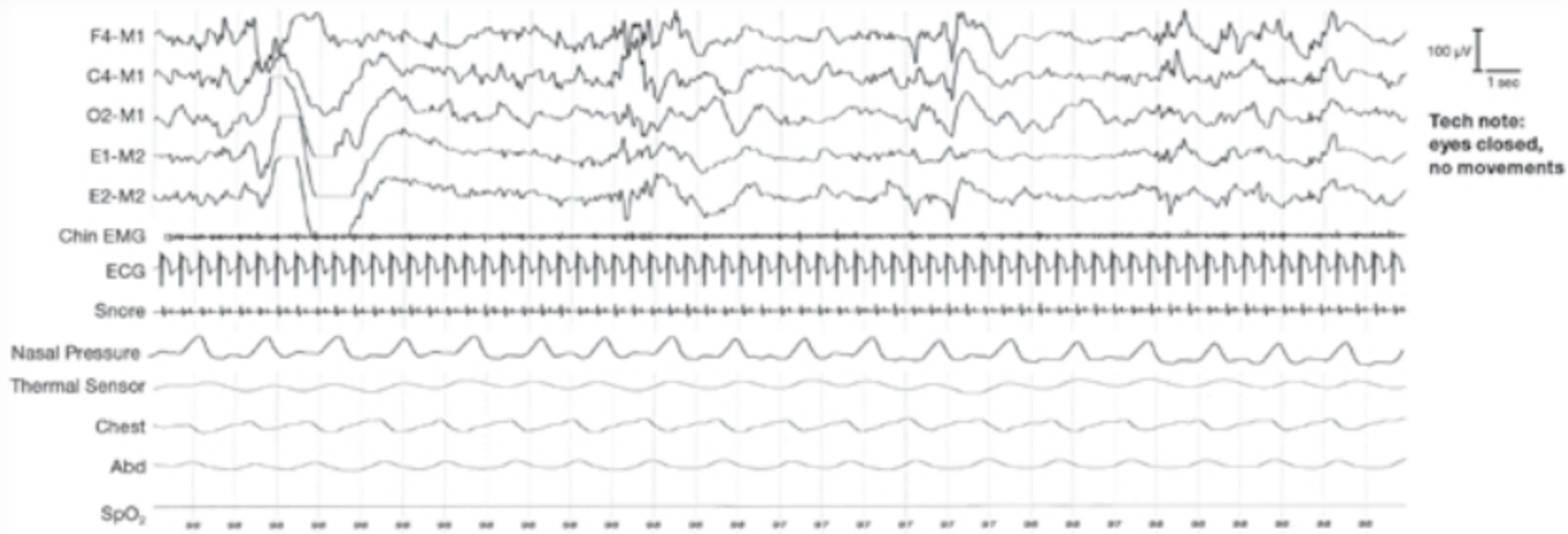


Figure 3. A 30 second tracing of stage N sleep in an infant. EEG: Trace alternant; EOG: no REMs; Chin EMG: present; Respiration: regular; Behavior: eyes closed, no movements. The thermal sensor is an oronasal flow sensor.

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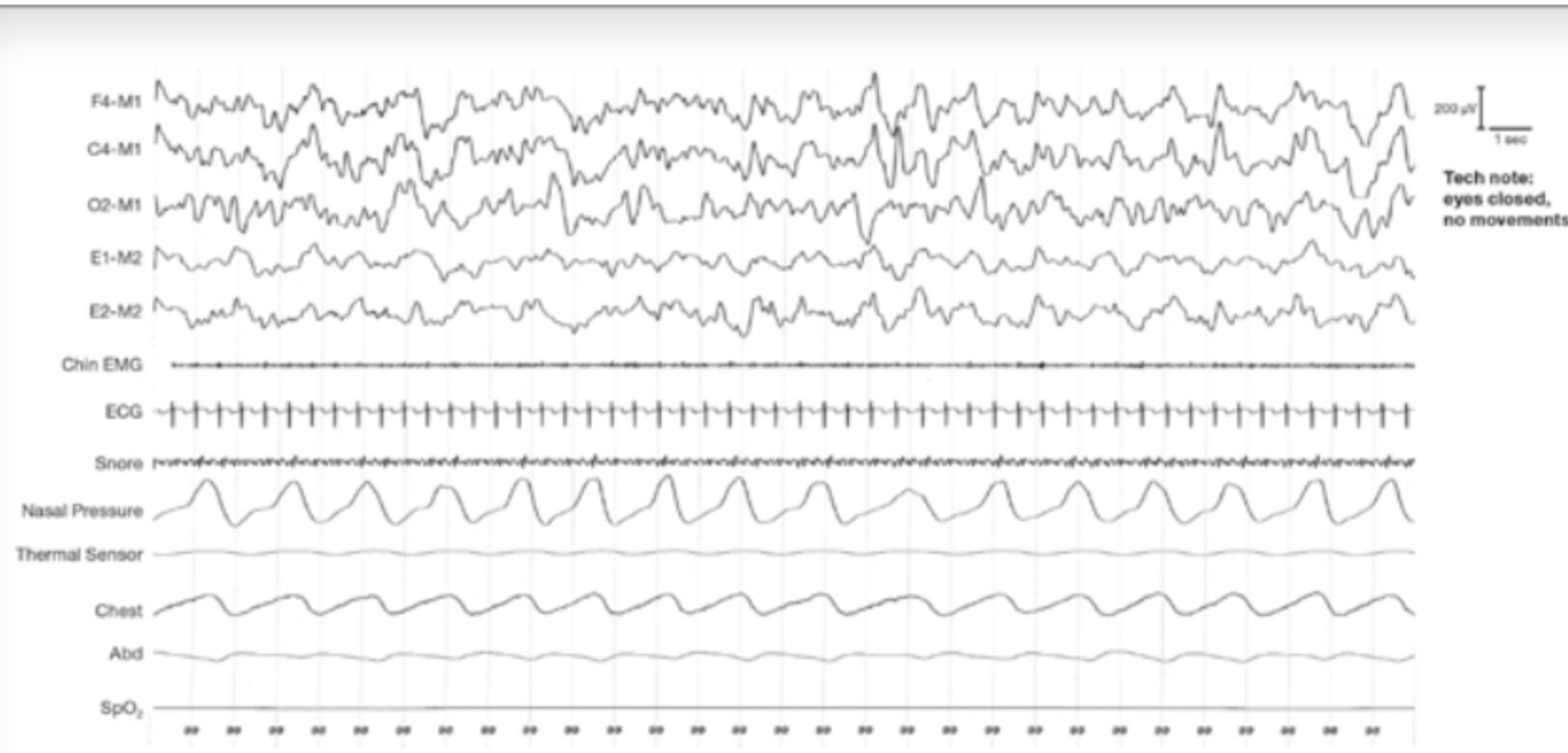


Figure 4. A 30 second tracing of stage N sleep in an infant. EEG: HVS; EOG: no eye movements; Chin EMG: present; Respiration: regular; Behavior: eyes closed, no movements. The thermal sensor is an oronasal flow sensor.

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Note 1. Chin EMG in stage N is variable; it is generally lower than Wake and higher than in stage R. That is, if chin EMG activity is present (higher than stage R) this is evidence for stage N (Table 5). However, stage N can still be scored with low EMG tone provided at least four other criteria for stage N including regular respiration are met.

Note 2. Regularity or irregularity of respiration during sleep is the most reliable PSG characteristic in differentiating stage N and stage R sleep, respectively.

F. Scoring Stage R

1. **Score stage R sleep (definite R) in epochs with 4 or more of the following criteria present, including irregular respiration AND rapid eye movement:**[N1] (Figure 5) RECOMMENDED

   a. Low chin EMG (for the majority of the epoch)[N2]
   b. Eyes closed with at least one rapid eye movement (concurrent with low chin tone)
   c. Irregular respiration
   d. Mouthing, sucking, twitches or brief head movements
   e. EEG exhibits a continuous pattern without sleep spindles[N3]

2. **Score segments of sleep contiguous with and following an epoch of definite R (as defined in F.1) in the *absence of rapid eye movements*, as stage R if ALL of the following are present:** RECOMMENDED

   a. The EEG shows low or medium amplitude mixed-frequency activity without trace alternant or sleep spindles
   b. The chin muscle tone is low for the majority of the epoch
   c. There is no intervening arousal (see chapter V. Arousal Rule, same rule as for children and adults)

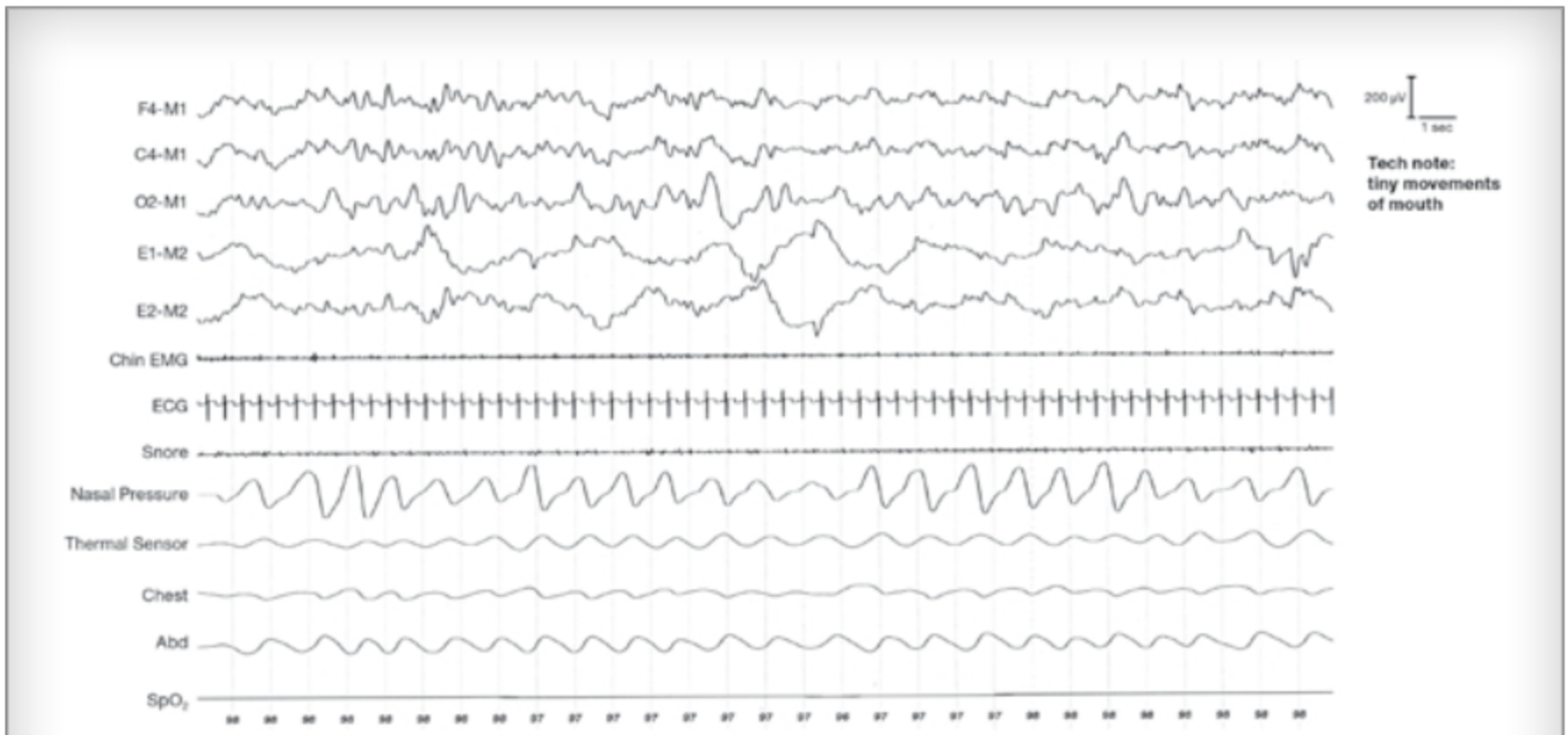


Figure 5. A 30 second tracing of stage R sleep in an infant. EEG: LVI; EOG: REMs; Chin EMG: low; Respiration: irregular; Behavior: eye movements noted with small movements of mouth. The thermal sensor is an oronasal flow sensor.

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Note 1. In infants, the first epoch of sleep is most commonly stage R. Given the difficulty in determining sleep onset, an epoch of definite stage R is required to begin scoring this sleep stage.

Note 2. Epochs of stage R sleep containing periods without atonia (sustained activity or transient muscle activity in the chin EMG) are not uncommon in infants. Bursts of muscle activity during stage R often occur associated with movements. The intervening chin EMG activity between movements is usually low.

Note 3. Continuous EEG pattern includes low voltage irregular (LVI), high voltage slow (HVS), and mixed (M) (Table 3).

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G. Scoring Stage T

1. **Score an epoch as stage N, stage R or stage W if only one PSG characteristic is discordant for the sleep state.**[N1,N2] RECOMMENDED

2. **Score an epoch as stage T (transitional) if it contains either 3 NREM and 2 REM characteristics or 2 NREM and 3 REM characteristics.** (Table 6, Figure 6) RECOMMENDED

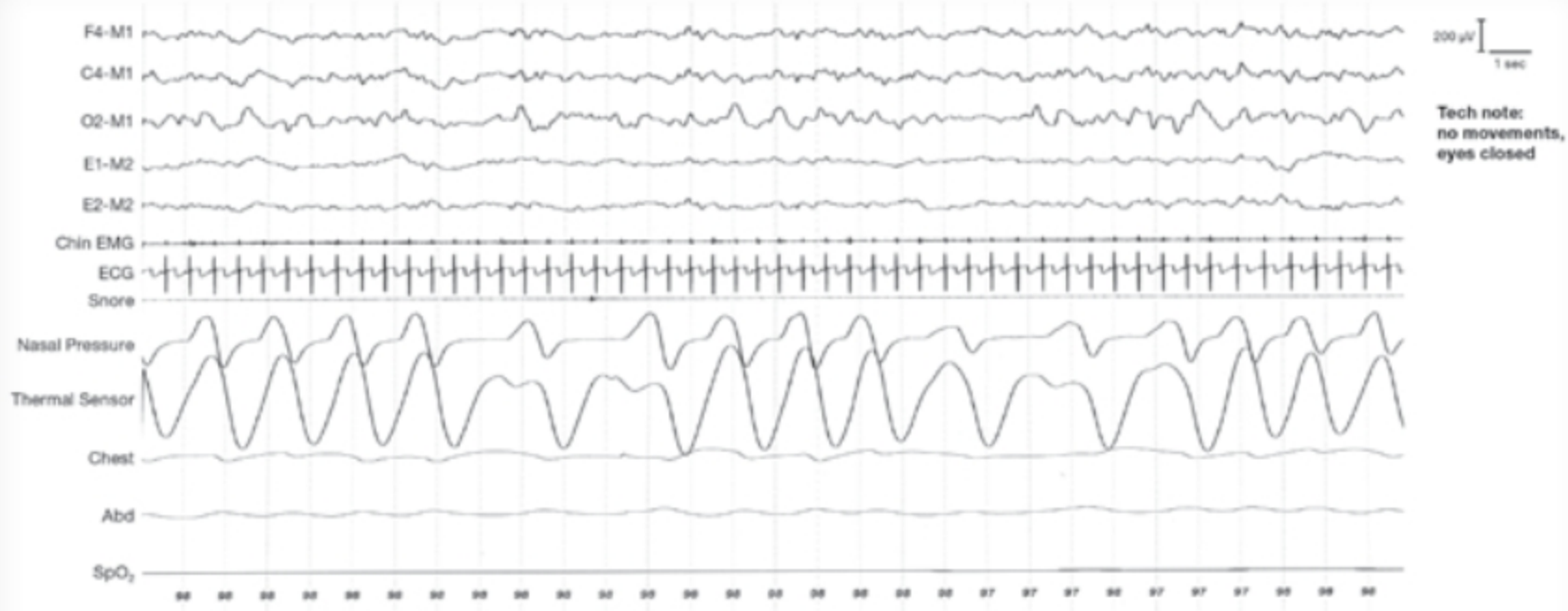


Figure 6. A 30 second tracing of Transitional (T) sleep in an infant. EEG: LVI; EOG: no REMs; Chin EMG: absent (low); Respiration: irregular; Behavioral: no movements, eye closed. Three characteristics of stage R (LVI, Chin EMG absent, irregular respiration) and two characteristics of NREM (no movement, no REMs) are seen in this epoch. This assumes that the epoch was not immediately preceded by an epoch of definite R. The thermal sensor is an oronasal flow sensor.

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Note 1. Transitional (T) or indeterminate sleep is common in infants because of discordant features (contains physiological markers of more than one sleep state).

Note 2. The terminology Transitional (T) sleep is favored over indeterminate sleep as the sleep stage most often occurs in transitions from stage W to stage R sleep, before awakening and at sleep onset.

H. Reference

The following reference applies to content throughout chapter IV. Sleep Staging Rules Part 3: Rules for Infants.

1. Anders T, Emde R, Parmelee A. *A Manual of Standardized Terminology, Techniques and Criteria for Scoring of States of Sleep and Wakefulness in Newborn Infants*. Los Angeles, CA: UCLA Brain Information Service/BRI Publications Office, NINDS Neurological Information Network; 1971.

V. Arousal Rule

A. Scoring Arousals

1. Score arousal during sleep stages N1, N2, N3, or R if there is an abrupt shift of EEG frequency including alpha, theta and/or frequencies greater than 16 Hz (but not spindles) that lasts at least 3 seconds, with at least 10 seconds of stable sleep preceding the change. Scoring of arousal during REM requires a concurrent increase in submental EMG lasting at least 1 second.[N1,N2,N3,N4,N5] RECOMMENDED

Note 1. Arousal scoring should incorporate information from the frontal, central, and occipital derivations.

Note 2. Arousal scoring can be improved by the use of additional information in the recording such as respiratory events and/or additional EEG channels. Scoring of arousals, however, cannot be based on this additional information alone and such information does not modify any of the arousal scoring rules.

Note 3. Arousals meeting all scoring criteria but occurring during an awake epoch in the recorded time between "lights out" and "lights on" should be scored and used for computation of the arousal index.

Note 4. The 10 seconds of stable sleep required prior to scoring an arousal may begin in the preceding epoch, including a preceding epoch that is scored as stage W.

Note 5 An arousal may still be scored if it immediately precedes a transition to stage W. That is, both the arousal and transition to wake are scored.

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VI. Cardiac Rules

A. Technical Specifications

1. Use a single modified electrocardiograph Lead II and torso electrode placement.[N1,N2,N3,N4] (see Figure 1) RECOMMENDED

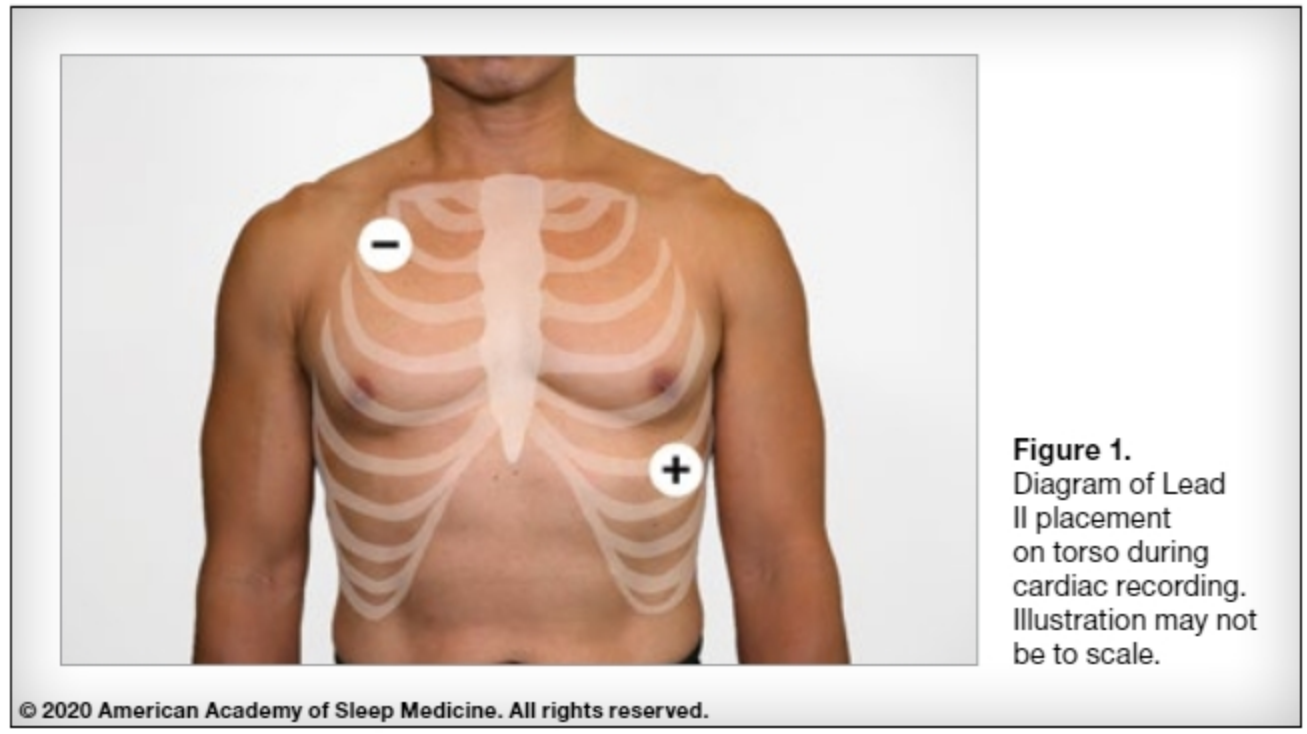


Figure 1.
Diagram of Lead II placement on torso during cardiac recording. Illustration may not be to scale.

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Note 1. Additional leads may be placed if clinically indicated at the discretion of the practitioner.

Note 2. Increasing the image size on the display may improve detection of arrhythmias.

Note 3. While classically Lead II is derived from electrodes placed on the right arm and left leg, the negative electrode may be placed below the right clavicle at the mid-clavicular line and the positive electrode on the left lower chest at the anterior axillary line in the 6th or 7th intercostal space.

Note 4. Standard ECG electrode applications are superior to EEG electrodes in minimizing artifact.

B. Scoring Cardiac Events[N1,N2]

1. **Score sinus tachycardia during sleep for a sustained sinus heart rate of greater than 90 beats per minute for adults.**[N3,N4] RECOMMENDED

2. **Score bradycardia during sleep for a sustained heart rate of less than 40/minute for ages 6 years through adult.**[N4] RECOMMENDED

3. **Score asystole for cardiac pauses greater than 3 seconds for ages 6 years through adult.** RECOMMENDED

4. **Score wide complex tachycardia for a rhythm lasting a minimum of 3 consecutive beats at a rate greater than 100 per minute with QRS duration of greater than or equal to 120 msec.** RECOMMENDED

5. **Score narrow complex tachycardia for a rhythm lasting a minimum of 3 consecutive beats at a rate of greater than 100 per minute with QRS duration of less than 120 msec.** RECOMMENDED

6. **Score atrial fibrillation if there are irregularly irregular QRS complexes associated with replacement of consistent P waves by rapid oscillations that vary in size, shape, and timing.** RECOMMENDED

Note 1. Significant arrhythmias such as heart block should be reported if the quality of the single lead is sufficient for accurate scoring.

Note 2. Ectopic beats should be reported if felt to be clinically significant.

Note 3. Sinus rates vary according to age in children, with faster rates in young children as compared to adults. For typical sinus rates in children, refer to the Cardiac Task Force review paper.[1]

Note 4. Sustained sinus bradycardia or tachycardia is defined by more than 30 seconds of a stable rhythm to distinguish it from transient responses, associated sleep disordered breathing events or arousals.

Reference

1. Caples SM, Rosen CL, Shen WK, et al. The scoring of cardiac events during sleep. *J Clin Sleep Med*. 2007;3(2):147–154.

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VII. Movement Rules

A. Technical Specifications[N1]

1. **For monitoring leg movements (LMs), surface electrodes should be placed longitudinally and symmetrically in the middle of the anterior tibialis muscle so that they are 2–3 cm apart or 1/3 of the length of the anterior tibialis muscle, whichever is shorter. Both legs should be monitored for the presence of the leg movements. Separate channels for each leg are strongly preferred. Combining electrodes from the 2 legs to give 1 recorded channel may suffice for some clinical settings, although it should be recognized that this strategy may reduce the number of detected LMs.** (see Figure 1) RECOMMENDED

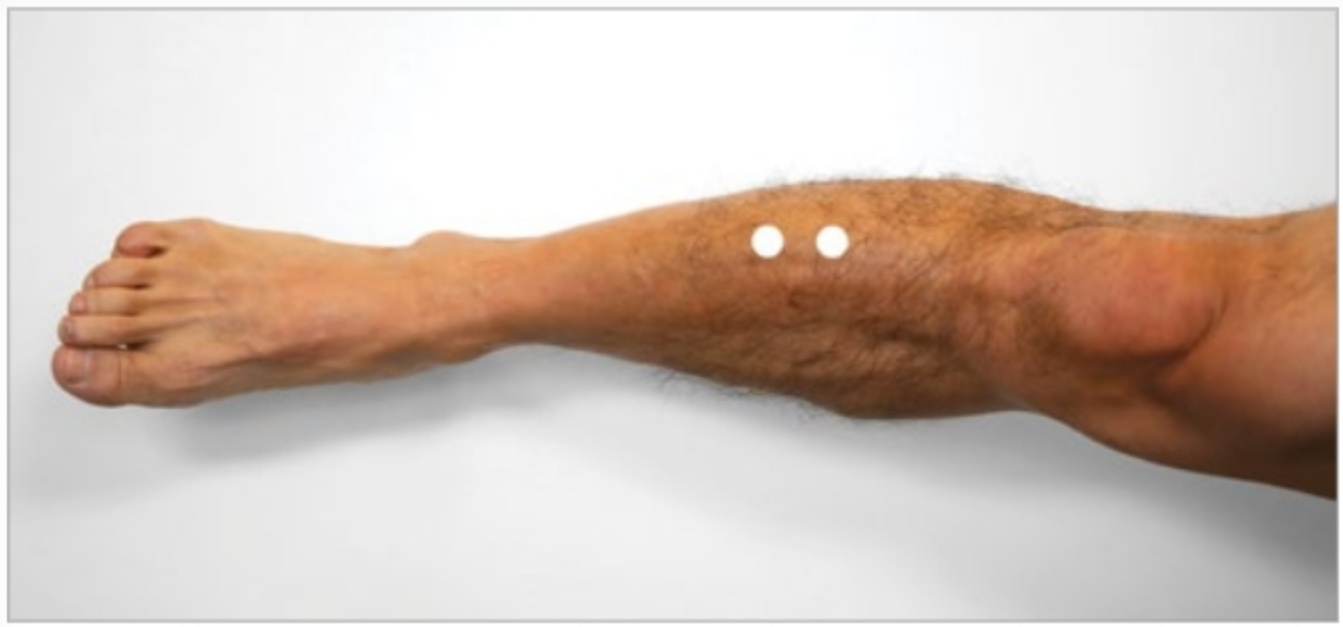


Figure 1. Placement of electrodes on the anterior tibialis muscle for monitoring leg movements. Illustration may not be to scale.

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2. **For monitoring leg movements, use of 60 Hz (notch) filters should be avoided. Impedances need to be less than 10,000 Ω. Less than 5,000 Ω is preferred but may be difficult to obtain.** RECOMMENDED

3. **Movements of the upper limbs may be sampled using a similar method as for legs if clinically indicated.** (see Figures 2 and 3) OPTIONAL

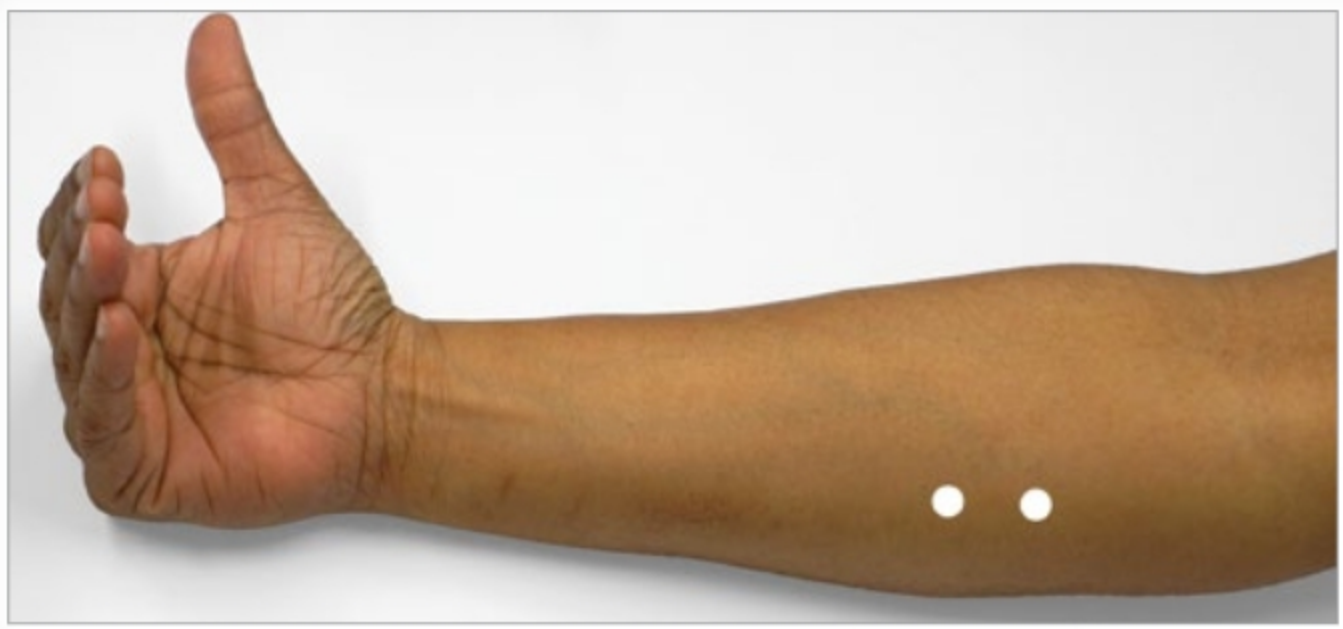


Figure 2. Placement of electrodes on the flexor digitorum superficialis for detecting transient muscle activity in REM sleep. Illustration may not be to scale.

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Figure 3. Placement of electrodes on the extensor digitorum communis for detecting transient muscle activity in REM sleep. Illustration may not be to scale.

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4. For detecting bruxism, in addition to the recommended placement of chin EMG electrodes as noted in the adult sleep staging rules chapter (IV.C), additional masseter electrodes may be placed if clinically indicated.[N2] (see Figure 4) OPTIONAL

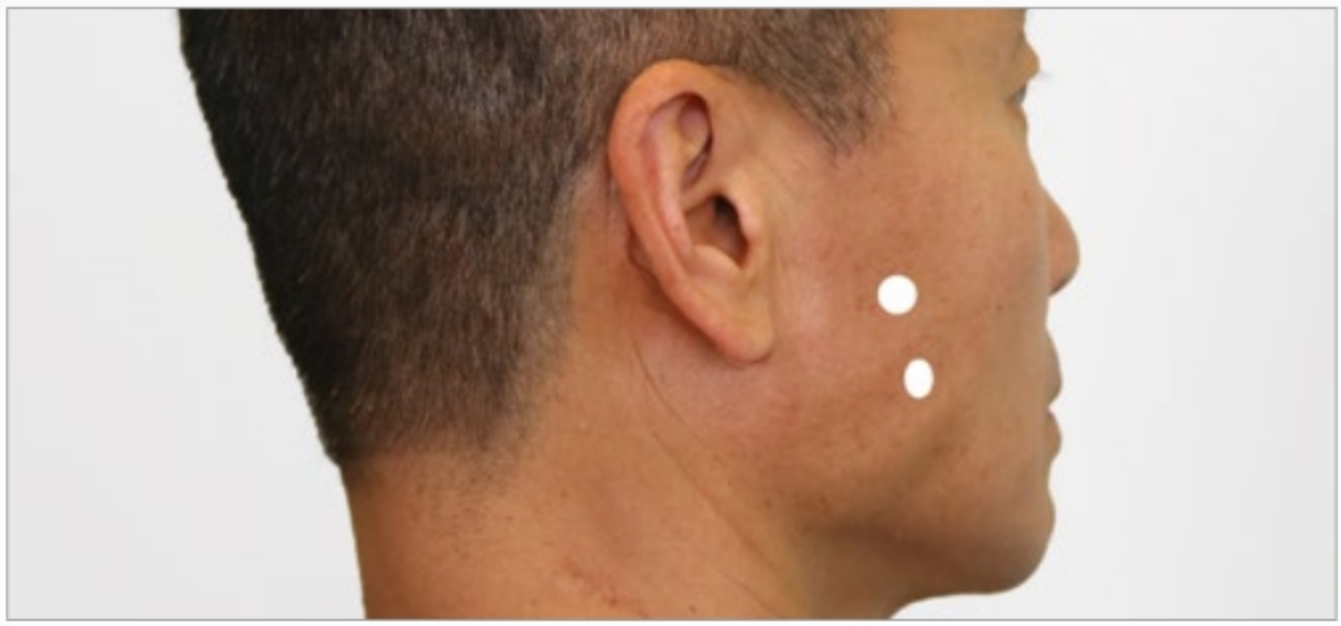


Figure 4. Placement of electrodes on the masseter muscle for detecting bruxism. Illustration may not be to scale.

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5. For detecting transient muscle activity in REM sleep, use one of the following EMG recordings:[N3] OPTIONAL

a. Flexor digitorum superficialis (see Figure 2)
b. Extensor digitorum communis (see Figure 3)

6. For diagnosis of RBD, time-synchronized, audio-equipped video PSG is essential to document complex motor behaviors and vocalizations during REM sleep. A diagnosis of RBD is based on demonstration of such episodes or a characteristic clinical history of dream enactment in addition to polysomnographic evidence of REM sleep without atonia. RECOMMENDED

7. For monitoring rhythmic movement disorder (RMD), bipolar surface electrodes should be placed to record electrical activity of the large muscle groups involved.[N3] (see Figure 5) OPTIONAL

8. For diagnosis of RMD, time-synchronized video PSG is necessary to accurately characterize the disorder, in addition to polysomnographic criteria. RECOMMENDED

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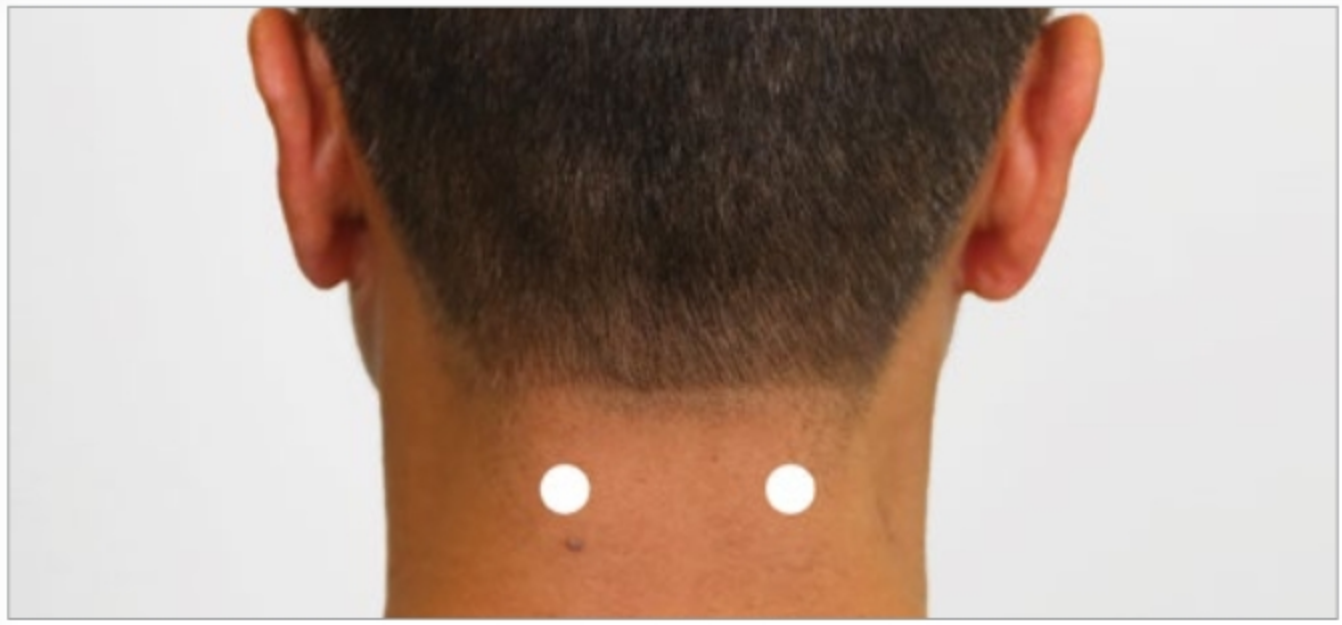


Figure 5. Placement of electrodes on the neck paraspinal muscles for monitoring rhythmic movement disorder. Illustration may not be to scale.

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Note 1. For accurate electrode placement, the patient should be asked to activate the muscle so that the muscle can be more readily felt. The following are the actions to activate various muscles:

- Anterior tibialis: patient should raise foot toward their head or flex their foot up
- Flexor digitorm superficialis: patient should bend only at the base of their fingers (avoid bending at the distal two joints)
- Extensor digitorum communis: patient should extend their fingers back without moving their wrist
- Masseter: patient should bite down

Note 2. If two electrodes are used (see Figure 4), they should be 2–3 cm apart. A single masseter electrode may be used using a chin EMG electrode as the reference.

Note 3. Surface electrodes should be placed 2–3 cm apart.

B. Scoring Periodic Limb Movements in Sleep (PLMS)

1. The following define a significant leg movement (LM) event: [N1] RECOMMENDED

a. The minimum duration of a LM event is 0.5 seconds.
b. The maximum duration of a LM event is 10 seconds.
c. The minimum amplitude of a LM event is an 8 μV increase in EMG voltage above resting EMG (duration of at least 0.5 seconds).
d. The timing of the onset of a LM event is defined as the point at which there is an 8 μV increase in EMG voltage above resting EMG.
e. The timing of the ending of a LM event is defined as the start of a period lasting at least 0.5 seconds during which the EMG does not exceed 2 μV above resting EMG.

2. The following define a PLM series: [N2] RECOMMENDED

a. The minimum number of consecutive LM events needed to define a PLM series is 4 LMs.
b. The period length between LMs (defined as the time between onsets of consecutive LMs) to include them as part of a PLM series is 5 to 90 seconds.
c. Leg movements on 2 different legs separated by less than 5 seconds between movement onsets are counted as a single leg movement. The period length to the next LM following this group of LMs is measured from the onset of the first LM to the onset of the next. (see Figure 6)

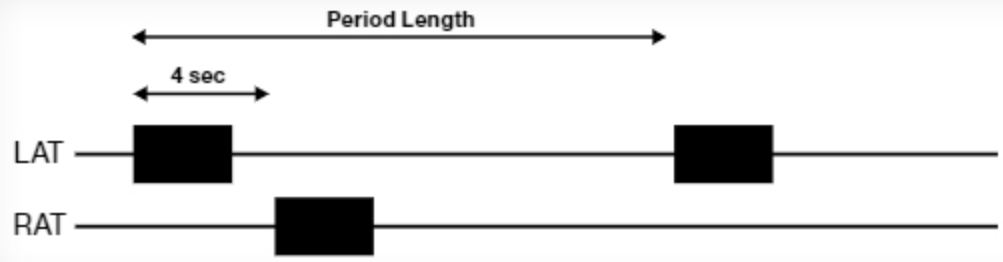


Figure 6. The first two LMs are counted as one leg movement since the time from onset to onset of the LMs in the left anterior tibial EMG channel (LAT) and right anterior tibial EMG channel (RAT) is less than 5 seconds. The period length to the next LM is measured from the onset of the first LM in the group considered to be a single LM.

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3. An arousal and a limb movement that occur in a PLM series should be considered associated with each other if they occur simultaneously, overlap, or when there is <0.5 seconds between the end of one event and the onset of the other event regardless of which is first. (see Figure 7) RECOMMENDED

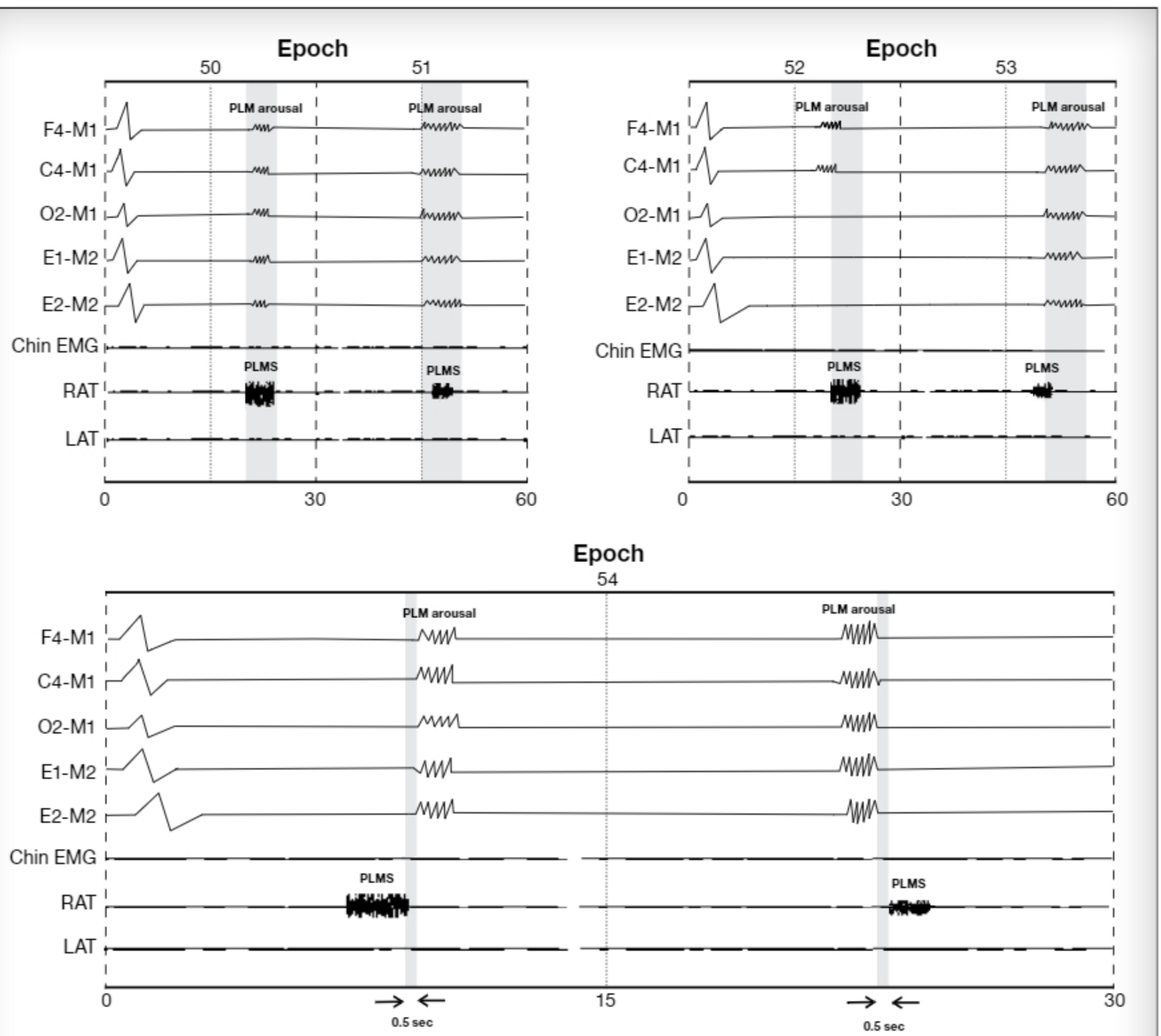


Figure 7. An arousal and LM occurring in a PLM series are considered to be associated if they occur simultaneously (epochs 50 and 51), overlap (epochs 52 and 53) or if the time from the end of one event to the start of the next is less than 0.5 seconds, regardless which event comes first (epoch 54).

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4. **An LM should not be scored if it occurs during a period from 0.5 seconds preceding an apnea, hypopnea, or RERA to 0.5 seconds following the event.** RECOMMENDED

5. **When a period of wake <90 seconds separates a series of LMs, this does not prevent LMs preceding the period of wake from being included with the subsequent LMs as part of a PLM series.** (see Figure 8) RECOMMENDED

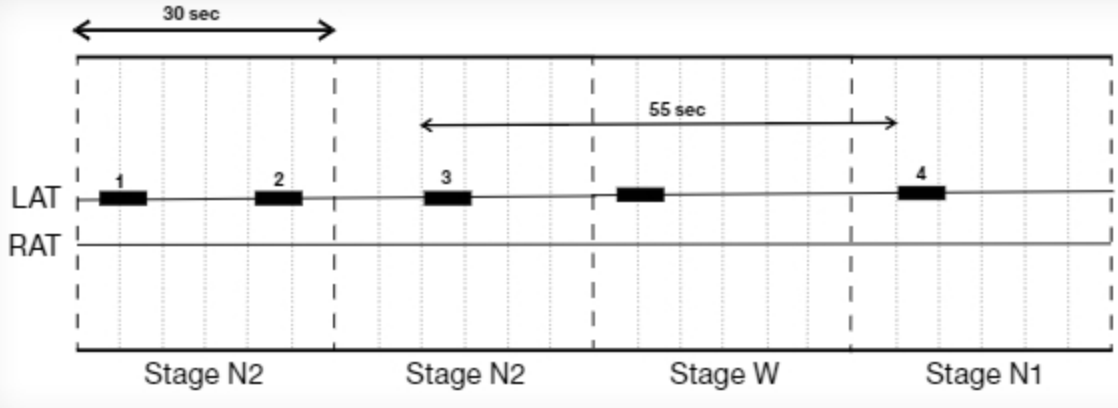


Figure 8. Five LMs are depicted. The fourth occurs in an epoch of wake and cannot be counted as a PLM in sleep. However, the other 4 LMs would be included in the same PLM series.

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Note 1. Rule 1.c. defines a significant leg movement event by an absolute increase of 8 μV above resting baseline for the anterior tibialis EMG. This requires a stable resting EMG for the relaxed anterior tibialis whose absolute signal should be no greater than +10 μV between negative and positive deflection (±5 μV) or +5 μV for rectified signals.

Note 2. When periodic limb movements occur with an interval of less than 10 seconds and each is associated with a ≥ 3 second change in the EEG/chin EMG meeting criteria for an arousal, only the first EEG/chin EMG change should be scored as an arousal (assuming it is preceded by at least 10 seconds of sleep). Both limb movements may be scored, assuming the onsets are separated by 5 seconds or more, but only one PLM associated with an arousal (and only one arousal) would be scored.

C. Scoring Alternating Leg Muscle Activation (ALMA)

1. **The following define ALMA:** [N1,N2,N3] OPTIONAL
   a. The minimum number of discrete and alternating EMG bursts of leg muscle activity events needed to score an ALMA series is 4 ALMAs.
   b. The minimum frequency of the alternating EMG bursts in ALMA is 0.5 Hz.
   c. The maximum frequency of the alternating EMG bursts in ALMA is 3.0 Hz.

Note 1. ALMAs alternate between legs.

Note 2. The usual range for duration of ALMA is 100–500 msec.

Note 3. ALMA may simply be a benign movement phenomenon associated with characteristic EMG patterns as there have been no reported clinical consequences.

D. Scoring Hypnagogic Foot Tremor (HFT)

1. The following define HFT: [N1,N2] OPTIONAL

a. The minimum number of EMG bursts needed to make a train of bursts in a HFT series is 4 HFT bursts.
b. The minimum frequency of the EMG bursts in a HFT is 0.3 Hz.
c. The maximum frequency of the EMG bursts in a HFT is 4.0 Hz.

Note 1. The usual range for duration of hypnagogic foot tremor is 250–1,000 msec.

Note 2. HFT may simply be a benign movement phenomenon associated with characteristic EMG patterns as there have been no reported clinical consequences.

E. Scoring Excessive Fragmentary Myoclonus (EFM)

1. The following define EFM: [N1,N2,N3] OPTIONAL

a. The usual maximum EMG burst duration seen in fragmentary myoclonus is 150 msec.
b. At least 20 minutes of NREM sleep with EFM must be recorded.
c. At least 5 EMG potentials per minute must be recorded.

Note 1. EFM may be a benign movement phenomenon associated with a characteristic EMG pattern as there have been no reported clinical consequences.

Note 2. In many cases no visible movements are present. Gross, jerk-like movements across the joint spaces are not observed. When minor movement across a joint space is present, the movement resembles the small twitch-like movements of the fingers, toes, and the corner of the mouth intermittently seen in REM sleep in normal individuals.

Note 3. In some cases when visible movement is present, the EMG burst duration may be >150 msec.

F. Scoring Bruxism

1. The following define bruxism: [N1,N2] RECOMMENDED

a. Bruxism may consist of brief (phasic) or sustained (tonic) elevations of chin EMG activity that are at least twice the amplitude of background EMG.
b. Brief elevations of chin or masseter EMG activity are scored as bruxism if they are 0.25–2 seconds in duration and if at least 3 such elevations occur in a regular sequence.
c. Sustained elevations of chin or masseter EMG activity are scored as bruxism if the duration is more than 2 seconds.
d. A period of at least 3 seconds of stable background chin EMG must occur before a new episode of bruxism can be scored.
e. Bruxism can be scored reliably by audio in combination with polysomnography by a minimum of 2 audible tooth grinding episodes/night of polysomnography in the absence of epilepsy.

Note 1. In sleep, jaw contraction frequently occurs. This contraction can take 2 forms: (a) sustained (tonic) jaw clenching contractions or (b) a series of repetitive brief (phasic) muscle contractions termed rhythmic masticatory muscle activity (RMMA).

Note 2. Characteristic changes in masseter EMG are often more prominent than changes in the chin EMG.

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G. Scoring REM Without Atonia (RWA)

Scoring RWA is optional as noted in Parameters to be Reported (II.E).

1. If electing to score RWA, score in accordance with the following definitions [N1]: RECOMMENDED

Excessive sustained muscle activity (tonic activity) in REM: An epoch of stage R with at least 50% of the duration of the epoch having a chin EMG amplitude at least two times greater than the stage R atonia level (or lowest amplitude in NREM, if no stage R atonia is present). Multiple segments may contribute to the total duration, but each segment must be greater than 5 seconds.

Excessive transient muscle activity (phasic activity) in REM [N2]: In a 30-second epoch of stage R divided into 10 sequential 3-second mini-epochs, at least 5 (50%) of the mini-epochs contain bursts of transient muscle activity in the chin or limb EMG. In RWA, excessive transient muscle activity bursts are 0.1–5.0 seconds in duration and at least two times as high in amplitude as the stage R atonia level (or lowest amplitude in NREM, if no stage R atonia is present).

Any chin EMG activity [N3]: Activity with a minimum amplitude two times greater than the stage R atonia level (or lowest amplitude in NREM, if no stage R atonia is present) without regard to the duration of the activity (including bursts of 5 to 15 seconds).

2. If electing to score RWA, score an epoch as exhibiting RWA when one of the following is present:[N1,N2,N3,N4,N5]

a. Excessive sustained muscle activity in REM in the chin EMG (as defined in rule V.G.1) RECOMMENDED
b. Excessive transient muscle activity during REM in the chin or limb EMG (as defined in rule V.G.1) RECOMMENDED
c. At least 50% of 3 second mini-epochs contain any chin activity (as defined in rule V.G.1) or limb EMG activity (bursts of EMG activity 0.1–5.0 seconds in duration and at least two times as high in amplitude as the stage R atonia level or lowest amplitude in NREM, if no stage R atonia is present).[N2,N3] ACCEPTABLE

3. If electing to score RWA, score the RWA index as the % of stage R epochs that meet criteria in rule V.G.2.[N3] OPTIONAL

Note 1. The definitions of sustained and transient muscle activity are based on duration rather than morphology. Although transient activity is often composed of intermittent brief bursts, activity with relatively constant amplitude that otherwise meets criteria VII.G.2 qualifies as transient activity.

Note 2. If a periodic limb movement (PLM) is scored as part of a PLM series, it should not be counted in determining if an epoch has RWA.

Note 3. Based on SINBAR (Sleep Innsbruck Barcelona) Group recommended criteria.[1]

Note 4. Epochs containing RWA with sustained chin activity as defined above may not meet criteria for stage R but in these cases, the epoch can still be scored as stage R if other criteria for stage R are met or if the epoch is contiguous with an epoch scored as stage R.

Note 5. If electing to measure RWA, the leads used to determine the presence of RWA should be included in the PSG report (e.g., chin, chin and lower limbs, chin and upper limbs).

Reference

1. Frauscher B; Iranzo A; Gaig C; Gschliesser V; Guaita M; Raffelseder V; Ehrmann L; Sola N; Salamero M; Tolosa E; Poewe W; Santamaria J; Högl B; SINBAR (Sleep Innsbruck Barcelona) Group. Normative EMG values during REM sleep for the diagnosis of REM sleep behavior disorder. *SLEEP* 2012;35(6):835-847.

H. Scoring the PSG Features of Rhythmic Movement Disorder

1. The following define the polysomnographic characteristics of rhythmic movement disorder: RECOMMENDED

a. The minimum frequency for scoring rhythmic movements is 0.5 Hz.
b. The maximum frequency for scoring rhythmic movements is 2.0 Hz.
c. The minimum number of individual movements required to make a cluster of rhythmic movements is 4 movements.
d. The minimum amplitude of an individual rhythmic burst is 2 times the background EMG activity.

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VIII. Respiratory Rules Part 1: Rules for Adults

A. Technical Specifications

1. **For identification of an apnea during a diagnostic study, use an oronasal thermal airflow sensor to monitor airflow.**[N1] RECOMMENDED

2. **For identification of an apnea during a diagnostic study *when the oronasal thermal airflow sensor is not functioning or the signal is not reliable,* use one of the following (*alternative* apnea sensors):**[N2]
   a. nasal pressure transducer (with or without square root transformation) RECOMMENDED
   b. Respiratory inductance plethysmography sum (RIPsum) (calibrated or uncalibrated) RECOMMENDED
   c. Respiratory inductance plethysmography flow (RIPflow) (calibrated or uncalibrated) RECOMMENDED
   d. PVDFsum ACCEPTABLE

3. **For identification of a hypopnea during a diagnostic study, use a nasal pressure transducer (with or without square root transformation of the signal) to monitor airflow.**[N3] RECOMMENDED

4. **For identification of a hypopnea during a diagnostic study *when the nasal pressure transducer is not functioning or the signal is not reliable*, use one of the following (*alternative* hypopnea sensors):**[N2]
   a. oronasal thermal airflow RECOMMENDED
   b. RIPsum (calibrated or uncalibrated) RECOMMENDED
   c. RIPflow (calibrated or uncalibrated) RECOMMENDED
   d. dual thoracoabdominal RIP belts (calibrated or uncalibrated) RECOMMENDED
   e. PVDFsum ACCEPTABLE

5. **During positive airway pressure (PAP) titration, use the PAP device flow signal to identify apneas or hypopneas.** RECOMMENDED

6. **For monitoring respiratory effort, use one of the following:**
   a. esophageal manometry RECOMMENDED
   b. dual thoracoabdominal RIP belts (calibrated or uncalibrated)[N4] RECOMMENDED
   c. dual thoracoabdominal PVDF belts[N4] ACCEPTABLE

7. **For monitoring oxygen saturation, use pulse oximetry with a maximum acceptable signal averaging time of ≤3 seconds at a heart rate of 80 beats per minute.** RECOMMENDED

8. **For monitoring snoring, use an acoustic sensor (e.g., microphone), piezoelectric sensor or nasal pressure transducer.**[N5] RECOMMENDED

9. **For detection of hypoventilation during a diagnostic study, use arterial PCO_2, transcutaneous PCO_2 or end-tidal PCO_2.**[N6,N7] RECOMMENDED

10. **For detection of hypoventilation during PAP titration, use arterial PCO_2, or use transcutaneous PCO_2.**[N6,N7] RECOMMENDED

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Note 1. Thermal sensors include thermistors, thermocouples, or polyvinylidene fluoride (PVDF) airflow sensors.

Note 2. The RIPsum is the sum of the signals from thoracic and abdominal RIP sensors (belts) and excursions in the signal are an estimate of tidal volume. The RIPflow is the time derivative of the RIPsum and excursions in the signal are an estimate of airflow. The PVDFsum is the sum of signals from thoracic and abdominal PVDF sensors (belts). Recording of RIPsum, RIPflow, or PVDFsum is optional.

Note 3. Using the nasal pressure signal without square root transformation for scoring hypopneas will result in a slightly higher hypopnea index than scoring using a square root transformation of the signal. This difference is not clinically significant in most patients.

Note 4. A surface diaphragmatic/intercostal EMG signal may be used for detection of respiratory effort during apnea, hypopnea, or RERA events to complement effort belt signals when unambiguous inspiratory EMG bursts are visible during normal breathing.

Various electrode placements have been used in the published literature. Some of the placements are illustrated in Figure 1. If one electrode placement does not yield a good signal, others may be tried. Some placements utilize an electrode above and another below a rib while others place both electrodes in the same intercostal space. Positions at the mid-clavicular, anterior axillary, and mid-axillary lines have been used. The 6th, 7th, or 8th intercostal space is commonly used but slightly higher or lower may result in a better signal in some patients. While low and high filter settings recommended for recording of the anterior tibial EMG can be used (low 10 Hz, high 100 Hz), ECG artifact will be reduced if a low filter setting of 25 to 40 Hz is used. Some polysomnography programs have an option for removal of ECG artifact from EMG signals.

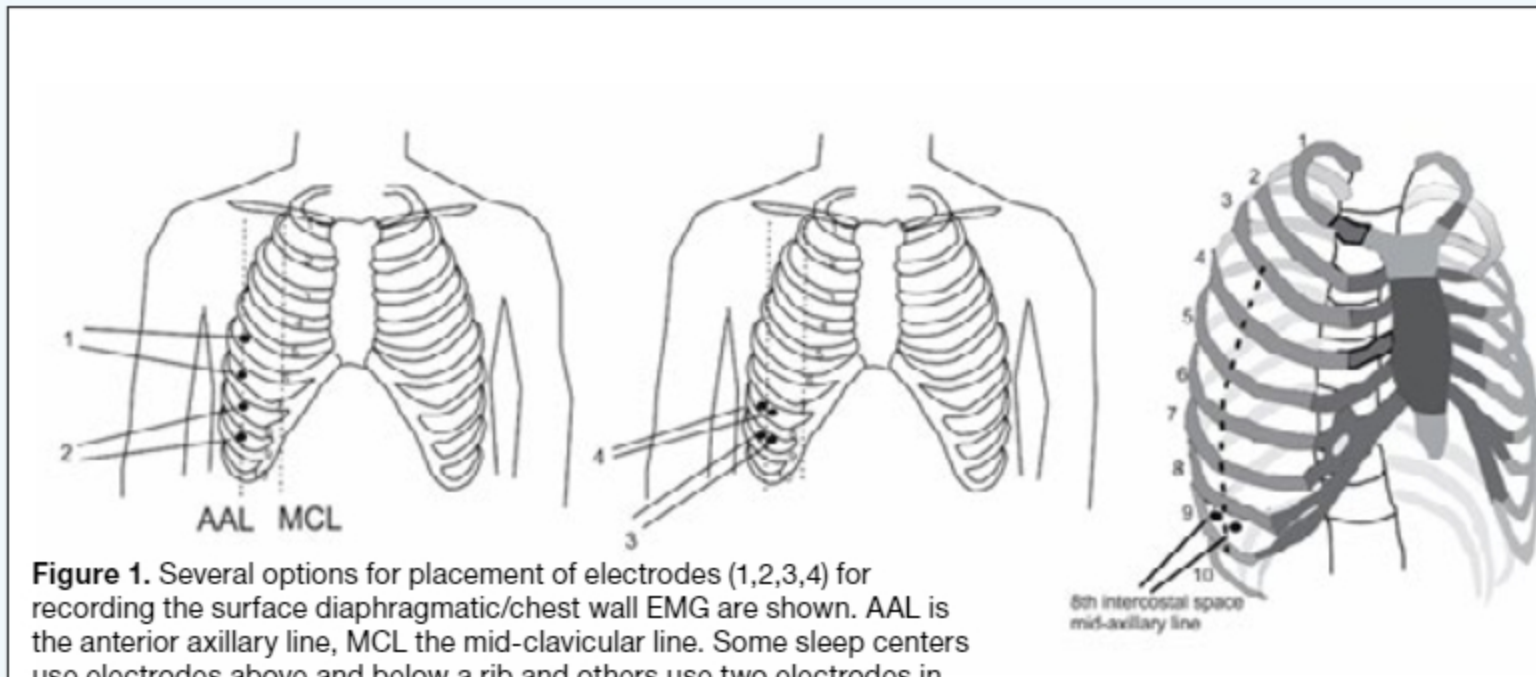


Figure 1. Several options for placement of electrodes (1,2,3,4) for recording the surface diaphragmatic/chest wall EMG are shown. AAL is the anterior axillary line, MCL the mid-clavicular line. Some sleep centers use electrodes above and below a rib and others use two electrodes in the same intercostal space.

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Note 5. Monitoring snoring is optional as noted in Parameters to be Reported (II.F).

Note 6. Monitoring hypoventilation is optional as noted in Parameters to be Reported (II.F).

Note 7. a. . Clinical judgment is essential when assessing the accuracy of end-tidal PCO2 and transcutaneous PCO2 readings. The values should not be assumed to be accurate surrogates of the arterial PCO2 when the values do not fit the clinical picture.

b. The transcutaneous PCO_2 sensor should be calibrated with a reference gas according to the manufacturer's recommendations and when the accuracy of the reading is doubtful. Of note, the value of the transcutaneous PCO_2 typically lags behind changes in the arterial PCO_2 by two minutes or more.

c. The end-tidal PCO_2 often malfunctions or provides falsely low values in patients who have marked nasal obstruction, profuse nasal secretions, are obligate mouth breathers, or who are receiving supplemental oxygen It is crucial to obtain a plateau in the end-tidal waveform for the signal to be considered valid.

B. Measuring Event Duration

1. **For scoring either an apnea or a hypopnea, the event duration is measured from the nadir preceding the first breath that is clearly reduced to the beginning of the first breath that approximates the baseline breathing amplitude.** (see red bracket, Figures 2 and 3) RECOMMENDED

2. **For apnea duration, the oronasal thermal sensor signal (diagnostic study) or PAP device flow signal (PAP titration study) should be used to determine the event duration. For hypopnea event duration, the nasal pressure signal (diagnostic study) or PAP device flow signal (PAP titration study) should be utilized. When the diagnostic study sensors fail or are inaccurate, *alternative* sensors may be used.** (see Technical Specifications for adults A.2 and A.4) RECOMMENDED

3. **When baseline breathing amplitude cannot be easily determined (and when underlying breathing variability is large), events can also be terminated when either there is a clear and sustained increase in breathing amplitude, or in the case where a desaturation has occurred, there is event-associated resaturation of at least 2%.** RECOMMENDED

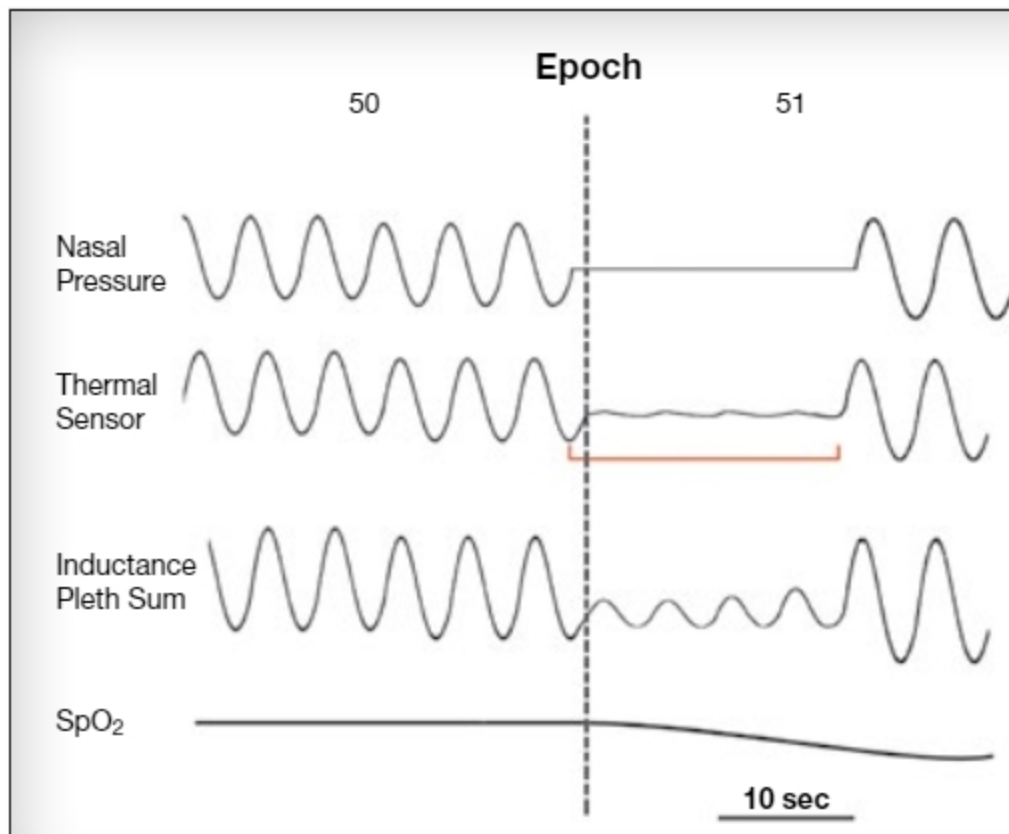


Figure 2. A respiratory event that should be scored as an apnea. The red bracket indicates the full duration of the apnea event.

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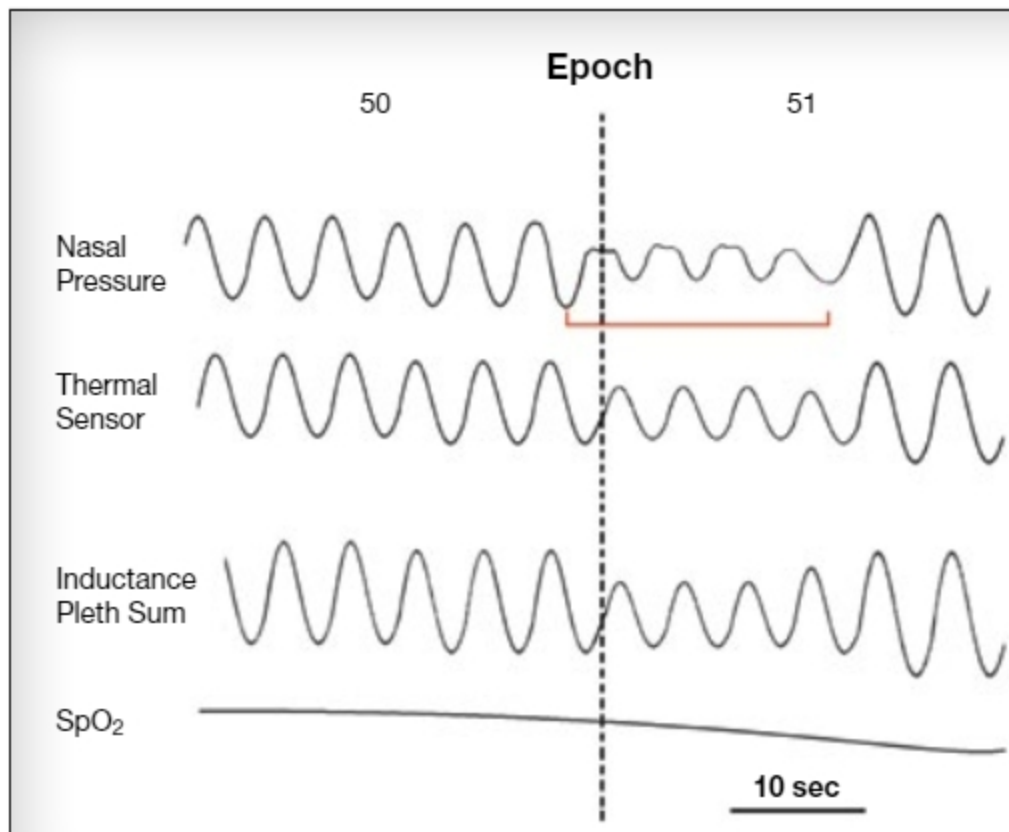


Figure 3. A respiratory event that should be scored as a hypopnea. The red bracket indicates the full duration of the hypopnea event.

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C. Scoring of Apneas

1. **Score a respiratory event as an apnea when BOTH of the following criteria are met:**[N1,N2,N3,N4] (see Figure 2) RECOMMENDED
   a. There is a drop in the peak signal excursion by ≥90% of pre-event baseline using an oronasal thermal sensor (diagnostic study), PAP device flow (titration study) or an *alternative* apnea sensor (diagnostic study).
   b. The duration of the ≥90% drop in sensor signal is ≥10 seconds.

2. **Score an apnea as obstructive if it meets apnea criteria and is associated with continued or increased inspiratory effort throughout the entire period of absent airflow.** RECOMMENDED

3. **Score an apnea as central if it meets apnea criteria and is associated with absent inspiratory effort throughout the entire period of absent airflow.** RECOMMENDED

4. **Score an apnea as mixed if it meets apnea criteria and is associated with absent inspiratory effort in the initial portion of the event, followed by resumption of inspiratory effort in the second portion of the event.**[N5] RECOMMENDED

Note 1. Identification of an apnea does not require a minimum desaturation criterion.

Note 2. If a portion of a respiratory event that would otherwise meet criteria for a hypopnea meets criteria for apnea, the entire event should be scored as an apnea. (see Figure 4)

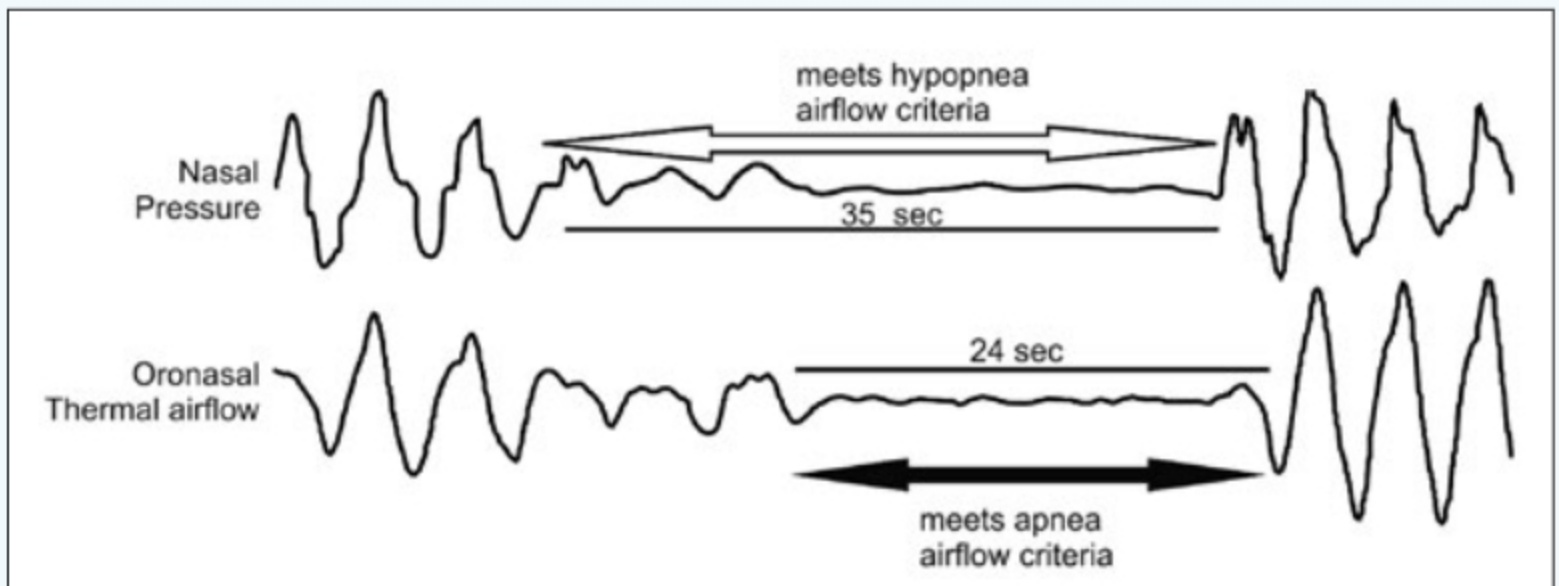


Figure 4. The longer duration, depicted by the white arrows in the nasal pressure channel, meets airflow criteria for a hypopnea, whereas the shorter duration, depicted by the black arrows in the oronnasal thermal airflow channel, meets airflow criteria for an apnea. The event would be scored as an apnea.

Note 3. If the apnea or hypopnea event begins or ends during an epoch that is scored as sleep, then the corresponding respiratory event can be scored and included in the computation of the apnea-hypopnea index (AHI). This situation usually occurs when an individual has a high AHI with events occurring so frequently that sleep is severely disrupted, and epochs may end up being scored as wake even though <15 seconds of sleep is present during the epoch containing that portion of the respiratory event. However, if the apnea or hypopnea occurs entirely during an epoch scored as wake, it should not be scored or counted towards the apnea-hypopnea index because of the difficulty of defining a denominator in this situation. If these occurrences are a prominent feature of the polysomnogram and/or interfere with sleep onset, their presence should be mentioned in the narrative summary of the study.

Note 4. For *alternative* apnea sensors see Technical Specifications for adults (A.2).

Note 5. There is not sufficient evidence to support a specific duration of the central and obstructive components of a mixed apnea; thus, specific durations of these components are not recommended.

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D. Scoring of Hypopneas

Scoring hypopneas as central or obstructive events is optional as noted in Parameters to be Reported (II.F).

1A. Score a respiratory event as a hypopnea if ALL of the following criteria are met: [N1,N2,N3] (see Figure 3) RECOMMENDED

a. The peak signal excursions drop by ≥30% of pre-event baseline using nasal pressure (diagnostic study), PAP device flow (titration study), or an *alternative* hypopnea sensor (diagnostic study).
b. The duration of the ≥30% drop in signal excursion is ≥10 seconds.
c. There is a ≥3% oxygen desaturation from pre-event baseline or the event is associated with an arousal.

1B. Score a respiratory event as a hypopnea if ALL of the following criteria are met: [N1,N2,N3] ACCEPTABLE

a. The peak signal excursions drop by ≥30% of pre-event baseline using nasal pressure (diagnostic study), PAP device flow (titration study), or an *alternative* hypopnea sensor (diagnostic study).
b. The duration of the ≥30% drop in signal excursion is ≥10 seconds.
c. There is a ≥4% oxygen desaturation from pre-event baseline.

2. If electing to score obstructive hypopneas, score a hypopnea as obstructive if ANY of the following criteria are met: RECOMMENDED

a. There is snoring during the event.
b. There is increased inspiratory flattening of the nasal pressure or PAP device flow signal compared to baseline breathing.
c. There is an associated thoracoabdominal paradox that occurs during the event but not during pre-event breathing.

3. If electing to score central hypopneas, score a hypopnea as central if NONE of the following criteria are met: RECOMMENDED

a. There is snoring during the event.
b. There is increased inspiratory flattening of the nasal pressure or PAP device flow signal compared to baseline breathing.
c. There is an associated thoracoabdominal paradox that occurs during the event but not during pre-event breathing.

Note 1. The criteria used to score a respiratory event as a hypopnea (either rule 1A or 1B) should be specified in the PSG report. It is the responsibility of the individual practitioner to confirm and follow the criteria that should be used for reporting to the patient's payer in order to be reimbursed and qualify the patient for therapy.

Note 2. For *alternative* hypopnea sensors see Technical Specifications for adults (A.4).

Note 3. Supplemental oxygen may blunt desaturation. There are currently no scoring guidelines for when a patient is on supplemental oxygen and no desaturation is noted. If the diagnostic study is performed while the individual is on supplemental oxygen, its presence should be mentioned in the narrative summary of the study.

E. Scoring Respiratory Effort-Related Arousal

Scoring respiratory effort-related arousals is optional as noted in Parameters to be Reported (II.F).

1. If electing to score respiratory effort-related arousals, score a respiratory event as a respiratory effort-related arousal (RERA) if there is a sequence of breaths lasting ≥10 seconds characterized by increasing respiratory effort or by flattening of the inspiratory portion of the nasal pressure (diagnostic study) or PAP device flow (titration study) waveform leading to arousal from sleep when the sequence of breaths does not meet criteria for an apnea or hypopnea. (see Figure 5) RECOMMENDED

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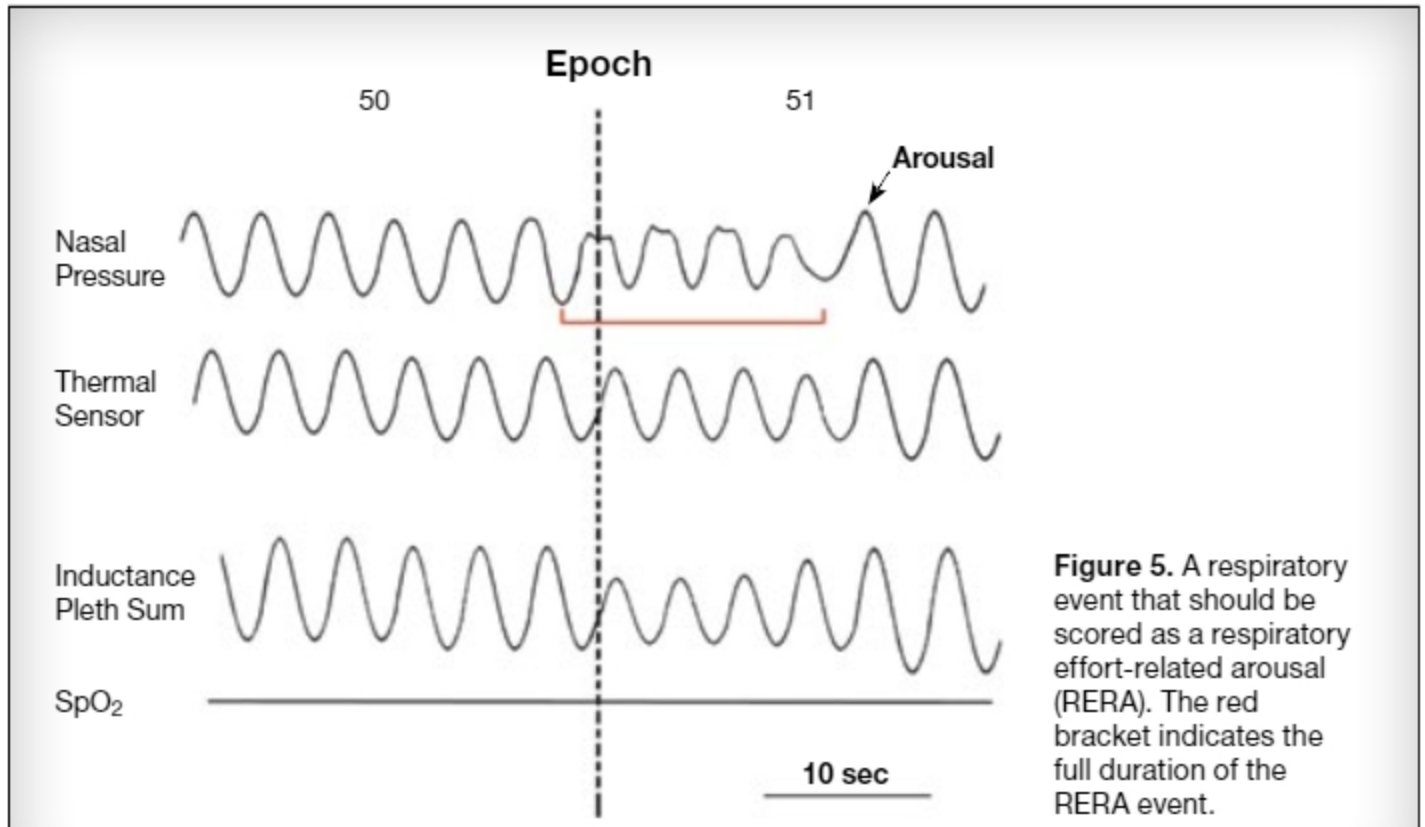


Figure 5. A respiratory event that should be scored as a respiratory effort-related arousal (RERA). The red bracket indicates the full duration of the RERA event.

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F. Scoring Hypoventilation

Monitoring hypoventilation is optional as noted in Parameters to be Reported (II.F).

1. If electing to score hypoventilation, score hypoventilation during sleep if EITHER of the below occur: [N1,N2] RECOMMENDED

a. There is an increase in the arterial PCO_2 (or surrogate) to a value >55 mmHg for ≥10 minutes.

b. There is ≥10 mmHg increase in arterial PCO_2 (or surrogate) during sleep (in comparison to an awake supine value) to a value exceeding 50 mmHg for ≥10 minutes.

Note 1. See Technical Specifications for adults (A.9 and A.10) for information on surrogate signals for monitoring hypoventilation.

Note 2. Use the following conversion factor in order to change the units of the pressures listed from mmHg to kPa: 1 mmHg = 0.133 kPA.

G. Scoring Cheyne-Stokes Breathing

1. Score a respiratory event as Cheyne-Stokes breathing if BOTH of the following are met: [N1,N2] (see Figure 6) RECOMMENDED

a. There are episodes of ≥3 consecutive central apneas and/or central hypopneas separated by a crescendo and decrescendo change in breathing amplitude with a cycle length of ≥40 seconds.

b. There are ≥5 central apneas and/or central hypopneas per hour of sleep associated with the crescendo/decrescendo breathing pattern recorded over ≥2 hours of monitoring.

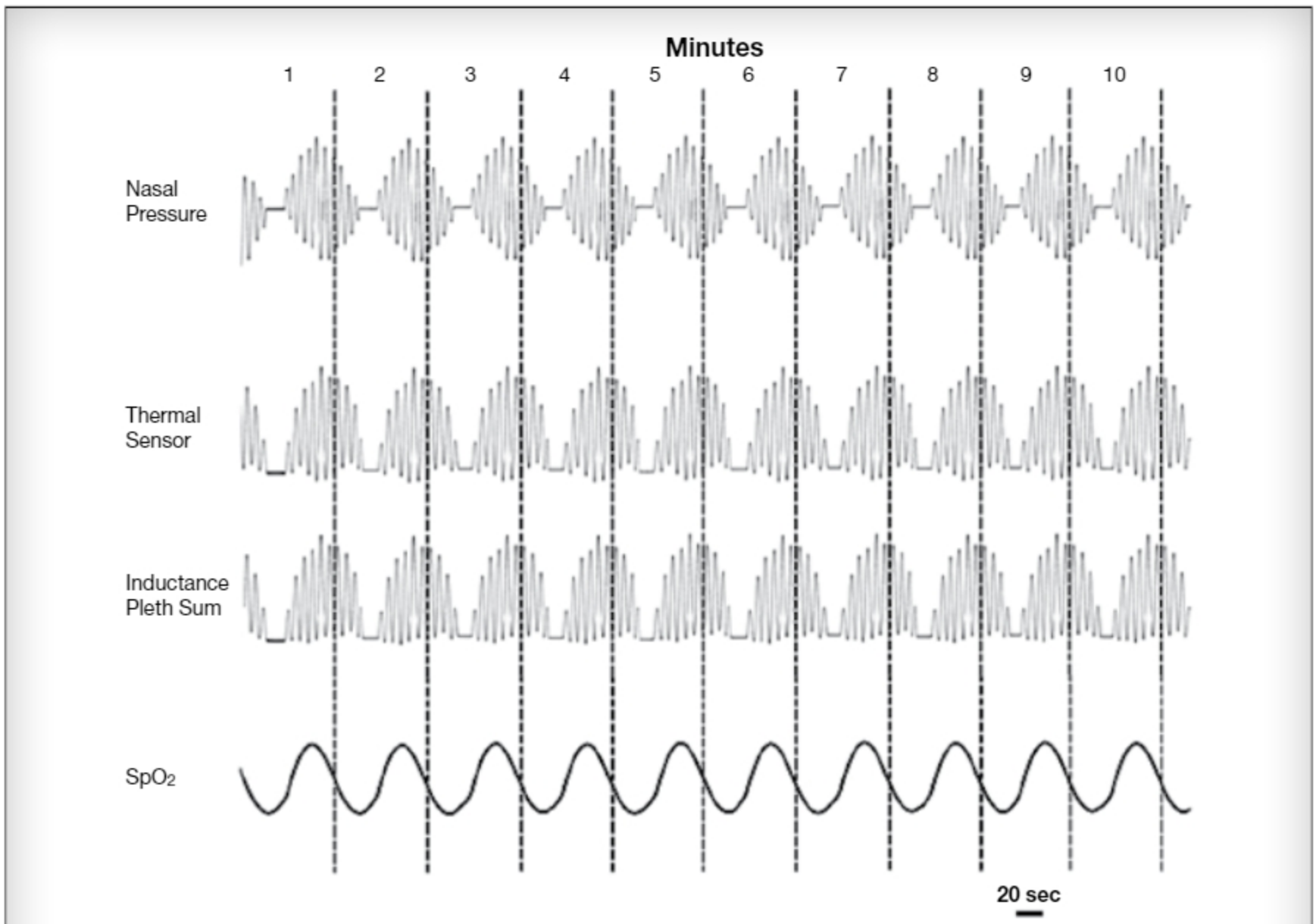


Figure 6. A respiratory event that should be scored as Cheyne-Stokes breathing due ≥3 consecutive apneas with crescendo and decrescendo breathing in between.

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Note 1. Cycle length is the time from the beginning of a central apnea to the end of the next crescendo-decrescendo respiratory phase (start of the next apnea).

Note 2. Central apneas that occur within a run of Cheyne-Stokes breathing should be scored as individual apneas as well.

H. Special Circumstances for Scoring Respiratory Events

Scoring respiratory events during a positive airway pressure (PAP) titration using a backup rate:

1. **Score a respiratory event occurring during PAP device-triggered breaths as a central apnea if all of the following criteria are met:**[N1] RECOMMENDED
   a. There is a decrease in the PAP flow signal meeting apnea criteria
   b. Device triggered pressure pulses (pressure support) occur during the event
   c. There is no evidence of spontaneous (patient triggered) respiratory effort during the event

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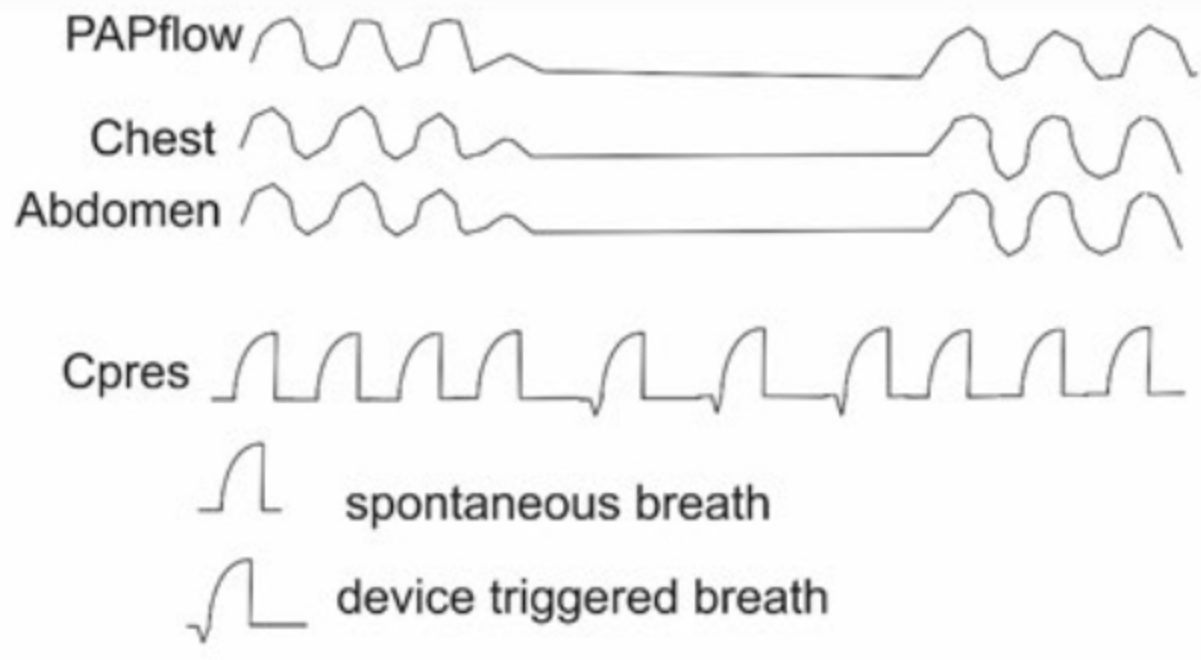


Figure 7. A central apnea during PAP device-triggered breaths. A reduction in PAP flow meeting criteria for an apnea is present. Cpres is the delivered pressure signal from the PAP device. The small downward artifact identifies a device-triggered pressure pulse. During the apnea, several device-triggered pressure pulses are noted in the absence of deflections in the chest or abdominal effort belt signals.

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Note 1. Laboratories should check with the manufacturer of their polysomnogram recording equipment to determine whether it is capable of displaying device-triggered pressure pulses and/or the proper configuration required to display them.

VIII. Respiratory Rules Part 2: Rules for Children

A. Ages for Which Pediatric Respiratory Scoring Rules Apply

1. Criteria for respiratory events during sleep for infants and children can be used for children <18 years, but an individual sleep specialist can choose to score children ≥13 years using adult criteria.[N1] RECOMMENDED

> Note 1. Several studies suggest that the apnea-hypopnea index (AHI) will be higher in adolescent patients when using pediatric compared to the adult rules presented in the 2007 version of the AASM scoring manual. As adult hypopnea rule 1A and pediatric hypopnea rules are similar, there may now be less difference in the AHI when using adult versus pediatric rules.

B. Technical Specifications

1. For identification of an apnea during a diagnostic study, use an oronasal thermal airflow sensor to monitor airflow.[N1] RECOMMENDED

2. For identification of an apnea during a diagnostic study *when the oronasal thermal airflow sensor is not functioning or the signal is not reliable*, use one of the following (*alternative* apnea sensors):[N2]

a. nasal pressure transducer (with or without square root transformation) RECOMMENDED
b. Respiratory inductance plethysmography sum (RIPsum) (calibrated or uncalibrated) RECOMMENDED
c. Respiratory inductance plethysmography flow (RIPflow) (calibrated or uncalibrated) RECOMMENDED
d. end-tidal PCO_2 ACCEPTABLE
e. PVDFsum ACCEPTABLE

3. For identification of a hypopnea during a diagnostic study, use a nasal pressure transducer (with or without square root transformation of the signal) to monitor airflow.[N3] RECOMMENDED

4. For identification of a hypopnea during a diagnostic study *when the nasal pressure transducer is not functioning or the signal is not reliable*, use one of the following to monitor airflow (*alternative* hypopnea sensors):[N2]

a. oronasal thermal airflow RECOMMENDED
b. RIPsum (calibrated or uncalibrated) RECOMMENDED
c. RIPflow (calibrated or uncalibrated) RECOMMENDED
d. dual thoracoabdominal RIP belts (calibrated or uncalibrated) RECOMMENDED
e. PVDFsum ACCEPTABLE

5. During positive airway pressure (PAP) titration, use the PAP device flow signal to identify apneas or hypopneas. RECOMMENDED

6. For monitoring respiratory effort, use one of the following:

a. esophageal manometry RECOMMENDED
b. dual thoracoabdominal RIP belts (calibrated or uncalibrated) RECOMMENDED
c. dual thoracoabdominal PVDF belts ACCEPTABLE

7. For monitoring oxygen saturation, use pulse oximetry with a maximum acceptable signal averaging time of ≤3 seconds at a heart rate of 80 beats per minute. RECOMMENDED

8. For monitoring snoring, use an acoustic sensor (e.g., microphone), piezoelectric sensor or nasal pressure transducer[N4] RECOMMENDED

9. For detection of hypoventilation during a diagnostic study, use arterial PCO_2, transcutaneous PCO_2 or end-tidal PCO_2.[N5,N6] RECOMMENDED

10. For detection of hypoventilation during PAP titration, use arterial PCO_2, or use transcutaneous PCO_2.[N5,N6] RECOMMENDED

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Note 1. Thermal sensors include thermistors, thermocouples, or polyvinylidene fluoride (PVDF) airflow sensors.

Note 2. The RIPsum is the sum of the signals from thoracic and abdominal RIP sensors (belts) and excursions in the signal are an estimate of tidal volume. The RIPflow is the time derivative of the RIPsum and excursions in the signal are an estimate of airflow. Recording of RIPsum or RIPflow is optional.

Note 3. Using the nasal pressure signal without square root transformation for scoring hypopneas will result in a slightly higher hypopnea index than scoring using a square root transformation of the signal. This difference is not clinically significant in most patients.

Note 4. Monitoring snoring is optional, as noted in Parameters to be Reported (II.F).

Note 5. Monitoring hypoventilation during diagnostic study is recommended, as noted in Parameters to be Reported (II.F). Monitoring hypoventilation during PAP titration is optional, as noted in Parameters to be Reported (II.F)

Note 6. a. Clinical judgment is essential when assessing the accuracy of end-tidal PCO_2 and transcutaneous PCO_2 readings. The values should not be assumed to be accurate surrogates of the arterial PCO_2 when the values do not fit the clinical picture.

b. The transcutaneous PCO_2 sensor should be calibrated with a reference gas according to the manufacturer's recommendations and when the accuracy of the reading is doubtful. Of note, the value of the transcutaneous PCO_2 typically lags behind changes in the arterial PCO_2 by two minutes or more.

c. The end-tidal PCO_2 often malfunctions or provides falsely low values in patients who have marked nasal obstruction, profuse nasal secretions, are obligate mouth breathers, or who are receiving supplemental oxygen It is crucial to obtain a plateau in the end-tidal waveform for the signal to be considered valid.

C. Measuring Event Duration

1. Same as Measuring Event Duration in adults (B.1–3)[N1,N2] RECOMMENDED

Note 1. For *alternative* apnea sensors see Technical Specifications for children (B.2).

Note 2. For *alternative* hypopnea sensors see Technical Specifications for children (B.4).

D. Scoring of Apneas

1. Score a respiratory event as an apnea when ALL of the following criteria are met:[N1,N2,N3,N4,N5,N6] RECOMMENDED

a. There is a drop in the peak signal excursion by ≥90% of pre-event baseline using an oronasal thermal sensor (diagnostic study), PAP device flow (titration study), or an *alternative* apnea sensor (diagnostic study).

b. The duration of the ≥90% drop in sensor signal lasts at least the minimum duration as specified by obstructive, mixed, or central apnea duration criteria.

c. The event meets respiratory effort criteria for obstructive, central or mixed apnea.

2. Score an apnea as obstructive if it meets apnea criteria for at least the duration of 2 breaths during baseline breathing AND is associated with the presence of respiratory effort throughout the entire period of absent airflow. RECOMMENDED

3. Score an apnea as central if it meets apnea criteria, is associated with absent inspiratory effort throughout the entire duration of the event AND at least one of the following is met: RECOMMENDED

a. The event lasts ≥20 seconds.

b. The event lasts at least the duration of two breaths during baseline breathing and is associated with an arousal or a ≥3% arterial oxygen desaturation.

c. The event lasts at least the duration of two breaths during baseline breathing and is associated with a decrease in heart rate to less than 50 beats per minute for at least 5 seconds or less than 60 beats per minute for 15 seconds (infants under 1 year of age only).

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4. Score an apnea as mixed if it meets apnea criteria for at least the duration of 2 breaths during baseline breathing AND is associated with absent respiratory effort during one portion of the event AND the presence of inspiratory effort in another portion, regardless of which portion comes first. RECOMMENDED

Note 1. Identification of an apnea does not require a minimum desaturation criterion.

Note 2. If a portion of a respiratory event that would otherwise meet criteria for a hypopnea meets criteria for apnea (including 2 breath minimum), the entire event should be scored as an apnea.

Note 3. If the apnea or hypopnea event begins or ends during an epoch that is scored as sleep, then the corresponding respiratory event can be scored and included in the computation of the apnea-hypopnea index (AHI). This situation usually occurs when an individual has a high AHI with events occurring so frequently that sleep is severely disrupted and epochs may end up being scored as wake even though <15 seconds of sleep is present during the epochs containing that portion of the respiratory event. However, if the apnea or hypopnea occurs entirely during an epoch scored as wake, it should not be scored or counted towards the AHI because of the difficulty of defining a denominator in this situation. If these occurrences are a prominent feature of the polysomnogram and/or interfere with sleep onset, their presence should be mentioned in the narrative summary of the study.

Note 4. For *alternative* apnea sensors see Technical Specifications for children (B.2).

Note 5. There is not sufficient evidence to support a specific duration of the central and obstructive components of a mixed apnea; thus, specific durations of these components are not recommended.

Note 6. While not a requirement for reporting, it is valuable to describe any airway protective maneuvers, such as persistent mouth opening/mouth breathing, neck hyperextension and avoidance of sleep in the supine position, as these can be supplemental evidence of obstructive sleep apnea.

E. Scoring of Hypopneas

Scoring hypopneas as central or obstructive events is optional as noted in Parameters to be Reported (II.F).

1. Score a respiratory event as a hypopnea if ALL of the following criteria are met: [N1,N2,N3] RECOMMENDED

a. The peak signal excursions drop by ≥30% of pre-event baseline using nasal pressure (diagnostic study), PAP device flow (titration study) or an *alternative* hypopnea sensor (diagnostic study).
b. The duration of the ≥30% drop in signal excursion lasts for ≥2 breaths.
c. There is a ≥3% oxygen desaturation from pre-event baseline or the event is associated with an arousal.

2. If electing to score obstructive hypopneas, score a hypopnea as obstructive if ANY of the following criteria are met: RECOMMENDED

a. There is snoring during the event.
b. There is increased inspiratory flattening of the nasal pressure or PAP device flow signal compared to baseline breathing.
c. There is an associated thoracoabdominal paradox that occurs during the event but not during pre-event breathing.

3. If electing to score central hypopneas, score a hypopnea as central if NONE of the following criteria are met: RECOMMENDED

a. There is snoring during the event.
b. There is increased inspiratory flattening of the nasal pressure or PAP device flow signal compared to baseline breathing.
c. There is an associated thoracoabdominal paradox that occurs during the event but not during pre-event breathing.

Note 1. For *alternative* hypopnea sensors see Technical Specifications for children (B.4).

Note 2. Supplemental oxygen may blunt desaturation. There are currently no scoring guidelines for when a patient is on supplemental oxygen and no desaturation is noted. If the diagnostic study is performed while the individual is on supplemental oxygen, its presence should be mentioned in the narrative summary of the study.

Note 3. While not a requirement for reporting, it is valuable to describe any airway protective maneuvers, such as persistent mouth opening/mouth breathing, neck hyperextension and avoidance of sleep in the supine position, as these can be supplemental evidence of obstructive sleep apnea.

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F. Scoring Respiratory Effort-Related Arousal

Scoring respiratory effort-related arousals is optional as noted in Parameters to be Reported (II.F).

1. **If electing to score respiratory effort-related arousals, score a respiratory event as a RERA if there is a sequence of breaths lasting ≥2 breaths (or the duration of two breaths during baseline breathing) that do not meet criteria for an apnea or hypopnea and lead to an arousal from sleep. The breathing sequence can be characterized when one or more of the following is present:** RECOMMENDED
   a. Increasing respiratory effort
   b. Flattening of the inspiratory portion of the nasal pressure (diagnostic study) or PAP device flow (titration study) waveform
   c. Snoring
   d. An elevation in the end-tidal PCO_2 above pre-event baseline

G. Scoring of Hypoventilation

Monitoring hypoventilation in children is recommended during a diagnostic study and optional during a PAP titration study.

1. **Score as hypoventilation during sleep when >25% of the total sleep time as measured by either the arterial PCO_2 or surrogate is spent with a PCO_2 >50 mmHg.**[N1,N2] RECOMMENDED

> Note 1. See Technical Specifications for children (B.9 and B.10) for information on surrogate signals for monitoring hypoventilation.
>
> Note 2. Use the following conversion factor in order to change the units of the pressures listed from mmHg to kPa: 1 mmHg = 0.133 kPA.

H. Scoring of Periodic Breathing

1. **Score a respiratory event as periodic breathing if there are ≥3 episodes of central pauses in respiration (absent airflow and inspiratory effort) lasting >3 seconds separated by ≤20 seconds of normal breathing.**[N1] RECOMMENDED

> Note 1. Central apneas that occur within a run of periodic breathing should be scored as individual apneas as well.

I. Special Circumstances for Scoring Respiratory Events

Scoring respiratory events during a positive airway pressure (PAP) titration using a backup rate:

1. **Score a respiratory event occurring during PAP device-triggered breaths as a central apnea if all of the following criteria are met:**[N1] RECOMMENDED
   a. There is a decrease in the PAP flow signal meeting apnea criteria
   b. Device triggered pressure pulses (pressure support) occur during the event
   c. There is no evidence of spontaneous (patient triggered) respiratory effort during the event

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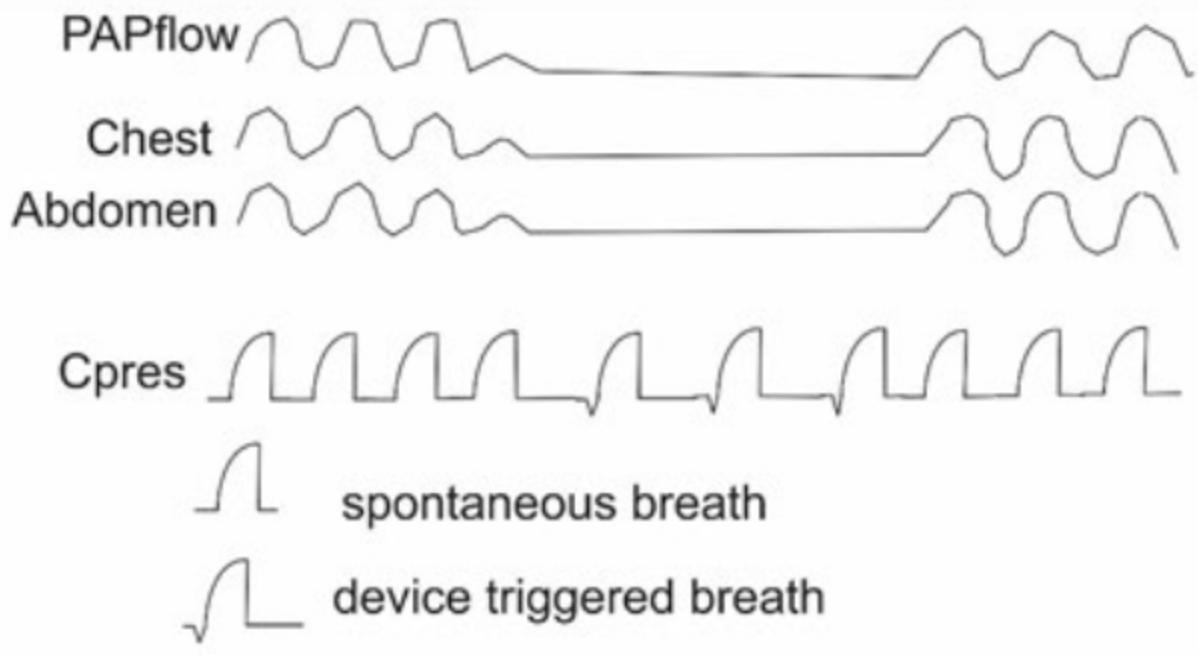


Figure 1. A central apnea during PAP device-triggered breaths. A reduction in PAP flow meeting criteria for an apnea is present. Cpres is the delivered pressure signal from the PAP device. The small downward artifact identifies a device-triggered pressure pulse. During the apnea, several device-triggered pressure pulses are noted in the absence of deflections in the chest or abdominal effort belt signals.

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Note 1. Laboratories should check with the manufacturer of their polysomnogram recording equipment to determine whether it is capable of displaying device-triggered pressure pulses and/or the proper configuration required to display them.

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IX. Home Sleep Apnea Testing (HSAT) Rules for Adults

Part 1: HSAT Utilizing Respiratory Flow and/or Effort Parameters

Recommended parameters must be reported. Optional parameters may be monitored at the discretion of the clinician or investigator and if monitored, should be reported.

A. General Parameters to be Reported[N1]

1. Type of device	RECOMMENDED
2. Type of airflow sensor(s)[N2]	RECOMMENDED
3. Type of respiratory effort sensor(s) (single or dual)	RECOMMENDED
4. Oxygen saturation	RECOMMENDED
5. Heart rate (ECG or derived from oximeter)	RECOMMENDED
6. Body position	OPTIONAL
7. Sleep/wake or monitoring time (method of determination)[N3]	OPTIONAL
8. Snoring (acoustic or piezoelectric sensor or signal derived from nasal pressure sensor)	OPTIONAL

Note 1. For alternative measures see Part 2: HSAT Utilizing Peripheral Arterial Tonometry (PAT).

Note 2. Tidal volume sensors (i.e., RIPsum) can also be used.

Note 3. Sleep should be determined using EEG, EOG, and chin (submental) EMG recording. The method used to determine monitoring time (MT) should be specified in the report.

B. Recording Data to be Reported if Sleep is NOT Recorded

1. Recording start time (hr:min)	RECOMMENDED
2. Recording end time (hr:min)	RECOMMENDED
3. Total recording time (TRT) min (including wake and artifact)	RECOMMENDED
4. Monitoring time (MT)[N1] in min (time used to calculate respiratory event index)[N2]	RECOMMENDED
5. Heart rate (average, highest, lowest)	RECOMMENDED
6. Number of respiratory events (RE)	RECOMMENDED
6a. Number of apneas	RECOMMENDED
6b. Number of hypopneas	RECOMMENDED

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6c. Number of obstructive, central, and mixed apneas	OPTIONAL
7. Respiratory event index (REI) based on monitoring time (MT) = (# respiratory events × 60) / MT in min	RECOMMENDED
8. REI in the supine and non-supine positions	OPTIONAL
9. Central apnea index (CAI) = (# central apneas × 60) / MT in min	OPTIONAL
10. A measure of oxygen saturation (one of these three parameters)[N3]	RECOMMENDED
10a. Oxygen desaturation index (ODI) ≥3 or ≥4% = (# oxygen desaturations ≥3% or ≥4% × 60) / MT in min [Specify measure of desaturation ≥3 or ≥4%][N4]	
10b. Arterial oxygen saturation, mean value, maximum value, and minimum value	
10c. Arterial oxygen saturation % of time at or below 88% or other thresholds	
11. Occurrence of snoring (if recorded)	OPTIONAL

Note 1. Monitoring time (MT) = Total recording time minus periods of artifact and time the patient was awake as determined by actigraphy, body position sensor, respiratory pattern, or patient diary. The method used to determine MT should be stated. For reimbursement purposes, individual practitioners may need to indicate in their HSAT report that monitoring time (MT) is being used in place of total recording time (TRT).

Note 2. Respiratory event index (REI) = Total number of respiratory events scored × 60 divided by monitoring time (MT). For reimbursement purposes, individual practitioners may need to indicate in their HSAT report that REI is a surrogate for AHI.

Note 3. Reporting all three parameters may provide important information for the clinician.

Note 4. ODI should report the same desaturation as used for scoring hypopneas. For example, if hypopnea is scored based on a ≥3% desaturation, the ODI should be the number of ≥3% desaturations × 60 divided by MT.

C. Recording Data to be Reported if Sleep is Recorded

1. Recording start time (hr:min)	RECOMMENDED
2. Recording end time (hr:min)	RECOMMENDED
3. Total recording time (TRT) min (including wake and artifact)	RECOMMENDED
4. Total sleep time (TST) in min[N1]	RECOMMENDED
5. Heart rate (average, highest, lowest)	RECOMMENDED
6. Number of respiratory events (RE)	RECOMMENDED
6a. Number of apneas	RECOMMENDED
6b. Number of hypopneas	RECOMMENDED
6c. Number of obstructive, central, and mixed apneas	OPTIONAL

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7. Apnea-hypopnea index (AHI) = ((# apneas + # hypopneas) × 60) / TST in min [N1]	RECOMMENDED
8. AHI in the supine and non-supine positions	OPTIONAL
9. Central apnea index (CAI) = (# central apneas × 60) / TST in min	OPTIONAL
10. A measure of oxygen saturation (one of these three parameters) [N2]	RECOMMENDED
10a. Oxygen desaturation index (ODI) ≥3 or ≥4% = (# oxygen desaturations ≥3% or ≥4% × 60) / TST in min [Specify measure of desaturation ≥3 or ≥4%] [N3]	
10b. Arterial oxygen saturation, mean value, maximum value, and minimum value	
10c. Arterial oxygen saturation % of time at or below 88% or other thresholds	
11. Occurrence of snoring (if recorded)	OPTIONAL

Note 1. This assumes monitoring EEG, EOG, and submental chin EMG.

Note 2. Reporting all three parameters may provide important information for the clinician.

Note 3. ODI should report the same desaturation as used for scoring hypopneas. For example, if hypopnea is scored based on a ≥3% desaturation, the ODI should be the number of ≥3% desaturations × 60 divided by TST.

D. Summary Statements

1. Date of test/date of interpretation	RECOMMENDED
2. Technical adequacy of study (defined by sleep center policy and procedure)	RECOMMENDED
2a. Document repeat study for technical failures	RECOMMENDED
2b. Limitations of study	RECOMMENDED
3. Interpretation of REI (based on MT) or AHI (if sleep is recorded)	RECOMMENDED
4. Occurrence of snoring	OPTIONAL
5. Interpretation	RECOMMENDED
5a. Study supports diagnosis of OSA or not	RECOMMENDED
5b. Statement of diagnostic severity (if applicable)	RECOMMENDED
5c. If study is non-diagnostic, recommend in-laboratory PSG (if clinically indicated)	RECOMMENDED
6. Printed name and signature of interpreting physician (verifying review of raw data)	RECOMMENDED
7. Recommendation for management that meets AASM Clinical Practice Guidelines and Practice Parameters	RECOMMENDED
8. Chain of custody (if applicable)	OPTIONAL

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E. Technical and Digital Specifications: HSAT Equipment Recording Features

1. FDA approval of device	RECOMMENDED
2. Unique identifier for each unit	RECOMMENDED
3. Must meet minimum definition for CPT codes 95800, 95801 or 95806[N1]	RECOMMENDED
4. Ability to record oximetry	RECOMMENDED
5. Ability to record a measure of heart rate	RECOMMENDED
6. Ability to display raw data for review, manual scoring or editing of automated scoring[N2]	RECOMMENDED
7. Ability to calculate a respiratory event index (REI) based on monitoring time (MT) as a surrogate for the apnea-hypopnea index (AHI) determined by PSG	RECOMMENDED
8. Ability to determine chain of custody	OPTIONAL

Note 1. 95800—Sleep study, unattended, simultaneous recording; heart rate, oxygen saturation, respiratory analysis (e.g., by airflow or peripheral arterial tone), and sleep time
95801—Sleep study, unattended, simultaneous recording; heart rate, oxygen saturation, respiratory analysis (e.g., by airflow or peripheral arterial tone)
95806—Sleep study, unattended, simultaneous recording; heart rate, oxygen saturation, respiratory airflow and respiratory effort (e.g., thoracoabdominal movement)

Note 2. Raw tracings must be viewable in detail with the ability to edit events.

F. HSAT Respiratory Events Rules: Technical Specifications

1. For identification of respiratory events (RE) based on respiratory airflow during a home sleep apnea test (HSAT) diagnostic study, use at least one of the following sensors:[N1]

a. oronasal thermal airflow sensor[N2] RECOMMENDED
b. nasal pressure transducer (with or without square root transformation)[N3,N4] RECOMMENDED
c. alternative sensors include:[N5]
   i. respiratory inductance plethysmography sum (RIPsum) or flow (RIPflow) RECOMMENDED
   ii. PVDFsum ACCEPTABLE

2. For monitoring respiratory effort,[N6] **use one of the following technologies:**

a. dual thoracoabdominal RIP belts[N5] RECOMMENDED
b. single thoracoabdominal RIP belts[N5] ACCEPTABLE
c. single or dual thoracoabdominal PVDF belts[N5] ACCEPTABLE
d. single or dual thoracoabdominal piezo belts[N5] ACCEPTABLE
e. single or dual pneumatic belts[N5] ACCEPTABLE

3. For monitoring oxygen saturation, use pulse oximetry.[N7] RECOMMENDED

4. For monitoring snoring, use an acoustic sensor (e.g., microphone), piezoelectric sensor or nasal pressure transducer. OPTIONAL

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Note 1. At least one airflow sensor is required. Ideally both an oronasal thermal sensor and a nasal pressure transducer should be used to record airflow. An alternative sensor (as listed above) may be a substituted for an oronasal thermal sensor.

Note 2. Thermal sensors include thermistors, thermocouples, or polyvinylidene fluoride (PVDF) airflow sensors. If used without simultaneous nasal pressure monitoring, some thermal sensors may be less sensitive for detection of hypopneas.

Note 3. Using the nasal pressure signal without square root transformation for scoring sleep-related respiratory events (SRE) will result in a slightly higher hypopnea index than scoring using a square root transformation of the signal. This difference is not clinically significant in most patients.

Note 4. If the nasal pressure signal is used without simultaneous recording of oronasal thermal sensor signal, some hypopneas may be classified as apneas.

Note 5. The RIPsum is the sum of the signals from thoracic and abdominal RIP sensors (belts) and excursions in the signal are an estimate of tidal volume. The RIPflow is the time derivative of the RIPsum and excursions in the signal are an estimate of airflow. The PVDFsum is the sum of signals from thoracic and abdominal PVDF sensors (belts).

Note 6. Only CPT code 95806 requires respiratory effort monitoring. If respiratory effort monitoring is performed one of these technologies should be used. The use of two belts is preferred; however, one respiratory monitoring belt is acceptable.

Note 7. The recording device should meet the same requirements for oximetry as the in-laboratory PSG.

G. HSAT Respiratory Events Rules: Scoring Apnea Utilizing Respiratory Flow and/or Effort Sensors

1. Score a respiratory event as an apnea when BOTH of the following criteria are met: [N1,N2,N3,N4] **RECOMMENDED**

a. There is a drop in the peak signal excursion by ≥90% of pre-event baseline using a recommended or *alternative* airflow sensor.
b. The duration of the ≥90% drop in sensor signal is ≥10 seconds.

2. Score an apnea as obstructive if it meets apnea criteria and is associated with continued or increased inspiratory effort throughout the entire period of absent airflow. **RECOMMENDED**

3. Score an apnea as central if it meets apnea criteria and is associated with absent inspiratory effort throughout the entire period of absent airflow. **RECOMMENDED**

4. Score an apnea as mixed if it meets apnea criteria and is associated with absent inspiratory effort in the initial portion of the event, followed by resumption of inspiratory effort in the second portion of the event. **RECOMMENDED**

Note 1. Identification of an apnea does not require a minimum desaturation criterion.

Note 2. If a portion of a respiratory event that would otherwise meet criteria for a hypopnea meets criteria for apnea, the entire event should be scored as an apnea.

Note 3. There is not sufficient evidence to support a specific duration of the central and obstructive components of a mixed apnea; thus, specific durations of these components are not recommended.

Note 4. Some devices may not differentiate between different types of apneas.

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H. HSAT Respiratory Events Rules: Scoring Hypopnea Utilizing Respiratory Flow and/or Effort Sensors[N1]

1A. If sleep is NOT recorded, score a respiratory event as a hypopnea if ALL of the following criteria are met:[N1] RECOMMENDED

a. The peak signal excursions drop by ≥30% of pre-event baseline using a recommended or *alternative* airflow sensor.
b. The duration of the ≥30% drop in signal excursion is ≥10 seconds.
c. There is a ≥3% oxygen desaturation from pre-event baseline.

1B. If sleep is NOT recorded, score a respiratory event as a hypopnea if ALL of the following criteria are met:[N1] ACCEPTABLE

a. The peak signal excursions drop by ≥30% of pre-event baseline using a recommended or *alternative* airflow sensor.
b. The duration of the ≥30% drop in signal excursion is ≥10 seconds.
c. There is a ≥4% oxygen desaturation from pre-event baseline.

2A. If sleep IS recorded, score a respiratory event as a hypopnea if ALL of the following criteria are met:[N1,N2] RECOMMENDED

a. The peak signal excursions drop by ≥30% of pre-event baseline using a recommended or *alternative* airflow sensor.
b. The duration of the ≥30% drop in signal excursion is ≥10 seconds.
c. There is a ≥3% oxygen desaturation from pre-event baseline or the event is associated with an arousal.[N2]

2B. If sleep IS recorded, score a respiratory event as a hypopnea if ALL of the following criteria are met:[N1,N2] ACCEPTABLE

a. The peak signal excursions drop by ≥30% of pre-event baseline using a recommended or *alternative* airflow sensor.
b. The duration of the ≥30% drop in signal excursion is ≥10 seconds.
c. There is a ≥4% oxygen desaturation from pre-event baseline.

Note 1. The criteria used to score a respiratory event as a hypopnea should be specified in the report.

Note 2. Scoring a hypopnea based on arousals is only possible if sleep is recorded.

I. References

The following references apply to content throughout chapter IX. Home Sleep Apnea Testing (HSAT) Rules for Adults Part 1: HSAT Utilizing Respiratory Flow and/or Effort Parameters.

1. Collop NA, Anderson WM, Boehlecke B, et al.; for the Portable Monitoring Task Force of the American Academy of Sleep Medicine. Clinical guidelines for the use of unattended portable monitors in the diagnosis of obstructive sleep apnea in adult patients. *J Clin Sleep Med*. 2007;3(7):737–747.
2. Collop NA, Tracy SL, Kapur V, et al. Obstructive sleep apnea devices for out-of-center (OOC) testing: technology evaluation. *J Clin Sleep Med*. 2011;7(5):531–548.

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IX. Home Sleep Apnea Testing (HSAT) Rules for Adults

Part 2: HSAT Utilizing Peripheral Arterial Tonometry (PAT)

Recommended parameters must be reported. Optional parameters may be monitored at the discretion of the clinician or investigator and if monitored, should be reported.

A. General Parameters to be Reported

1. Type of device	RECOMMENDED
2. Sleep/wake and REM time estimates	RECOMMENDED
3. Airflow/effort surrogate (peripheral arterial tone) signals	RECOMMENDED
4. Oxygen saturation	RECOMMENDED
5. Heart rate	RECOMMENDED
6. Occurrence of snoring (if recorded)	OPTIONAL
7. Body position (if recorded)	OPTIONAL

B. Recording Data to be Reported

1. Recording start time (hr:min)	RECOMMENDED
2. Recording end time (hr:min)	RECOMMENDED
3. Duration of recording (hr:min) (total recording time, TRT)	RECOMMENDED
4. Estimated sleep time (in min)	RECOMMENDED
4a. Estimated % REM, deep sleep, light sleep	OPTIONAL
5. Heart rate (average, highest, lowest)	RECOMMENDED
6. Respiratory event index (REI; use peripheral arterial tonometry AHI (pAHI) as a surrogate for REI)	RECOMMENDED
7. Oxygen desaturation index (ODI) ≥4% = (# oxygen desaturations ≥4% × 60) / MT in min	RECOMMENDED

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C. Summary Statements

1. Date of test/Date of interpretation	RECOMMENDED
2. Technical adequacy of study (defined by sleep center policy and procedure)	RECOMMENDED
2a. Document repeat study for technical failures	RECOMMENDED
2b. Limitations of study	RECOMMENDED
3. Interpretation of estimated sleep time	RECOMMENDED
4. Occurrence of snoring	OPTIONAL
5. Interpretation	RECOMMENDED
5a. Study supports diagnosis of OSA or not	RECOMMENDED
5b. Statement of diagnostic severity (if applicable)	RECOMMENDED
5c. If study is non-diagnostic, recommend in-laboratory PSG (if clinically indicated)	RECOMMENDED
6. Printed name and signature of interpreting physician (verifying review of raw data)	RECOMMENDED
7. Recommendation for management that meets AASM Clinical Practice Guidelines and Practice Parameters	RECOMMENDED
8. Chain of custody (if applicable)	OPTIONAL

D. Technical and Digital Specifications: HSAT Equipment Recording Features

1. FDA approval of device	RECOMMENDED
2. Unique identifier for each unit	RECOMMENDED
3. Must meet minimum definition for CPT codes 95800 or 95801[N1]	RECOMMENDED
4. Ability to record oximetry	RECOMMENDED
5. Ability to record a measure of heart rate	RECOMMENDED
6. Ability to display raw data for review, manual scoring or editing of automated scoring[N2]	RECOMMENDED
7. Ability to calculate REI (a surrogate apnea-hypopnea index (AHI))[N3] that is analogous to apnea-hypopnea index (AHI) used for in-laboratory PSG	RECOMMENDED
8. Ability to determine chain of custody	OPTIONAL

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Note 1. 95800—Sleep study, unattended, simultaneous recording; heart rate, oxygen saturation, respiratory analysis (e.g., by airflow or peripheral arterial tone), and sleep time
95801—Sleep study, unattended, simultaneous recording; heart rate, oxygen saturation, respiratory analysis (e.g., by airflow or peripheral arterial tone)

Note 2. Raw tracings must be viewable in detail with the ability to edit events.

Note 3. Surrogate AHI is based on estimated sleep time derived from actigraphy rather than EEG measurement of total sleep time (TST).

E. HSAT Respiratory Event Rules: Technical Specifications

1. For identification of respiratory events (RE) based on peripheral arterial tone during a home sleep apnea test (HSAT) diagnostic study, use peripheral arterial tone, oxygen desaturation and changes in heart rate derived from oximetry.[N1] ACCEPTABLE

2. For monitoring oxygen saturation, use pulse oximetry. RECOMMENDED

Note 1. The algorithm used by the device must meet current AASM accreditation standards.

F. References

The following references apply to content throughout chapter IX. Home Sleep Apnea Testing (HSAT) Rules for Adults Part 2: HSAT Utilizing Peripheral Arterial Tonometry (PAT).

1. Collop NA, Anderson WM, Boehlecke B, et al.; for the Portable Monitoring Task Force of the American Academy of Sleep Medicine. Clinical guidelines for the use of unattended portable monitors in the diagnosis of obstructive sleep apnea in adult patients. *J Clin Sleep Med*. 2007;3(7):737–747.

2. Collop NA, Tracy SL, Kapur V, et al. Obstructive sleep apnea devices for out-of-center (OOC) testing: technology evaluation. *J Clin Sleep Med*. 2011;7(5):531–548.

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X. Development Process

Development of Version 2.0

The principal participants in the development of Version 2.0 of *The AASM Manual for the Scoring of Sleep and Associated Events: Rules, Terminology and Technical Specifications* (AASM Scoring Manual) included: (a) the Scoring Manual Committee of 5 clinicians with a range of expertise, 1 technologist and 1 board liaison appointed by the American Academy of Sleep Medicine (AASM) Board of Directors, (b) the 13 members of the Sleep Apnea Definitions (SAD) Task Force appointed by the AASM Board of Directors and (c) the science and research, graphics, communications, and information technology staff of the AASM. All Scoring Manual Committee members completed AASM conflict of interest statements. Scoring Manual Committee members did not have any level 1 conflicts of interest with any medical device that might be affected by the development of any recommendation. The SAD Task Force consisted of 9 of the original 13 individuals who authored the evidence review[1] used to develop the 2007 respiratory scoring rules and 4 additional respiratory scoring experts. After a review of the literature, the task force developed recommendations on the sensors and rules to be used for scoring respiratory events, which were subsequently approved by the AASM Board of Directors. More information on the methods used and the evidence examined by the SAD task force may be found in the 2012 review paper published in the *Journal of Clinical Sleep Medicine*.[2]

The content of the chapters on parameters to be reported, technical and digital specifications, visual rules (now sleep staging rules), arousal rules, cardiac rules and movement rules remains largely unchanged from the first edition of the AASM Scoring Manual published in 2007. The 2007 manual should be consulted for the development process of these chapters.[3] The Scoring Manual Committee, two members of which also served on the SAD Task Force, drafted rules for a new respiratory chapter based on the recommendations in the SAD Task Force review paper.[2] Headings and formatting throughout the manual were edited for clarity and consistency. Critical terminology was made up-to-date and consistent. The use of certain definitions in the manual were made into rules to emphasize their importance. Scoring Manual FAQs from the AASM website were incorporated as notes in the appropriate sections of the manual. Already existing notes in the manual were examined for relevance and clarity. New figures were designed for the sleep staging rules chapter that better illustrate the rules for scoring sleep stages. Upon completion of the edits, all rules, figures and notes were re-edited and re-voted on until there was consensus agreement among the committee. The AASM Board of Directors approved Version 2.0 of the AASM Scoring Manual in July 2012.

Future Versions

According to the tenets of evidence-based medicine, clinical decision-making should be guided by the best evidence from the research field, the expertise of the clinician, and the expectations and values of the patient. The AASM is committed to utilizing evidence-based medicine in the updating of the AASM Scoring Manual. Systematic literature searches are conducted to collect all available evidence. Clinician content experts provide guidance and feedback on drafts of potential rules. Sleep technologists and other sleep center staff contribute to expert opinion and communicate the priorities of the patient. Finally, the online format of the manual makes it particularly amendable to incorporating new evidence and feedback from users and beneficiaries alike.

The Scoring Manual Committee has been tasked to continuously review and update the AASM Scoring Manual in order to further clarify existing rules and notes or to recommend revisions based on new clinical evidence or advances in technology. The AASM Board of Directors reviews and approves all revisions before a new version of the manual is published. A summary of changes is also published online when a new version of the manual is released.

References

1. Redline S, Budhiraja R, Kapur V, et al. The scoring of respiratory events in sleep: reliability and validity. *J Clin Sleep Med*. 2007;3(2):169–200.
2. Berry RB, Budhiraja R, Gottlieb DJ, et al. Rules for scoring respiratory events in sleep: update of the 2007 AASM Manual for the Scoring of Sleep and Associated Events. Deliberations of the Sleep Apnea Definitions Task Force of the American Academy of Sleep Medicine. *J Clin Sleep Med*. 2012;8(5):597–619.
3. Iber C, Ancoli-Israel S, Chesson AL Jr, Quan SF; for the American Academy of Sleep Medicine. *The AASM Manual for the Scoring of Sleep and Associated Events: Rules, Terminology and Technical Specifications*. 1st ed. Westchester, IL: American Academy of Sleep Medicine; 2007.

Previous Versions and Release Dates

- Version 2.5: April 2018
- Version 2.4: April 2017
- Version 2.3: April 2016
- Version 2.2: July 2015
- Version 2.1: July 2014
- Version 2.0.3: January 2014
- Version 2.0.2: September 2013
- Version 2.0.1: July 2013
- Version 2.0: October 2012

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XI. Procedural Notes

Levels of Evidence

STANDARD	Recommendation based on level 1 evidence or overwhelming level 2 evidence.
GUIDELINE	Recommendation based on level 2 evidence or a consensus of level 3 evidence.
CONSENSUS	Recommendation with less evidence than guideline for which agreement was reached in a standardized consensus process based on available information.
ADJUDICATION	Recommendation from the steering committee based on all available information. Adjudication was only performed (a) when there was insufficient evidence and no consensus agreement or (b) in conjunction with task force leaders on issues regarding minor clarifications and additions to rules.

II. Parameters to be Reported for Polysomnography		
A.1–10	Parameters. No evidence. Adopted and modified from previous AASM practice parameter. Consensus of Task Force with approval by Steering Committee.	CONSENSUS
B.1–10	Sleep scoring data. No evidence. Adopted and modified from previous AASM practice parameter. Consensus of Task Force with approval by Steering Committee.	CONSENSUS
C.1–2	Arousal events. No evidence. Adopted and modified from previous AASM practice parameter and compliant with rules of Arousal Task Force. Consensus of Task Force with approval by Steering Committee.	CONSENSUS
D.1–10	Cardiac events. No evidence. Compliant with rules of Cardiac Task Force. Consensus of Cardiac Task Force with approval by Steering Committee.	CONSENSUS
E.5	Movement events. No evidence. Consensus agreement of Scoring Manual Committee and approved by the AASM Board of Directors.	CONSENSUS
F.1–25	Respiratory events. No evidence. Adopted and modified from previous AASM practice parameter and compliant with rules of Respiratory Task Force. Consensus of Respiratory Task Force with approval by Steering Committee. Version 2.0 additions and approval from Scoring Manual Committee (SMC).*	CONSENSUS
G.1–5	Summary statements. No evidence. Adopted and modified from previous AASM practice parameter. Consensus of Movements Task Force with approval by Steering Committee.	CONSENSUS

III. Technical and Digital Specifications		
A.1–4	Sampling frequency and filter specifications for routine PSG recordings. No evidence. Non-systematic review on ECG sampling rates and commonly applied principles in practice. Consensus of Digital Task Force with approval by Steering Committee.	CONSENSUS

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B.1–8	Digital PSG recording systems features. No evidence. Consensus of Digital Task Force with approval by Steering Committee.	CONSENSUS
C.1–10	PSG display and display manipulation. No evidence. Consensus of Digital Task Force with approval by Steering Committee.	CONSENSUS
D.1–4	Digital analysis of PSG. No evidence. Consensus of Digital Task Force with approval by Steering Committee.	CONSENSUS
E.1–21	Calibrations to document appropriate system response. No evidence. Consensus agreement of Scoring Manual Editorial Board and approved by the AASM Board of Directors.	CONSENSUS

IV. Sleep Staging Rules Part 1: Rules for Adults		
A.1	Recommended EEG derivation. Level 4 evidence. Consensus agreement by Visual Task Force approved by Steering Committee.	CONSENSUS
A.2	Alternative EEG derivation. Level 4 evidence. Consensus agreement by Visual Task Force approved by Steering Committee.	CONSENSUS
A.3	Ten-twenty application map. No evidence. Consensus vote was not felt necessary, Steering Committee approved as a standardized and universally accepted procedure.	ADJUDICATION
B.1	Recommended EOG derivation. Level 4 evidence. Consensus agreement by Visual Task Force approved by Steering Committee.	CONSENSUS
B.2	Alternative EOG derivation. Level 4 evidence. Consensus agreement by Visual Task Force approved by Steering Committee.	CONSENSUS
C.1–2	EMG derivation. No evidence. Consensus agreement with clarification of specific distances and back-up electrode requested by industry and technical review panel and provided by Visual Task Force chair with Steering Committee approval.	CONSENSUS and ADJUDICATION
D.1	Sleep stage terminology. No evidence. Consensus agreement by Visual Task Force approved by Steering Committee.	CONSENSUS
D.2.a–b,d	Epoch scoring parameters. No evidence. Consensus agreement by Visual Task Force approved by Steering Committee.	CONSENSUS
D.2.c	Assignment of epoch with multiple stages. No evidence. Clarification was provided by agreement of Visual Task Force chair and Steering Committee.	ADJUDICATION
D.3	Limited evidence. Consensus agreement of Scoring Manual Committee and approved by the AASM Board of Directors.	CONSENSUS
E.1	Stage W definitions. Very limited level 3 and 4 evidence. Consensus agreement by Visual Task Force approved by Steering Committee.	CONSENSUS
E.2	Presence of alpha. Inconsistent level 1 and level 2 evidence for reliability and level 3 evidence for validity. Consensus agreement by Visual Task Force approved by Steering Committee.	CONSENSUS
F.1	Stage N1 definitions. Limited evidence. Consensus agreement by Visual Task Force approved by Steering Committee.	CONSENSUS

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F.2	Stage N1 based on replacement of alpha. Inconsistent level 1 and 2 evidence for reliability and level 3 evidence for validity. Consensus agreement by Visual Task Force approved by Steering Committee.	CONSENSUS
F.3	Stage N1 based on frequency slowing, vertex waves, and slow eye movements. Limited evidence. Consensus agreement of Visual Task Force approved by Steering Committee.	CONSENSUS
F.4	Limited evidence. Consensus agreement of Scoring Manual Committee and approved by the AASM Board of Directors.	CONSENSUS
F.5	Limited evidence. Consensus agreement of Scoring Manual Committee and approved by the AASM Board of Directors.	CONSENSUS
F.6	Limited evidence. Consensus agreement of Scoring Manual Committee and approved by the AASM Board of Directors.	CONSENSUS
G.1	Stage N2 definitions. Limited level 3 and 4 evidence. Consensus agreement of Visual Task Force approved by Steering Committee.	CONSENSUS
G.2	Stage N2 based on K complexes and spindles. Consistent level 1 and 2 evidence. Decision by Steering Committee and consensus agreement of Visual Task Force.	STANDARD
G.3	Limited evidence. Consensus agreement of Scoring Manual Committee and approved by the AASM Board of Directors.	CONSENSUS
G.4	Stage N2 continuation. Limited evidence. Consensus agreement of Visual Task Force approved by Steering Committee.	CONSENSUS
G.5	Limited evidence. Consensus agreement of Scoring Manual Committee and approved by the AASM Board of Directors.	CONSENSUS
G.6	Stage N2 ending. Limited evidence, inferred from other rules. Consensus agreement of Visual Task Force approved by Steering Committee.	CONSENSUS
H.1	Stage N3 definition. Consistent levels 3 and 4 evidence. Consensus agreement of Visual Task Force approved by Steering Committee.	CONSENSUS
H.2	Stage N3 rule. Consistent level 1 and 2 evidence. Decision by Steering Committee and consensus agreement of Visual Task Force.	STANDARD
I.1	Stage R definitions. Limited evidence. Consensus agreement of Visual Task Force approved by Steering Committee.	CONSENSUS
I.2	Stage R based on rapid eye movements, low EMG and EEG. Consistent level 1 and 2 evidence. Decision by Steering Committee and consensus agreement of Visual Task Force.	STANDARD
I.3	Limited evidence. Consensus agreement of Scoring Manual Committee and approved by the AASM Board of Directors.	CONSENSUS
I.4	Limited evidence. Consensus agreement of Scoring Manual Committee and approved by the AASM Board of Directors.	CONSENSUS
I.5	Continuation of stage R. Limited evidence. Consensus agreement of Visual Task Force approved by Steering Committee.	CONSENSUS

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I.6	Stage R ending. Inferred from other rules. Limited evidence. Consensus agreement of Visual Task Force approved by Steering Committee.	CONSENSUS
I.7	Limited evidence. Consensus agreement of Scoring Manual Committee and approved by the AASM Board of Directors.	CONSENSUS
J.1	Major body movement definition. No evidence. Consensus agreement of Visual Task Force approved by Steering Committee.	CONSENSUS
J.2–4	Major body movement rules. No evidence. Consensus agreement of Visual Task Force approved by Steering Committee.	CONSENSUS

IV. Sleep Staging Rules Part 2: Rules for Children		
A.1	Ages. Limited evidence. Consensus agreement of Pediatric Task Force approved by Steering Committee.	CONSENSUS
B.1	Technical considerations. Adult rules accepted by Pediatric Task Force with pediatric caveats provided in notes.	CONSENSUS
C.1	Terminology. No evidence. Consensus agreement of Pediatric Task Force approved by Steering Committee.	CONSENSUS
C.2–5	Scoring sleep stages. Limited evidence. Consensus agreement of Pediatric Task Force approved by Steering Committee.	CONSENSUS
D.1	Stage W definitions. Limited evidence. Consensus agreement of Pediatric Task Force approved by Steering Committee.	CONSENSUS
D.2	Stage W rules. Limited evidence. Consensus agreement of Pediatric Task Force approved by Steering Committee.	CONSENSUS
E.1	Stage N1 definitions. Limited evidence. Consensus agreement of Pediatric Task Force approved by Steering Committee.	CONSENSUS
E.2–3	Stage N1 rules. Limited evidence. Consensus agreement of Pediatric Task Force approved by Steering Committee.	CONSENSUS
F.1	Stage N2 rules. Adult rules accepted by Pediatric Task Force.	CONSENSUS
G.1	Stage N3. Adult rules accepted by Pediatric Task Force.	CONSENSUS
H.1	Stage R. Adult rules accepted by Pediatric Task Force.	CONSENSUS

IV. Sleep Staging Rules Part 3: Rules for Infants		
A.1	Ages. Consensus agreement of Scoring Manual Editorial Board and approved by the AASM Board of Directors.	CONSENSUS
B.1	Technical considerations. Adult rules accepted by Scoring Manual Editorial Board.	CONSENSUS
B.2	*Recommended* technical considerations. Consensus agreement of Scoring Manual Editorial Board and approved by the AASM Board of Directors.	CONSENSUS

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B.3	*Optional* technical considerations. Consensus agreement of Scoring Manual Editorial Board and approved by the AASM Board of Directors.	CONSENSUS
B.4	*Recommended* technical considerations. Consensus agreement of Scoring Manual Committee and approved by the AASM Board of Directors.	CONSENSUS
C.1	Terminology. Consensus agreement of Scoring Manual Editorial Board and approved by the AASM Board of Directors.	CONSENSUS
C.2–6	Scoring sleep stages. Consensus agreement of Scoring Manual Editorial Board and approved by the AASM Board of Directors.	CONSENSUS
C.7	EOG characteristics definitions. Consensus agreement of Scoring Manual Editorial Board and approved by the AASM Board of Directors.	CONSENSUS
C.8	Chin EMG patterns definitions. Consensus agreement of Scoring Manual Editorial Board and approved by the AASM Board of Directors.	CONSENSUS
D.1.a–c	Stage W rules. Consensus agreement of Scoring Manual Editorial Board and approved by the AASM Board of Directors.	CONSENSUS
E.1.a–e	Stage N rules. Consensus agreement of Scoring Manual Editorial Board and approved by the AASM Board of Directors.	CONSENSUS
F.1–2	Stage R rules. Consensus agreement of Scoring Manual Editorial Board and approved by the AASM Board of Directors.	CONSENSUS
G.1–2	Stage T rules. Consensus agreement of Scoring Manual Editorial Board and approved by the AASM Board of Directors.	CONSENSUS

V. Arousal Rule

A.1	Arousal rule. Duration and EEG change. Level 1 and 2 evidence. Decision by Steering Committee and consensus of Arousal Task Force.	STANDARD
A.1	Arousal rule. Specification for duration of EMG increase was requested by technical/ industry and recommended by task force chair. This decision was then adjudicated by Steering Committee.	ADJUDICATION

VI. Cardiac Rules

A.1	Single lead. No evidence. Consensus agreement by Cardiac Task Force approved by Steering Committee.	CONSENSUS
B.1	Tachycardia. Level 3 and 4 evidence. Consensus agreement by Cardiac Task Force approved by Steering Committee.	CONSENSUS
B.2	Bradycardia. Level 3 and 4 evidence. Consensus agreement by Cardiac Task Force approved by Steering Committee.	CONSENSUS
B.3	Asystole. Limited evidence. Consensus agreement by Cardiac Task Force approved by Steering Committee.	CONSENSUS

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B.4	Wide complex tachycardia. Limited evidence. Consensus of Cardiac Task Force and approved by Steering Committee.	CONSENSUS
B.5	Narrow complex tachycardia. Limited evidence. Consensus of Cardiac Task Force and approved by Steering Committee.	CONSENSUS
B.6	Atrial fibrillation. American Heart Association consensus modified by consensus of Cardiac Task Force and approved by Steering Committee.	CONSENSUS

VII. Movement Rules

A.1	Recommended electrode placement for monitoring leg movements. Consensus agreement of Scoring Manual Editorial Board and approved by the AASM Board of Directors.	CONSENSUS
A.2	Recommended parameters for monitoring leg movements. Consensus agreement of Scoring Manual Editorial Board and approved by the AASM Board of Directors.	CONSENSUS
A.3	Optional sampling of upper limbs. Consensus agreement of Scoring Manual Editorial Board and approved by the AASM Board of Directors.	CONSENSUS
A.4	Optional masseter electrodes. Consensus agreement of Scoring Manual Editorial Board and approved by the AASM Board of Directors.	CONSENSUS
A.5	Optional EMG recordings for detecting transient muscle activity in REM sleep. Consensus agreement of Scoring Manual Editorial Board and approved by the AASM Board of Directors.	CONSENSUS
A.6	Recommended video PSG for diagnosis of RBD. Consensus agreement of Scoring Manual Editorial Board and approved by the AASM Board of Directors.	CONSENSUS
A.7	Optional electrode placement for monitoring RMD. Consensus agreement of Scoring Manual Editorial Board and approved by the AASM Board of Directors.	CONSENSUS
A.8	Recommended video PSG for diagnosis of RMD. Consensus agreement of Scoring Manual Editorial Board and approved by the AASM Board of Directors.	CONSENSUS
B.1.a	Leg movements. Evidence level 5. Consensus agreement by Movements Task Force, approved by Steering Committee.	CONSENSUS
B.1.b	Leg movements. Evidence level 5. Rule states 10 seconds instead of the previous 5 second rule based on consensus agreement by Movements Task Force; approved by Steering Committee.	CONSENSUS
B.1.c–e	Leg movements. Evidence level 5. Consensus agreement by Movements Task Force, approved by Steering Committee.	CONSENSUS
B.2.a	PLM series. Evidence level 5. Consensus agreement by Movements Task Force, approved by Steering Committee.	CONSENSUS
B.2.b–c	PLM series. Evidence level 5 based on ICSD Consensus. Consensus agreement by Movements Task Force, approved by Steering Committee.	CONSENSUS
B.3	Arousal and limb movement that occur in a PLM series. Consensus agreement of Scoring Manual Editorial Board and approved by the AASM Board of Directors.	CONSENSUS

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B.4	Leg movements preceding a respiratory event. Consensus agreement of Scoring Manual Editorial Board and approved by the AASM Board of Directors.	CONSENSUS
B.5	Wake that separates a series of leg movements. Consensus agreement of Scoring Manual Editorial Board and approved by the AASM Board of Directors.	CONSENSUS
C.1	The minimum duration of the muscle bursts for ALMA was removed due to concerns by the technical panel and Movements Task Force leader and adjudication by Steering Committee.	CONSENSUS
C.1.a–c	Alternating leg muscle activation (ALMA). Evidence level 4 based on ICSD Consensus. Consensus agreement by Movements Task Force; approved by Steering Committee.	CONSENSUS
D.1.a–c	Hypnagogic foot tremor (HFT). Evidence level 2 Consensus agreement by Movements Task Force; approved by Steering Committee	GUIDELINE
E.1.a–c	Excessive fragmentary myoclonus (EFM). Evidence level 4. Consensus agreement by Movements Task Force, approved by Steering Committee.	CONSENSUS
F.1.a–b	Bruxism phasic bursts. Evidence level 5. Consensus agreement by Movements Task Force, approved by Steering Committee.	CONSENSUS
F.1.a,c	Bruxism tonic bursts. Evidence level 5. Consensus agreement by Movements Task Force, approved by Steering Committee.	CONSENSUS
F.1.a	Bruxism amplitude of individual burst. No evidence. Consensus agreement by Movements Task Force plus adjudication by Steering Committee based on technical panel input and discussions of the Movements Task Force.	ADJUDICATION
F.1.d	Bruxism episodes. Evidence level 5. Consensus agreement by Movements Task Force, approved by Steering Committee.	CONSENSUS
F.1.e	Bruxism scoring. Evidence level 2 and evidence level 5. Consensus agreement by Movements Task Force, approved by Steering Committee.	STANDARD
G.1	Definitions for REM Without Atonia. Consensus agreement of Scoring Manual Committee and approved by the AASM Board of Directors.	CONSENSUS
G.2-3	Rule for REM Without Atonia. Consensus agreement of Scoring Manual Committee and approved by the AASM Board of Directors.	CONSENSUS
H.1.a–b	Rhythmic movement disorder (RMD) frequency. Evidence level 4. Consensus agreement by Movements Task Force, approved by Steering Committee.	CONSENSUS
H.1.c–d	Rhythmic movement disorder (RMD). No evidence. Consensus agreement by Movements Task Force approved by Steering Committee.	CONSENSUS

VIII. Respiratory Rules Part 1: Rules for Adults		
A.1	*Recommended* airflow sensor for apnea detection. Consensus agreement by Respiratory Task Force approved by Scoring Manual Committee (SMC).	CONSENSUS
A.2.a–c	*Alternative* airflow sensors for apnea detection. Consensus agreement by Respiratory Task Force approved by SMC.	CONSENSUS

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A.2.d	PVDFsum *alternative* and acceptable for apnea detection. No agreement by Respiratory Task Force, adjudicated by AASM Board of Directors, approved by SMC.	ADJUDICATION
A.3	*Recommended* airflow sensor for detection of a hypopnea. Consensus agreement by Respiratory Task Force approved by SMC.	CONSENSUS
A.4.a–d	*Alternative* airflow sensors for hypopnea detection. Consensus agreement by Respiratory Task Force approved by SMC.	CONSENSUS
A.4.e	PVDFsum *alternative* and acceptable for hypopnea detection. No agreement by Respiratory Task Force, adjudicated by AASM Board of Directors, approved by SMC.	ADJUDICATION
A.5	Airflow sensor for apnea and hypopnea detection during PAP titration. Consensus agreement by Respiratory Task Force approved by SMC.	CONSENSUS
A.6.a–b	Sensors for monitoring respiratory effort. Consensus agreement by Respiratory Task Force approved by SMC.	CONSENSUS
A.6.c	Thoracoabdominal PVDF belts acceptable for monitoring respiratory effort. No agreement by Respiratory Task Force, adjudicated by AASM Board of Directors, approved by SMC.	ADJUDICATION
A.7	Preferred sensor for detection of blood oxygen. Use of pulse oximetry and pulse oximetry averaging times. Consensus agreement by Respiratory Task Force, approved by SMC.	CONSENSUS
A.8	Preferred sensors for monitoring snoring. Consensus agreement by Respiratory Task Force, approved by SMC.	CONSENSUS
A.9	Preferred sensors for detecting hypoventilation during diagnostic study. Consensus agreement by Respiratory Task Force, approved by SMC.	CONSENSUS
A.10	Preferred sensors for detecting hypoventilation during a PAP titration study. Consensus agreement by Respiratory Task Force, approved by SMC.	CONSENSUS
B.1	Identification of breaths beginning and ending events. Consensus agreement by Respiratory Task Force, approved by SMC.	CONSENSUS
B.2	Sensors used to measure duration of apneas and hypopneas. Consensus agreement by Respiratory Task Force, approved by SMC.	CONSENSUS
B.3	Identification of beginning and end of events with large variability. Consensus agreement by Respiratory Task Force, approved by SMC.	CONSENSUS
C.1.a–b	Apnea amplitude criterion and duration of event criterion. Consensus agreement by Respiratory Task Force, approved by SMC.	CONSENSUS
C.2	Scoring criteria for obstructive apneas. Consensus agreement by Respiratory Task Force, approved by SMC.	CONSENSUS
C.3	Scoring criteria for central apneas. Consensus agreement by Respiratory Task Force, approved by SMC.	CONSENSUS
C.4	Scoring criteria for mixed apneas. Consensus agreement by Respiratory Task Force, approved by SMC.	CONSENSUS

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D.1A.a–c D.1B.a–c	Hypopnea amplitude, duration and minimum oxygen desaturation criterion. Consensus agreement by SMC.	CONSENSUS
D.2.a–c	Scoring criteria for obstructive hypopneas. Consensus agreement by Respiratory Task Force, approved by SMC.	CONSENSUS
D.3.a–c	Scoring criteria for central hypopneas. Consensus agreement by Respiratory Task Force, approved by SMC.	CONSENSUS
E.1	Scoring criteria for respiratory effort-related arousals. Consensus agreement by Respiratory Task Force, approved by SMC.	CONSENSUS
F.1.a–b	Scoring criteria for hypoventilation. Consensus agreement by Respiratory Task Force, approved by SMC.	CONSENSUS
G.1.a–b	Scoring criteria for Cheyne-Stokes breathing. Consensus agreement by Respiratory Task Force, approved by SMC.	CONSENSUS
H.1	Scoring respiratory events during a positive airway pressure (PAP) titration using a backup rate. Consensus agreement of Scoring Manual Committee and approved by the AASM Board of Directors.	CONSENSUS

VIII. Respiratory Rules Part 2: Rules for Children		
A.1	Ages for which pediatric respiratory scoring rules apply. Consensus agreement by Respiratory Task Force approved by Scoring Manual Committee (SMC).	CONSENSUS
B.1	*Recommended* airflow sensor for apnea detection. Consensus agreement by Respiratory Task Force approved by SMC.	CONSENSUS
B.2.a–c	*Alternative* airflow sensors for apnea detection. Consensus agreement by Respiratory Task Force approved by SMC.	CONSENSUS
B.2.d	End-tidal PCO_2 acceptable for apnea detection. Consensus agreement by Respiratory Task Force approved by SMC.	CONSENSUS
B.3	*Recommended* airflow sensor for detection of a hypopnea. Consensus agreement by Respiratory Task Force approved by SMC.	CONSENSUS
B.4.a–d	*Alternative* airflow sensors for hypopnea detection. Consensus agreement by Respiratory Task Force approved by SMC.	CONSENSUS
B.5	Airflow sensor for apnea and hypopnea detection during PAP titration. Consensus agreement by Respiratory Task Force approved by SMC.	CONSENSUS
B.6.a–c	Sensors for monitoring respiratory effort. Consensus agreement by Respiratory Task Force approved by SMC.	CONSENSUS
B.7	Preferred sensor for detection of blood oxygen. Use of pulse oximetry and pulse oximetry averaging times. Consensus agreement by Respiratory Task Force, approved by SMC.	CONSENSUS
B.8	Preferred sensors for monitoring snoring. Consensus agreement by Respiratory Task Force, approved by SMC.	CONSENSUS

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B.9	Preferred sensors for detecting hypoventilation during diagnostic study. Consensus agreement by Respiratory Task Force, approved by SMC.	CONSENSUS
B.10	Preferred sensors for detecting hypoventilation during a PAP titration study. Consensus agreement by Respiratory Task Force, approved by SMC.	CONSENSUS
C.1	Measuring event duration same as adults. Consensus agreement by Respiratory Task Force, approved by SMC.	CONSENSUS
D.1.a–c	Apnea amplitude criterion, duration of event and respiratory effort criterion. Consensus agreement by Respiratory Task Force, approved by SMC.	CONSENSUS
D.2	Scoring criteria for obstructive apneas. Consensus agreement by Respiratory Task Force, approved by SMC.	CONSENSUS
D.3.a–c	Scoring criteria for central apneas. Consensus agreement by Respiratory Task Force, approved by SMC.	CONSENSUS
D.4	Scoring criteria for mixed apneas. Consensus agreement by Respiratory Task Force, approved by SMC.	CONSENSUS
E.1.a–c	Hypopnea amplitude, duration and minimum oxygen desaturation criterion. Consensus agreement by Respiratory Task Force, approved by SMC.	CONSENSUS
E.2.a–c	Scoring criteria for obstructive hypopneas. Consensus agreement by Respiratory Task Force, approved by SMC.	CONSENSUS
E.3.a–c	Scoring criteria for central hypopneas. Consensus agreement by Respiratory Task Force, approved by SMC.	CONSENSUS
F.1.a–d	Scoring criteria for respiratory effort-related arousals. Consensus agreement by Respiratory Task Force, approved by SMC.	CONSENSUS
G.1	Scoring criteria for hypoventilation. Consensus agreement by Respiratory Task Force, approved by SMC.	CONSENSUS
H.1	Scoring criteria for periodic breathing. Consensus agreement by Respiratory Task Force, approved by SMC.	CONSENSUS
I.1	Scoring respiratory events during a positive airway pressure (PAP) titration using a backup rate. Consensus agreement of Scoring Manual Committee and approved by the AASM Board of Directors.	CONSENSUS

IX. Home Sleep Apnea Testing (HSAT) Rules for Adults

Part 1: HSAT Utilizing Respiratory Flow and/or Effort Parameters

A.1–8	Parameters. Consensus agreement of Scoring Manual Editorial Board and approved by the AASM Board of Directors.	CONSENSUS
B.1–11	Recording data if sleep is NOT recorded. Consensus agreement of Scoring Manual Editorial Board and approved by the AASM Board of Directors.	CONSENSUS
C.1–11	Recording data if sleep is recorded. Consensus agreement of Scoring Manual Editorial Board and approved by the AASM Board of Directors.	CONSENSUS

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D.1–8	Summary statements. Consensus agreement of Scoring Manual Editorial Board and approved by the AASM Board of Directors.	CONSENSUS
E.1–8	Recording data. Adopted and modified from previous AASM practice parameters. Consensus agreement of Scoring Manual Editorial Board and approved by the AASM Board of Directors.	CONSENSUS
F.1.a–b	*Recommended* airflow sensors for respiratory event detection. Consensus agreement of Scoring Manual Editorial Board and approved by the AASM Board of Directors.	CONSENSUS
F.1.c.i	*Alternative Recommended* airflow sensor for respiratory event detection. Consensus agreement of Scoring Manual Editorial Board and approved by the AASM Board of Directors.	CONSENSUS
F.1.c.ii	*Alternative Acceptable* airflow sensor for respiratory event detection. Consensus agreement of Scoring Manual Editorial Board and approved by the AASM Board of Directors.	CONSENSUS
F.2.a	*Recommended* sensor for monitoring respiratory effort. Consensus agreement of Scoring Manual Editorial Board and approved by the AASM Board of Directors.	CONSENSUS
F.2.b	*Acceptable* sensor for monitoring respiratory effort. Consensus agreement of Scoring Manual Editorial Board and approved by the AASM Board of Directors.	CONSENSUS
F.2.c–d	*Acceptable* thoracoabdominal belts for monitoring respiratory effort. Consensus agreement of Scoring Manual Editorial Board and approved by the AASM Board of Directors.	CONSENSUS
F.2.e	*Acceptable* thoracoabdominal belts for monitoring respiratory effort. No agreement by Scoring Manual Editorial Board, adjudicated by the AASM Board of Directors.	ADJUDICATION
F.3	*Recommended* sensor for monitoring oxygen saturation. Consensus agreement of Scoring Manual Editorial Board and approved by the AASM Board of Directors.	CONSENSUS
F.4	*Optional* sensors for monitoring snoring. Consensus agreement of Scoring Manual Editorial Board and approved by the AASM Board of Directors.	CONSENSUS
G.1.a–b	HSAT apnea amplitude criterion and duration of event criterion. Consensus agreement of Scoring Manual Editorial Board and approved by the AASM Board of Directors.	CONSENSUS
G.2	HSAT scoring criteria for obstructive apneas. Consensus agreement of Scoring Manual Editorial Board and approved by the AASM Board of Directors.	CONSENSUS
G.3	HSAT scoring criteria for central apneas. Consensus agreement of Scoring Manual Editorial Board and approved by the AASM Board of Directors.	CONSENSUS
G.4	HSAT scoring criteria for mixed apneas. Consensus agreement of Scoring Manual Editorial Board and approved by the AASM Board of Directors.	CONSENSUS
H.1A.a–c H.1B.a–c	HSAT hypopnea amplitude, duration and minimum oxygen desaturation criterion if sleep is NOT recorded. Consensus agreement of Scoring Manual Editorial Board and approved by the AASM Board of Directors.	CONSENSUS
H.2A.a–c H.2B.a–c	HSAT hypopnea amplitude, duration and minimum oxygen desaturation criterion if sleep IS recorded. Consensus agreement of Scoring Manual Editorial Board and approved by the AASM Board of Directors.	CONSENSUS

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IX. Home Sleep Apnea Testing (HSAT) Rules for Adults Part 2: HSAT Utilizing Peripheral Arterial Tonometry (PAT)		
A.1–7	Parameters. Consensus agreement of Scoring Manual Editorial Board and approved by the AASM Board of Directors.	CONSENSUS
B.1–7	Recording data. Consensus agreement of Scoring Manual Editorial Board and approved by the AASM Board of Directors.	CONSENSUS
C.1–8	Summary statements. Consensus agreement of Scoring Manual Editorial Board and approved by the AASM Board of Directors.	CONSENSUS
D.1–8	Recording data. Adopted and modified from previous AASM practice parameters. Consensus agreement of Scoring Manual Editorial Board and approved by the AASM Board of Directors.	CONSENSUS
E.1	*Acceptable* sensors for respiratory event detection. Consensus agreement of Scoring Manual Editorial Board and approved by the AASM Board of Directors.	CONSENSUS
E.2	*Recommended* sensor for monitoring oxygen saturation. Consensus agreement of Scoring Manual Editorial Board and approved by the AASM Board of Directors.	CONSENSUS

*The Scoring Manual Committee (SMC) was called the Scoring Manual Editorial Board from 2015-2019.

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XII. Glossary of Terms

Alpha rhythm (posterior dominant rhythm in adults and older children): An EEG pattern consisting of trains of sinusoidal 8–13 Hz activity recorded over the occipital region with eye closure and attenuating with eye opening.

Any chin EMG activity: Activity with a minimum amplitude two times greater than the stage R atonia level (or lowest amplitude in NREM, if no stage R atonia is present) without regard to the duration of the activity (including bursts of 5 to 15 seconds).

Apnea: Cessation of airflow (≥90% decrease in apnea sensor excursions compared to baseline) of a minimum duration as defined by adult (VIII.C.1) and pediatric rules (VIII.D.1). Apneas are classified as obstructive, mixed, or central based on the pattern of respiratory effort.

Asystole: An interruption of cardiac rhythm lasting more than 3 seconds.

Atrial fibrillation: Irregularly irregular QRS complexes associated with replacement of consistent P waves by rapid oscillations that vary in size, shape and timing.

Beta rhythm: An EEG rhythm consisting of 13–30 Hz activity.

Bradycardia (during sleep): A sustained (>30 seconds) heart rate less than 40 beats per minute for ages 6 years through adulthood.

Bruxism: Grinding or clenching of the teeth during sleep that is often associated with arousal. (Scoring rule VII.E.1)

Central hypopnea: A specified reduction in airflow lasting at least 10 seconds in adults or the equivalent of 2 breaths in children during which there is no evidence of snoring, increased inspiratory flattening of the nasal pressure or PAP device flow signal compared to baseline breathing, or associated thoracoabdominal paradox.

Cheyne-Stokes breathing: A breathing rhythm with a specified crescendo and decrescendo change in breathing amplitude separating central apneas or hypopneas. (Scoring rule for adults VIII.G.1)

Chronological age: The time elapsed since birth expressed in either days, months, or years; also referred to as postnatal or legal age.

Conceptional age (CA): Gestational age (GA) at birth plus the number of weeks postpartum.

Delta frequency: An EEG rhythm consisting of 0–3.99 Hz activity. (See definition of slow wave activity.)

Derivation: The recorded voltage difference between two electrodes (e.g., EEG, EOG, chin EMG derivations).

Excessive fragmentary myoclonus: Limb EMG activity of a specified frequency and duration often unassociated with visible movement. This polysomnographic finding is not thought to have physiological significance.

Excessive sustained muscle activity (tonic activity) in REM: An epoch of stage R with at least 50% of the duration of the epoch having a chin EMG amplitude at least two times greater than the stage R atonia level (or lowest amplitude in NREM, if no stage R atonia is present). Multiple segments may contribute to the total duration, but each segment must be greater than 5 seconds.

Excessive transient muscle activity (phasic activity) in REM: : In a 30-second epoch of stage R divided into 10 sequential 3-second mini-epochs, at least 5 (50%) of the mini-epochs contain bursts of transient muscle activity in the chin or limb EMG. In RWA, excessive transient muscle activity bursts are 0.1–5.0 seconds in duration and at least two times as high in amplitude as the stage R atonia level (or lowest amplitude in NREM, if no stage R atonia is present).

Eye blinks: Conjugate vertical eye movements at a frequency of 0.5–2 Hz present in wakefulness with the eyes open or closed.

Gestational age (GA): The time elapsed between the first day of the mother's last menstrual period and the day of delivery expressed in completed weeks. If the pregnancy was achieved using assisted reproductive technology, GA is calculated by adding 2 weeks to the conceptional age.

High voltage slow (HVS): Continuous synchronous symmetrical predominantly high voltage 1–3 Hz delta activity.

Hypnagogic foot tremor: Trains of EMG activity of the lower limb with a specified frequency; not a defined disorder.

Hypnagogic hypersynchrony (HH): Paroxysmal bursts or runs of diffuse, high-amplitude, sinusoidal, 75–350 μV, 3–4.5 Hz waves which begin abruptly, are usually widely distributed but often are maximal over the central, frontal, or frontocentral scalp regions. These waveforms can occur in stage N1 and N2.

Hypnogram: A graphical representation of sleep stages which occur throughout the night.

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Hypopnea: A reduction in airflow with the minimum amplitude and duration as specified in the hypopnea rules for adults (VIII.D.1A and 1B) and children (VIII.E.1). The reduction in airflow must be accompanied by a ≥3% desaturation or an arousal (VIII.D.1A and VIII.E.1) or a ≥4% desaturation (VIII.D.1B).

Hypoventilation: A specified period of increased PCO_2 of >50 mmHg in children or >55 mmHg in adults, or a rise of PCO_2 during sleep of ≥10 mmHg that exceeds 50 mmHg for a specified period of time in adults.

K complex: A well-delineated, negative, sharp wave immediately followed by a positive component standing out from the background EEG, with total duration ≥0.5 seconds, usually maximal in amplitude when recorded using frontal derivations. For an arousal to be associated with a K complex, the arousal must either be concurrent with the K complex or commence no more than 1 second after termination of the K complex. (see V. Arousal Rule).

Low-amplitude, mixed-frequency (LAMF) activity: Low amplitude, predominantly 4–7 Hz activity.

Low chin EMG tone: Baseline EMG activity in the chin derivation no higher than in any other sleep stage and usually at the lowest level of the entire recording.

Low voltage irregular (LVI): Continuous low voltage mixed-frequency activity with delta and predominantly theta activity.

Major body movement: Movement and muscle artifact obscuring the EEG for more than half an epoch to the extent that the sleep stage cannot be determined.

Monitoring time (MT): Total recording time minus periods of artifact and time the patient was awake as determined by actigraphy, body position sensor, respiratory pattern, or patient diary.

Narrow complex tachycardia: A cardiac rhythm lasting a minimum of 3 consecutive beats with QRS duration of <120 msec and a rate of >100 per minute.

Nasal pressure transducer: A pressure transducer that measures the pressure (relative to atmospheric pressure) inside the nasal orifice using a nasal cannula. The pressure difference across the nasal inlet during breathing is proportional to the magnitude of airflow squared. A square root transformation of the nasal pressure signal is proportional to airflow. The inspiratory waveform of the nasal pressure signal exhibits a flattened pattern during airflow limitation provided the signal from the transducer is recorded as a DC signal or as an AC signal with an appropriate low filter setting.

Oxygen desaturation index (ODI): The number of oxygen desaturations × 60 divided by the monitoring time (for HSAT) or total sleep time (for in-laboratory PSG).

Periodic breathing: >3 episodes of central apnea lasting >3 seconds separated by no more than 20 seconds of normal breathing in children.

Periodic limb movements of sleep: Movements of the limbs during sleep occurring with a specified frequency, duration, and amplitude.

Peripheral arterial tone: A measure of pulsatile volume changes at the fingertip that reflects changes in sympathetic tone.

Peripheral arterial tonometry (PAT): A technique allowing noninvasive moment-to-moment measurement of sympathetic tone using finger plethysmography (measurement of pulsatile volume changes in the fingertip that reflects changes in sympathetic tone). Increases in sympathetic tone result in peripheral arterial constriction and reduced blood flow to the digit. The reduced volume at the finger is detected by the probe. The combination of a decrease in PAT signal (sympathetic tone increase following respiratory events), a fall in SaO_2 (oximetry), and an increase in heart rate is used to detect respiratory events.

Positive airway pressure (PAP) flow: An airflow signal derived from a pressure transducer built into the PAP device.

Posterior dominant rhythm (PDR): The dominant reactive EEG rhythm over the occipital regions in relaxed wakefulness with eyes closed which is slower in infants and young children and attenuates with eye opening or attention. Frequency is 3.5–4.5 Hz when first seen in infants 3–4 months post-term, 5–6 Hz by 5–6 months, and 7.5–9.5 Hz by 3 years of age and amplitude is usually >50 μV. In older children and adults, posterior dominant rhythm is often referred to as alpha rhythm.

Posterior slow waves of youth (PSW): Intermittent runs of bilateral but often asymmetric 2.5–4.5 Hz slow waves superimposed, riding upon, or fused with the PDR, are usually <120% of PDR voltage, block with eye opening and disappear with drowsiness and sleep. PSW are uncommon in children <2 years of age, have a maximal incidence between ages 8–14 years, and are uncommon after age 21 years.

PVDF sensor: Polyvinylidene fluoride (PVDF) film is a fluoropolymer substance that reacts to changes in temperature when used as a thermal airflow sensor and to impedance changes when used as an effort sensor.

PVDFsum: PVDFsum is the electrical sum of signals recorded from the thoracic and abdominal PVDF sensors.

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Rapid eye movements (REMs): Eye movements recorded in the EOG derivations consisting of conjugate, irregular, sharply peaked eye movements with an initial deflection usually lasting <500 msec. While rapid eye movements are characteristic of stage R sleep, they may also be seen in wakefulness with eyes open when individuals visually scan the environment.

Reading eye movements: Eye movements recorded in the EOG derivations consisting of trains of conjugate eye movements characterized by an initial slow phase followed by a rapid phase in the opposite direction as the individual reads.

REM Sleep Behavior Disorder: A parasomnia characterized by abnormal behaviors emerging from REM sleep and EMG abnormalities during REM sleep (REM sleep without atonia).

Respiratory effort-related arousal: A sequence of breaths characterized by increasing respiratory effort (esophageal manometry); inspiratory flattening in the nasal pressure or PAP device flow channel; or an increase in end-tidal PCO_2 (children) leading to an arousal from sleep. Respiratory effort-related arousals do not meet criteria for hypopnea and have a minimum duration of ≥10 seconds in adults or the duration of at least two breaths in children.

Respiratory event index (REI): Total number of respiratory events scored × 60 divided by monitoring time (MT).

Respiratory inductance plethysmography (RIP): A technology that uses alternating current in belts surrounding the thorax and abdomen to generate a signal based on changes in the inductance of belts during breathing. The band inductance depends on the cross-sectional area encircled by the band.

Rhythmic Movement Disorder: Repetitive, stereotyped and rhythmic motor behaviors that occur predominantly during drowsiness or sleep and involve large muscle groups.

RIPflow: RIPflow is the time derivative of the RIPsum signal; excursions in the signal are an estimate of airflow.

RIPsum: RIPsum is the electrical sum of the signals from the thoracic and abdominal RIP sensors; excursions in the signal are an estimate of tidal volume.

Sawtooth waves: An EEG pattern consisting of trains of sharply contoured or triangular, often serrated, 2–6 Hz waves maximal in amplitude over the central head regions and often, but not always, preceding a burst of rapid eye movements.

Scanning eye movements: Trains of conjugate eye movements with eyes open consisting of a slow phase followed by a rapid phase in the opposite direction as the infant visually scans the environment or follows objects.

Sleep onset: The start of the first epoch scored as any stage other than stage W. (In most subjects this will usually be the first epoch of stage N1.)

Sleep spindle: A train of distinct waves with frequency 11–16 Hz (most commonly 12–14 Hz) with a duration ≥0.5 seconds, usually maximal in amplitude over the central regions.

Slow eye movements (SEM): Conjugate, reasonably regular, sinusoidal eye movements with an initial deflection that usually lasts >500 msec. Slow eye movements may be seen during eyes closed wake and stage N1.

Slow wave activity: Waves of frequency 0.5–2 Hz and peak-to-peak amplitude >75 μV, measured over the frontal regions referenced to the contralateral ear or mastoid (F4-M1, F3-M2).

Sustained muscle activity (tonic activity) in REM sleep: An epoch of REM sleep with at least 50% of the duration of the epoch having a chin EMG amplitude greater than the minimum amplitude demonstrated in NREM sleep.

Tachycardia or sinus tachycardia (during sleep): A sustained (>30 seconds) sinus heart rate >90 beats per minute for adults.

Thermal sensor: A thermally sensitive device that detects changes in nasal and/or oral airflow based on changes in temperature; thermal sensors include thermistors, thermocouples, or polyvinylidene fluoride (PVDF) airflow sensors.

Theta rhythm: An EEG rhythm consisting of 4–7.99 Hz activity.

Trace alternant (TA): Generally only seen in stage N sleep; characterized by at least 3 alternating runs of bilaterally synchronous high voltage (50–150 μV) bursts of 1–3 Hz delta activity lasting 5–6 seconds (range 3–8 seconds) alternating with period of lower amplitude (25–50 μV) 4–7 Hz theta activity (range 4–12 seconds).

Transient muscle activity: Short irregular bursts of EMG activity usually with duration <0.25 seconds superimposed on low EMG tone. The activity may be seen in the chin or anterior tibial EMG derivations, as well as in EEG or EOG deviations, the latter indicating activity of cranial nerve innervated muscles (facial and scalp muscles). The activity is often maximal when associated with rapid eye movements.

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Vertex sharp waves (V waves): Sharply contoured waves with duration <0.5 seconds (as measured at the base of the wave), maximal over the central region and distinguishable from the background activity. They are most often seen during transition to stage N1 sleep but can occur in either stage N1 or N2 sleep. These waveforms typically first appear at 4–6 months post-term.

Wide complex tachycardia: A cardiac rhythm lasting a minimum of 3 consecutive beats with QRS duration ≥120 msec and a rate of >100 per minute.

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