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The AASM Manual for the Scoring of Sleep and Associated Events

RULES, TERMINOLOGY AND TECHNICAL SPECIFICATIONS

VERSION 3

American Academy of SLEEP MEDICINE™

The AASM Manual for the Scoring of Sleep and Associated Events

Rules, Terminology and Technical Specifications

Version 3

Matthew M. Troester, DO (2022-23 Chair); Stuart F. Quan, MD (2019-22 Chair); Richard B. Berry, MD; David T. Plante, MD, PhD (2022-23 Vice Chair); Alexandre R. Abreu, MD; Mohammed Alzoubaidi, MBBS; Anuja Bandyopadhyay, MBBS, MD; Lourdes DelRosso, MD; Matthew Ebben, PhD, RPSGT; Younghoon Kwon, MD; Molly-Min Mao, MS, RRT, RPSGT, RST; Syeda S. Munir, MD; Mark R. Pressman, PhD; Alcibiades J. Rodriguez, MD; Scott Ryals, MD; Jennifer Y. So, MD; Bradley V. Vaughn, MD; Sherene M. Thomas, PhD (Staff) for the American Academy of Sleep Medicine

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American Academy of Sleep Medicine
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2510 N Frontage Road Darien, IL 60561-1511
United States

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Contributors

Editors

VERSION 3 (2023)

Matthew M. Troester, DO, 2022-23 Chair
Stuart F. Quan, MD, 2019-22 Chair
Richard B. Berry, MD, 2019-23 Consultant
David T. Plante, MD, PhD, 2022-23 Vice Chair
Alexandre R. Abreu, MD
Mohammed Alzoubaidi, MBBS
Anuja Bandyopadhyay, MBBS, MD
Lourdes DelRosso, MD
Matthew Ebben, PhD, RPSGT
Younghoon Kwon, MD
Molly-Min Mao, MS, RRT, RPSGT, RST
Syeda S. Munir, MD
Mark R. Pressman, PhD
Alcibiades J. Rodriguez, MD
Scott Ryals, MD
Jennifer Y. So, MD
Bradley V. Vaughn, MD
Sherene M. Thomas, PhD, Staff

VERSION 2.6 (2020)

Richard B. Berry, MD, 2018-19 Chair
Stuart F. Quan, MD, 2019-20 Chair
Alexandre R. Abreu, MD
Marietta L. Bibbs, RPSGT, CCSH
Lourdes DelRosso, MD
Susan M. Harding, MD
Molly-Min Mao, MS, RRT, RPSGT, RST
David T. Plante, MD, PhD
Mark R. Pressman, PhD
Matthew M. Troester, DO
Bradley V. Vaughn, MD
Sherene M. Thomas, PhD, Staff

VERSION 2.5 (2018)

Richard B. Berry, MD, Chair
Claude L. Albertario, RST, RPSGT
Susan M. Harding, MD
Robin M. Lloyd, MD
David T. Plante, MD, PhD
Stuart F. Quan, MD
Matthew M. Troester, DO
Bradley V. Vaughn, MD
Sherene M. Thomas, PhD, Staff

VERSION 2.4 (2017)

Richard B. Berry, MD, Chair
Rita Brooks, MEd, RST, RPSGT
Charlene E. Gamaldo, MD
Susan M. Harding, MD
Robin M. Lloyd, MD
Stuart F. Quan, MD
Matthew M. Troester, DO
Bradley V. Vaughn, MD
Sherene M. Thomas, PhD, Staff

VERSION 2.0.2 – 2.3 (2013 – 2016)

Richard B. Berry, MD
Rita Brooks, MEd, RST, RPSGT
Charlene E. Gamaldo, MD
Susan M. Harding, MD
Robin M. Lloyd, MD
Carole L. Marcus, MBBCh
Bradley V. Vaughn, MD
Madeleine Grigg-Damberger, MD
(Infant Sleep Staging Rules Consultant, version 2.2)
Mark S. Scher, MD
(Infant Sleep Staging Rules Consultant, version 2.2)
Sherene M. Thomas, PhD, Staff

VERSION 2.0 – 2.0.1 (2012 – 2013)

Richard B. Berry, MD
Rita Brooks, MEd, RST, RPSGT
Charlene E. Gamaldo, MD
Susan M. Harding, MD
Carole L. Marcus, MBBCh
Bradley V. Vaughn, MD
Michelle Tangredi, PhD, Staff
Sherene M. Thomas, PhD, Staff

FIRST EDITION (2007 – 2011)

Conrad Iber, MD
Sonia Ancoli-Israel, PhD
Andrew L. Chesson Jr, MD
Stuart F. Quan, MD

AROUSAL TASK FORCE

Michael H. Bonnet, PhD, Chair
Karl Doghramji, MD
Timothy Roehrs, PhD
Stephen Sheldon, DO, FAAP
Edward J. Stepanski, PhD
Arthur S. Walters, MD
Merrill S. Wise, MD
Andrew L. Chesson Jr, MD

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Michael E. Adams, Research Associate
William G. Cotts, MD
Parvin Dorostkar, MD
Thomas Kara, MD
Timothy I. Morgenthaler, MD
Carol L. Rosen, MD
Edward J. Stepanski, PhD
Win K. Shen, MD
Kalyanam Shivkumar, MD
Conrad Iber, MD

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Nic Butkov, RPSGT
Ronald D. Chervin, MD, MS
Meir Kryger, MD
Clete A. Kushida, MD, PhD, RPSGT
Beth A. Malow, MD, MS
Michael H. Silber, MBChB
Michael V. Vitello, PhD
Andrew L. Chesson Jr, MD

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Susan Redline, MD, MPH
Edward Stepanski, PhD
Michael V. Vitiello, PhD
Timothy I. Morgenthaler, MD

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Wayne A. Hening, MD, PhD
Clete A. Kushida, MD, PhD, RPSGT
Gilles Lavigne, DMD, PhD, FRCD
Daniel Picchietti, MD
Sonia Ancoli-Israel, PhD

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David Gozal, MD, Co-Chair
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Timothy I. Morgenthaler, MD
Carol L. Rosen, MD
Stephen Sheldon, DO, FAAP
Stuart F. Quan, MD

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Sairam Parthasarathy, MD
Conrad Iber, MD
Reena Mehra, MD, MS
Daniel J. Gottlieb, MD
Kingman Strohl, MD
Stuart F. Quan, MD
Sally L. Davidson Ward, MD
David Gozal, MD
Vishesh K. Kapur, MD, MPH
Rohit Budhiraja, MD
Susan Redline, MD, MPH

VISUAL (SLEEP STAGING) TASK FORCE

Michael H. Silber, MBChB, Chair
Sonia Ancoli-Israel, PhD
Michael H. Bonnet, PhD
Sudhansu Chokroverty, MD, FRCP
Madeleine Grigg-Damberger, MD
Max Hirshkowitz, PhD
Sheldon Kapen, MD
Sharon Keenan, PhD, ABSM, RPSGT, REEGT
Meir Kryger, MD
Thomas Penzel, PhD
Mark Pressman, PhD
Conrad Iber, MD

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Jennifer Martin, PhD

Fariha Abbasi-Feinberg, MD

R. Nisha Aurora, MD, MHS

Vishesh Kapur, MD, MPH

David Kuhlmann, MD

Raman Malhotra, MD

Eric Olson, MD

Carol Rosen, MD

James Rowley, MD

Anita Shelgikar, MD, MHPE

Lynn Marie Trotti, MD, MSc

Emerson Wickwire, PhD

Steve Van Hout, MBA
Executive Director

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I. User Guide

Organization of the Manual

The AASM Manual for the Scoring of Sleep and Associated Events: Rules, Terminology and Technical Specifications guides 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 part 1 specifies all parameters that should be reported in a routine PSG test. Chapter II part 2 specifies all parameters that should be reported in a Multiple Latency Sleep Test or Maintenance of Wakefulness 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 rules for home sleep apnea tests, including those utilizing respiratory flow and/or effort and those utilizing peripheral arterial tonometry. The rules in chapter IX pertain to home sleep apnea tests that meet the recommendations and definitions in the current American Academy of Sleep Medicine clinical practice guideline on diagnostic testing for obstructive sleep apnea. Chapter X details the process by which the rules were developed and updated. An outline of the evidence level and decision-making process for each rule may be found in chapter XI. 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 and VIII due to critical age-specific differences in testing and scoring.

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 tests.
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]).

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

American Academy of Sleep Medicine Accreditation

American Academy of Sleep Medicine accreditation requires compliance with the rules, definitions, and notes in this manual. According to the American Academy of Sleep Medicine, rules specified to be RECOMMENDED are the preferred method 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, however, the rule used must be reported. OPTIONAL rules may be followed in addition to the recommended and acceptable rules without any risk to accreditation and should also be reported, if followed. For further information, please contact the American Academy of Sleep Medicine accreditation department at accreditation@aasm.org.

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II. Parameters to be Reported

Part 1: Rules for Reporting Polysomnography

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

Note 1. Time can be reported in hours or minutes, as appropriate.

Note 2. 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.

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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 and lowest heart rate during sleep	OPTIONAL
3.	Highest and lowest heart rate during recording	OPTIONAL
4.	Occurrence of bradycardia during sleep (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.	Occurrence of REM sleep without atonia (if observed); report REM sleep without atonia index (RWAI; [RWA / R] x 100) [N1, N2]	OPTIONAL

Note 1. For RWA / R, RWA is the number of epochs with RWA, and R is the total epochs of stage R. For scoring REM sleep without atonia, refer to chapter VII, section D.

Note 2. If electing to measure REM sleep without atonia, the leads used to determine the presence of REM sleep without atonia 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 index (CAI; # central apneas × 60 / TST)	OPTIONAL
13.	Central apnea-hypopnea index (CAHI; (# central apneas + # central hypopneas) × 60 / TST)	OPTIONAL
14.	Number of respiratory effort-related arousals (RERAs)	OPTIONAL
15.	Respiratory effort-related arousal index (RERA index; # of RERAs × 60 / TST)	OPTIONAL
16.	Respiratory disturbance index (RDI; (# apneas + # hypopneas + # RERAs) × 60 / TST)	OPTIONAL
17.	Number of oxygen desaturations ≥3% or ≥4%	OPTIONAL
18.	Oxygen desaturation index ≥3% or ≥4% (ODI; # oxygen desaturations ≥3% or ≥4% × 60 / TST)	OPTIONAL
19.	Arterial oxygen saturation, mean value	RECOMMENDED
20.	Time below specified oxygen saturation threshold [N2]	RECOMMENDED
21.	Minimum oxygen saturation during sleep	RECOMMENDED
22.	Occurrence of hypoventilation during diagnostic study [N3]	
	Adults	OPTIONAL
	Children	RECOMMENDED
23.	Occurrence of hypoventilation during PAP titration [N3]	
	Adults	OPTIONAL
	Children	OPTIONAL
24.	Occurrence of Cheyne-Stokes breathing in adults [N4]	RECOMMENDED
25.	Duration of Cheyne-Stokes breathing (absolute or as a percentage of total sleep time) or the number of Cheyne-Stokes breathing events	OPTIONAL
26.	Occurrence of periodic breathing in children	RECOMMENDED
27.	Occurrence of snoring	
	Adults	OPTIONAL
	Children	RECOMMENDED

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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 oxygen saturation threshold used is at the discretion of the clinician.

Note 3. 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 4. 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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II. Parameters to be Reported

Part 2: Rules for Reporting MSLT and MWT

A. General Parameters

1.	Electroencephalogram (EEG) derivations	RECOMMENDED
2.	Electrooculogram (EOG) derivations	RECOMMENDED
3.	Chin electromyogram (EMG)	RECOMMENDED
4.	Electrocardiogram (ECG)	RECOMMENDED

B. Patient Parameters

1.	Available pre-study data including sleep diary, actigraphy, and/or PAP download [N1]	RECOMMENDED
2.	Medications at the time of testing	RECOMMENDED
3.	Total sleep time (N1 + N2 + N3 + R) on preceding PSG [N2]	RECOMMENDED
4.	Documentation of whether sleep onset REM period (SOREMP) was observed on preceding PSG [N2]	RECOMMENDED
5.	Clinically relevant abnormalities of ECG, EEG, and patient behavior	RECOMMENDED

Note 1. These data may be documented on preceding polysomnography if performed in tandem.

Note 2. In the absence of preceding polysomnography, lack of such testing should be documented.

C. Sleep Scoring Data for Each Nap/Wake Trial

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.	Sleep latency (SL; lights out to first epoch of any sleep, in min)	RECOMMENDED
5.	Stage R latency (sleep onset to first epoch of stage R, in min)	RECOMMENDED
6.	Sleep time spent in N1, N2, N3 and R separately	OPTIONAL

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D. MSLT Summative Data

1.	Mean sleep latency (in min) [N1]	RECOMMENDED
2.	Total number of SOREMPs (whole integer value)	RECOMMENDED

Note 1. Mean sleep latency is the average of all individual sleep latencies divided by the number of nap/wake trials. Under standard protocols, if no sleep occurs on an individual MSLT nap trial, sleep latency equals 20 minutes for the nap.

E. MWT Summative Data

1.	Mean sleep latency (in min) [N1]	RECOMMENDED

Note 1. Mean sleep latency is the average of all individual sleep latencies divided by the number of nap/wake trials. Under standard protocols, if no sleep occurs on an individual MWT wake trial, sleep latency equals 40 minutes for the wake trial.

F. Reference

The following reference applies to content throughout chapter II part 2.

Krahn LE, Arand DL, Avidan AY, et al. Recommended protocols for the Multiple Sleep Latency Test and Maintenance of Wakefulness Test in adults: Guidance from the American Academy of Sleep Medicine. *J Clin Sleep Med.* 2021;17(12):2489-2498. doi:10.5664/jcsm.9620

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III. Technical and Digital Specifications

A. Digital Specifications for Routine PSG Recordings

1. Maximum electrode impedances: 5 KΩ [N1] RECOMMENDED

2. Minimum registry length or digital amplitude resolution: 12 bits per sample RECOMMENDED

3. Sampling rates [N2]

	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 [N13]	10 Hz	100 Hz	RECOMMENDED
ECG [N7]	0.3 Hz	100 Hz	RECOMMENDED
Oronasal thermal flow, thoracoabdominal belt signals [N14, N15]	0.1 Hz	15 Hz	RECOMMENDED
Nasal pressure [N15]	Direct current (DC) or ≤0.03 Hz	100 Hz	RECOMMENDED
PAP device flow [N15]	DC	DC	RECOMMENDED
Snoring	10 Hz	100 Hz	RECOMMENDED

5. Ability to display raw data for review, manual scoring, or editing of automated scoring [N16] RECOMMENDED

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Note 1. This applies to measured EEG, chin EMG, and EOG electrode impedance. Limb EMG impedances of 10 KΩ or less are acceptable, but impedances of 5 KΩ or less are preferred. The AASM Scoring Manual currently does not specify maximum impedance for ECG; however, it is suggested that the impedance be adjusted so that baseline amplitude of noise is minimized. Electrode impedances should be rechecked during a recording when any pattern that might be artifactual appears.

Note 2. These specifications are intended to homogenize the standard human visual analysis of sleep in 30-second epochs.

Note 3. For EEG, ≥500 Hz sampling rate could improve resolution of spikes 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 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/arm 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. Adjusting the high frequency filter to ≥150 Hz may be needed to identify pacemaker spikes in some instances. Adjusting the low frequency filter downward may help evaluate cardiac ischemia, though this is not a common PSG issue. Identification of heart rate and dysrhythmia are more relevant using single channel modified lead II.

Note 8. For oximetry, 25 Hz sampling is desirable to assist with artifact evaluation. Averaging times in pulse oximetry units are not standardized; however, the maximum acceptable averaging time for a pulse oximeter is 3 seconds. Longer averaging times increase the likelihood of not detecting transient desaturations from baseline.

Note 9. For nasal pressure transducer technology (especially with settings that 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 defining clearer waveforms with more accurate amplitude determination as the envelope of the rapidly oscillating signal is interpreted. 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. Although 35 Hz high-frequency filters are recognized as the historical standard, the use of 70 Hz high-frequency filters (without 60 Hz notch filters) for EEG, EOG, and EMG channels allows identification of 60 Hz artifact. The presence of 60 Hz artifact is an early indication of loss of electrical integrity within the recording system and that the signals presented may not be of biological origin.

Note 14. Optimal filter settings for thoracoabdominal belts signals may vary in the home versus laboratory environment. Reduction in the high-frequency filter to as low as 2 Hz may be reasonable to consistently eliminate artifact encountered in the home environment.

Note 15. For channels that are sampled at or below 120 Hz, the high-frequency filter should be adjusted to be no greater than half the sample rate to be consistent with the principle conveyed by the Nyquist theorem.

Note 16. Raw tracings must be viewable in detail with the ability to edit events.

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B. PSG Recording Features

1.	A method 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 notch filter control for each channel	RECOMMENDED
3.	The capability of providing the minimal recommended sampling rate (or higher) and minimal registry length (digital amplitude) or higher for all signals as specified in III.A	RECOMMENDED
4.	A method of measuring actual individual electrode impedance against a reference (the latter may be the sum of all other applied electrodes or a cephalic ground electrode)	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

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, O_2 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 within one second and have an accuracy of at least one video frame per second [N1]	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.	Multiple display setup profiles that may be activated at any time	OPTIONAL
10.	Fast Fourier transformation or spectral analysis on specifiable interval (omitting segments marked as data artifact)	OPTIONAL

Note 1. Video frames per second recorded should be increased for sufficient accuracy in the assessment of disorders for which nocturnal behaviors are a key feature of the pathology.

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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 (e.g., sleep spindle, K complex, alpha activity)	OPTIONAL
3.	Ability to turn off and on, as demanded, highlighting of patterns identifying respiratory events (e.g., apneas, hypopneas, desaturations)	OPTIONAL
4.	Ability to turn off and on, as demanded, highlighting of patterns identifying the movement analysis (e.g., 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	RECOMMENDED
2.	Record a minimum of 30 seconds of EEG with patient awake lying quietly with eyes open [N3]	RECOMMENDED
3.	Record a minimum of 30 seconds of EEG with patient lying quietly with eyes closed [N3]	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) [N4]	RECOMMENDED
8.	Ask the patient to simulate a snore or hum (5 seconds) [N5]	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) [N6]	RECOMMENDED
11.	Ask the patient to breathe normally, upon instruction to take a breath in and out; check polarity and mark the record IN and OUT accordingly [N6]	OPTIONAL
12.	Ask the patient to breathe through the nose only (10 seconds) [N6]	RECOMMENDED
13.	Ask the patient to breathe through the mouth only (10 seconds) [N6]	RECOMMENDED
14.	Ask the patient to take a deep breath and exhale slowly (prolonged expiration—10 seconds) [N6]	OPTIONAL
15.	Ask the patient to flex the left foot/raise toes on left foot (×5) [N7]	RECOMMENDED
16.	Ask the patient to flex the right foot/raise toes on right foot (×5) [N7]	RECOMMENDED
17.	If upper extremity EMG is recorded, ask the patient to flex/extend the fingers on the left hand, as appropriate [N7, N8]	RECOMMENDED
18.	If upper extremity EMG is recorded, ask the patient to flex/extend the fingers on the right hand, as appropriate [N7, N8]	RECOMMENDED
19.	Adjust ECG signal to provide a clear waveform—the R wave should deflect upward [N9]	RECOMMENDED
20.	Perform and document a repeat impedance check of the EEG, EOG and EMG electrodes at the end of the PSG recording	RECOMMENDED
21.	Repeat impedance measures and physiological calibrations at the end of the PSG recording	RECOMMENDED

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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. Check EEG channels for blocking, 60 Hz, ECG, and sweat or respiratory artifact and make any necessary adjustments to ensure a readable EEG recording.

Note 4. 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 5. 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 6. 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. Ensure that airflow and effort signals respond appropriately to a 10-second breath hold.

Note 7. Adjust limb EMG signal to reflect a low background; check signal with bilateral limb movements to verify a noticeable deflection with movement.

Note 8. 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 9. Compare heart rate to ECG signal (heart rate is collected from pulse oximetry) to ensure heart rate accuracy.

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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. **The 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

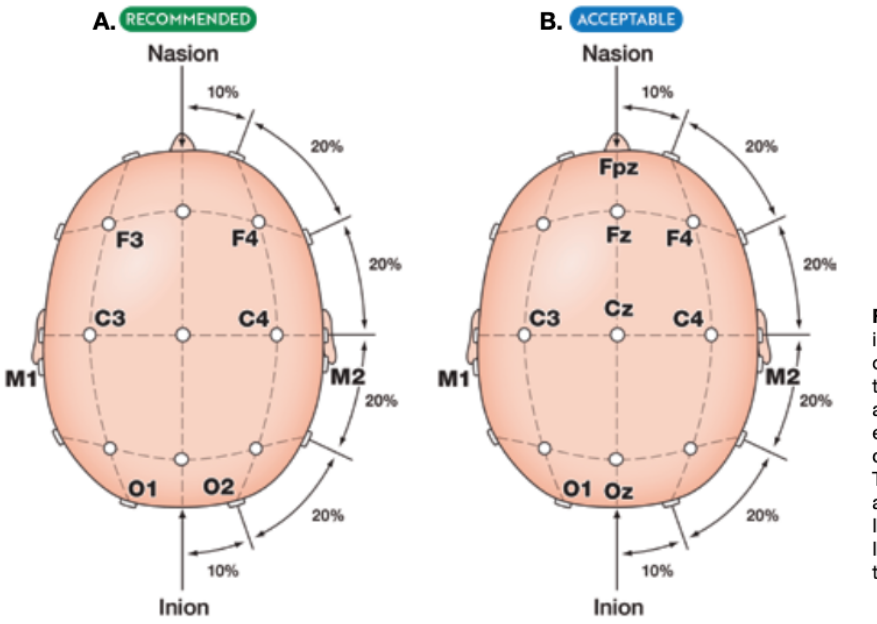


Figure 1. Images illustrating the placement of electrodes utilized in the recommended **(A)** and acceptable **(B)** derivations for electroencephalography (EEG) during polysomnography. The electrode placement and nomenclature follow the International 10-20 System. Illustration may not be to scale.

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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.

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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

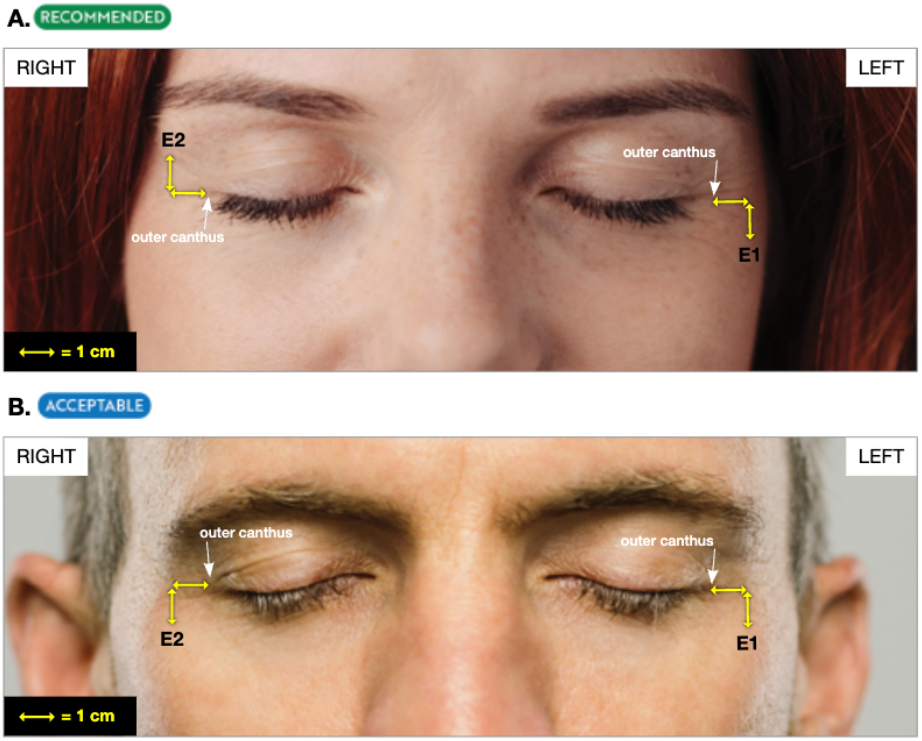


Figure 2.
A. Recommended and **B.** acceptable derivations for electrooculogram (EOG). Illustration may not be to scale.

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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.

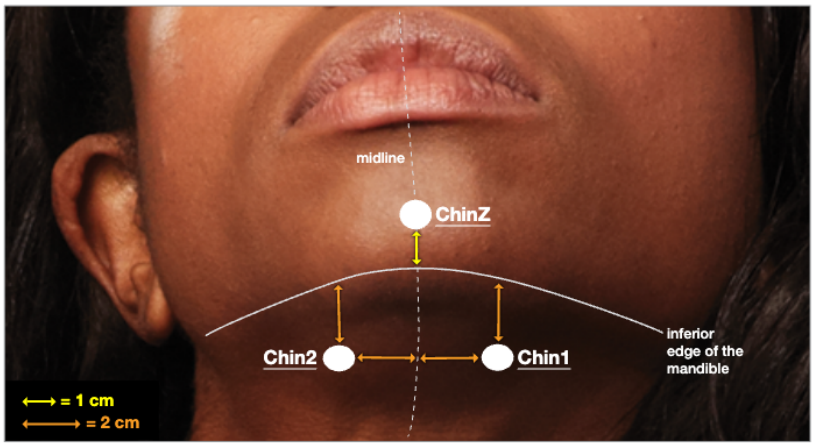
Note 2. When using the recommended electrode derivations, conjugate eye movements result in out-of-phase deflections. The acceptable derivations allow determination of the direction of eye movements (i.e., vertical movements will show in-phase deflections and horizontal eye movements, out-of-phase deflections).

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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)



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

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

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)

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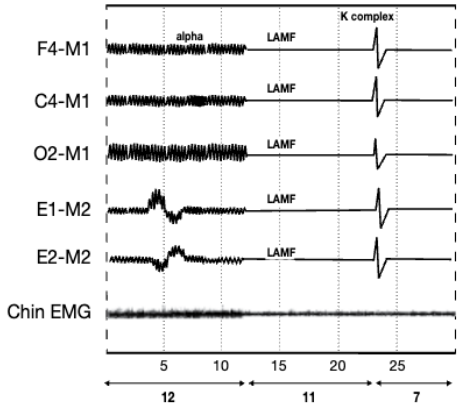


Figure 4. In this epoch, there is an initial segment meeting criteria for stage W (12 seconds), a second segment meeting criteria for stage N1 (11 seconds) and a final segment meeting criteria for stage N2 (7 seconds). The epoch is scored as sleep as the majority of the epoch is sleep. The epoch is scored 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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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

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

Posterior dominant rhythm (also known as alpha rhythm): N6 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)

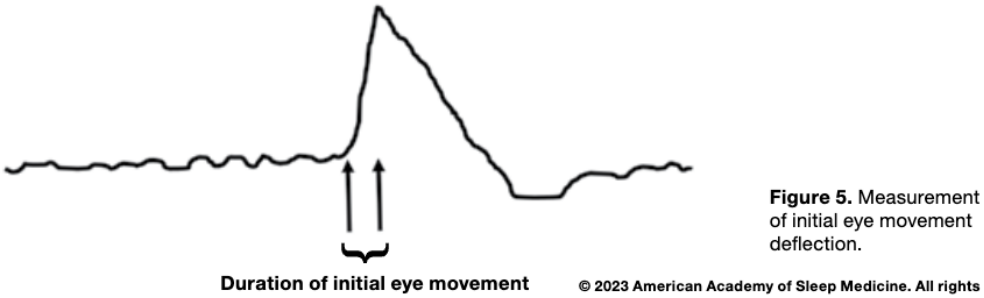


Figure 5. Measurement of initial eye movement deflection.

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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.

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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. Posterior dominant rhythm (alpha rhythm) over the occipital region (individuals generating posterior dominant rhythm [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

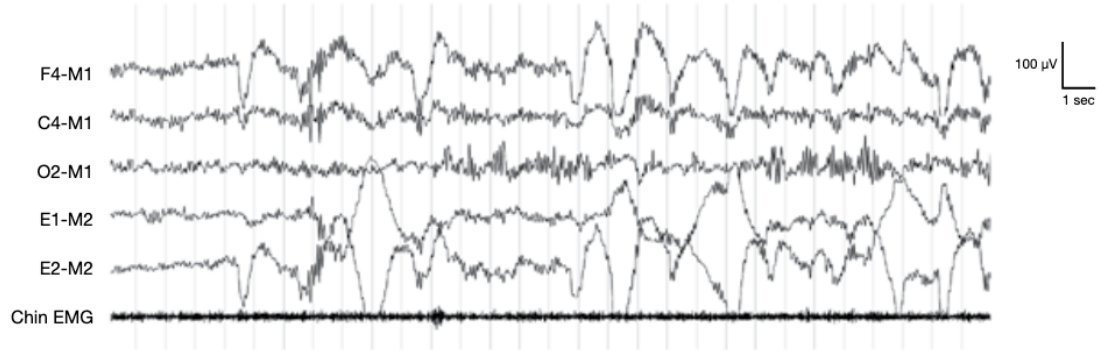


Figure 6. An epoch of stage W with both alpha rhythm (posterior dominant rhythm) and REMs. Note the EMG activity in the chin channel.

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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 posterior dominant rhythm (alpha rhythm). The EEG pattern with eyes open consists of low-amplitude activity (chiefly beta and alpha frequencies) without the rhythmicity of posterior dominant rhythm (alpha rhythm). About 10% of individuals do not generate a posterior dominant rhythm (alpha rhythm) upon eye closure, and a further 10% may generate a limited posterior dominant rhythm (alpha rhythm). In these individuals, the occipital EEG activity is similar during eye opening and eye closure. Time synchronized video verification of eyes open or closed can aid in the of determination posterior dominant rhythm (alpha rhythm) reactivity.

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.

Note 6. Posterior dominant rhythm has traditionally been called alpha rhythm, however, the term posterior dominant rhythm is preferred because not all alpha activity is posterior dominant rhythm (alpha activity predominant in other brain areas, for example, in frontal and central derivations in alpha sleep). The normal range for posterior dominant rhythm in adults is 8.5 to 13 Hz, and in infants over 6 months and young children it typically starts in the upper delta and theta frequency and gradually increases in frequency as the child ages.

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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 last >500 msec. Slow eye movements may be seen during eyes closed wake and stage N1.

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

   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 a posterior dominant rhythm (alpha rhythm), score stage N1 if the posterior dominant rhythm (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 a posterior dominant rhythm (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 activity) in the absence of evidence for another sleep stage. Subsequent epochs with an EEG showing LAMF 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

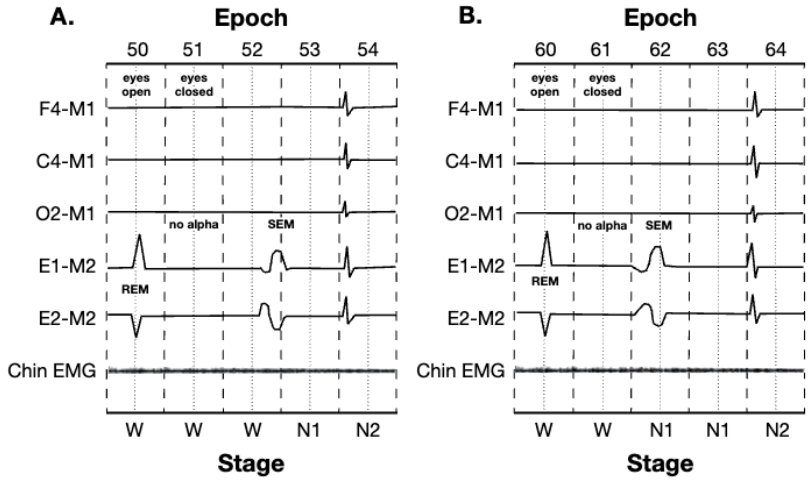


Figure 7. Transition from stage W to stage N1 in a patient who does not generate alpha rhythm (posterior dominant rhythm) with eye closure. It is assumed the EEG in epochs 52 and 62 do not meet criteria F.3.a. (that is, stage N1 cannot be scored based on the EEG criteria).
A. Epoch 52 continues to be 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 section 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 rule G.2 for scoring stage N2 and rule 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 and often lower than in stage W.

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

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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, and 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 chapter V. Arousal Rules)

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

2. **Begin scoring stage N2 (in absence of criteria for stage N3) if EITHER or BOTH of the following occur during the first half of the 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

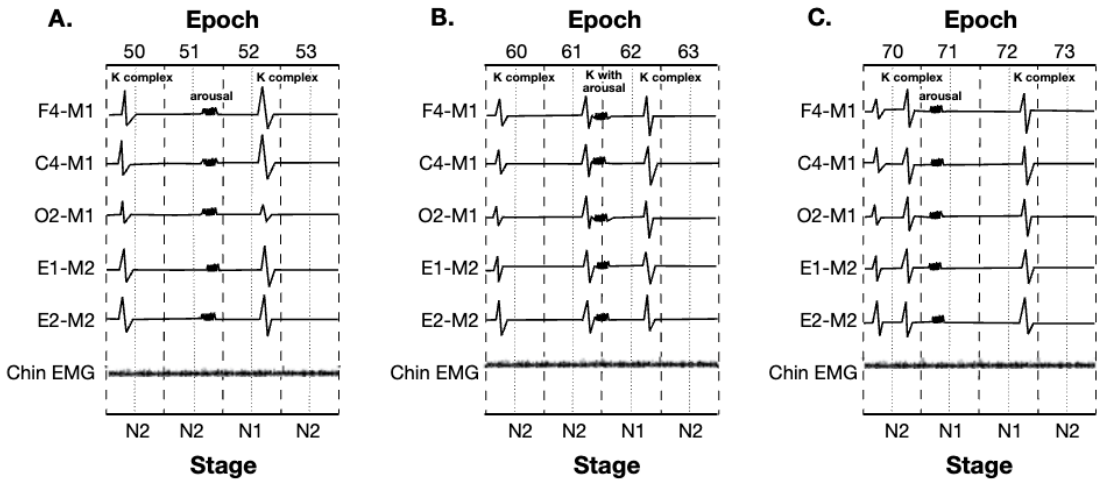


Figure 8. Start and continuation of stage N2. The EEG is assumed to show LAMF unless otherwise depicted.
A. Start of N2. Epoch 50 is scored as stage N2 as there is a K complex (unassociated with an arousal) in the first half of the epoch (rule G.2). Epoch 51 is stage N2 as this stage continues for the 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

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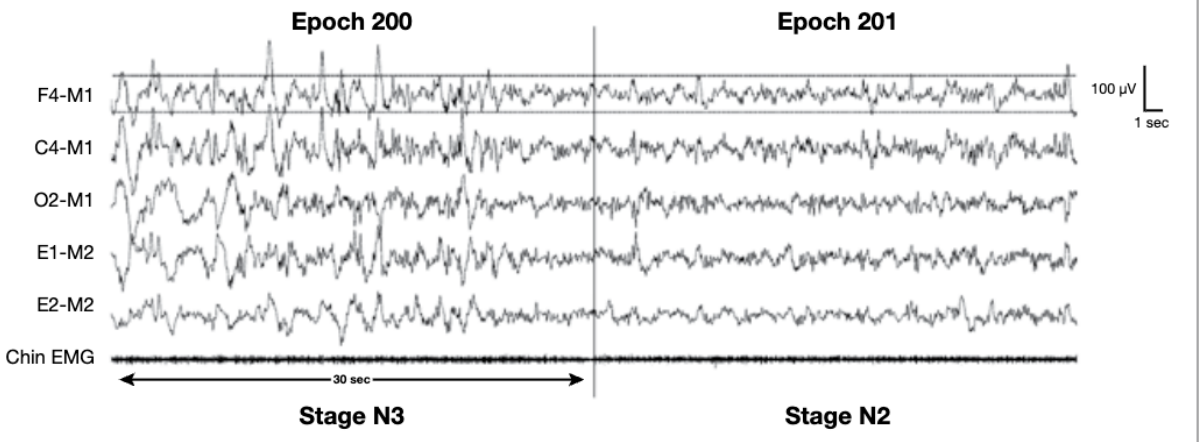


Figure 9. Transition from stage N3 to stage N2. The vertical distance between the lines in F4-M1 is 75 µV. Epoch 201 does not have sufficient slow wave activity to meet criteria for stage N3. There is no intervening arousal. Epoch 201 is scored as stage N2.

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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 (see rule I.3 and 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

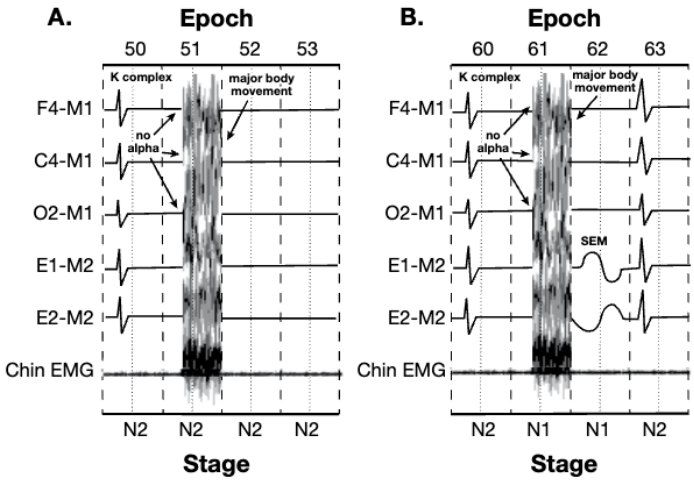


Figure 10. End of stage N2 due to a major body movement. The EEG is assumed to contain low-amplitude, mixed-frequency activity unless otherwise depicted. **A.** Epoch 52 continues to be scored as stage N2 as the major body movement is NOT followed by slow eye movements. Epoch 51 is scored according to 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 rule 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 chapter V, rule 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, 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, N7] RECOMMENDED

Note 1. Stage N3 represents slow wave sleep and replaces the Rechtschaffen 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 resulting from neurological impairment, encephalopathy, or epilepsy, 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.

Note 7. Due to reported difficulty correctly identifying qualifying slow waves, 75 μV lines inserted in the recording or identification of delta waves by concurrent digital analysis, may assist the scorer. Candidate slow waves may be marked such that the total duration of slow waves may be quantified.

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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 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 rule 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

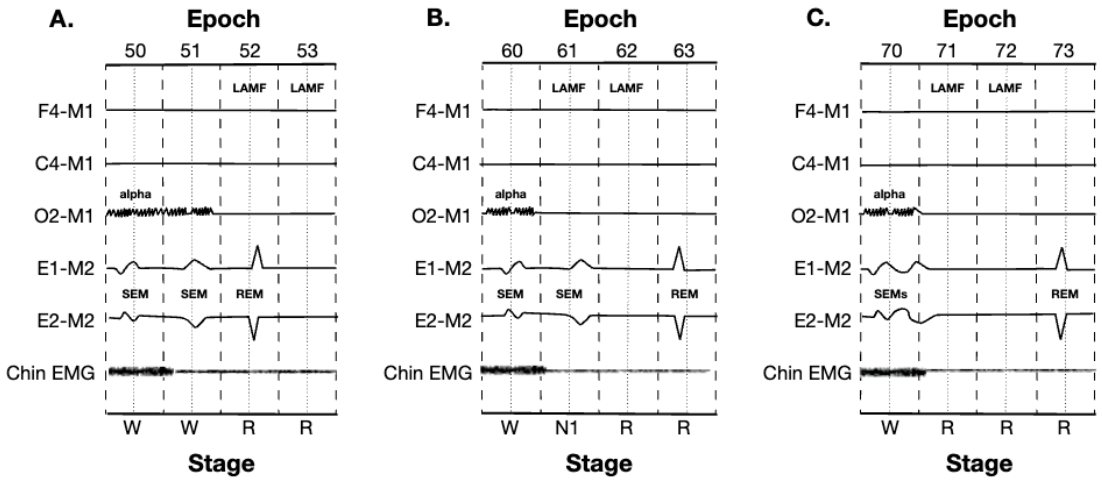


Figure 11. Start of stage R.
A. Epoch 52 is an epoch of definite stage R. Epoch 53 is scored as stage R by rule I.5 (REM continuation rule).
B. Epoch 61 is scored as stage N1 as alpha is replaced by low-amplitude, mixed-frequency (LAMF) EEG activity. A SEM is present in the second half of the epoch. 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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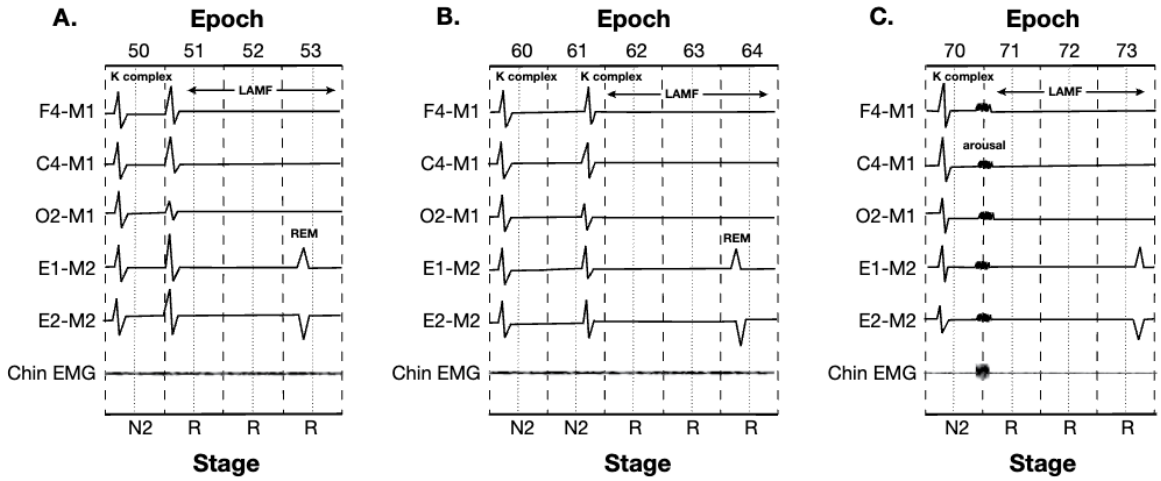


Figure 12. Start of stage R.
A. Transition from definite stage N2 (epoch 50) to definite stage R (epoch 53). The EEG of the majority of epoch 51 and all of epoch 52 has low-amplitude, mixed-frequency (LAMF) EEG without sleep spindles or K complexes and chin EMG is at the stage R level. As the epochs 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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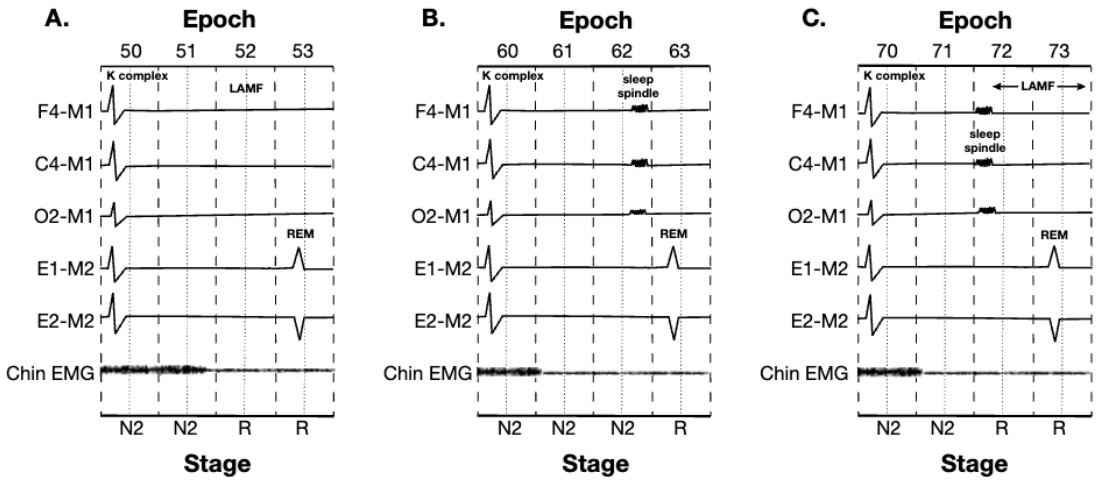


Figure 13. Scoring stage R.
A. A transition between definite stage N2 (epoch 50) and definite stage R (epoch 53). Epoch 52 is scored as stage R as the EEG shows low-amplitude, mixed-frequency (LAMF) without K complexes or sleep spindles and the chin EMG falls to the stage R level at the end of epoch 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 (rules I.2, I.3, and 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 low-amplitude, mixed-frequency 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

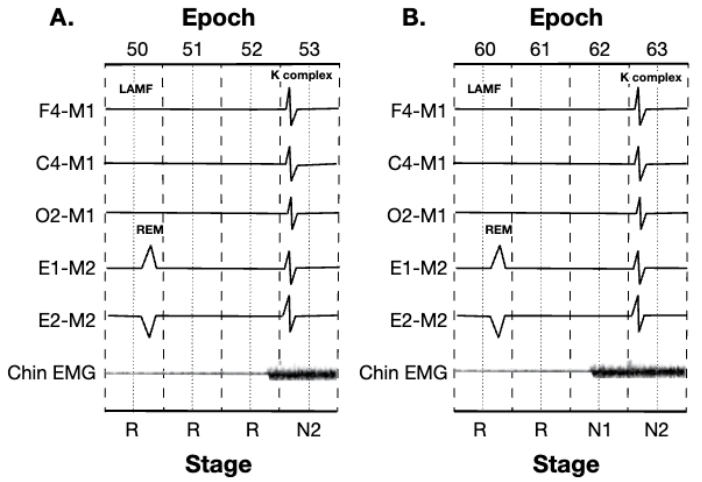


Figure 14. Continuation and end of stage R. The EEG is assumed to contain low-amplitude, mixed-frequency activity unless otherwise depicted.
A. Epoch 50 is definite stage R (rule I.2). Epochs 51 and 52 continue to be scored as stage R as the chin EMG remains low and the EEG does not contain K complexes 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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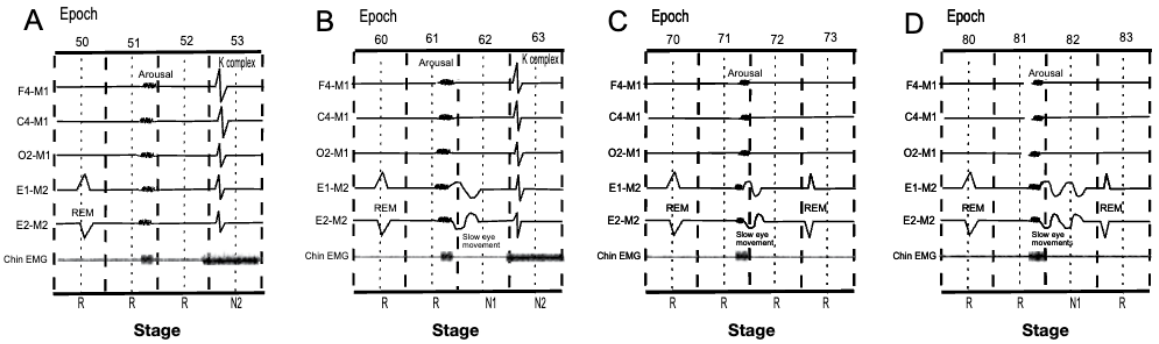


Figure 15. End of Stage R when an arousal is followed by slow eye movements. The EEG is assumed to contain low-amplitude, mixed-frequency activity unless otherwise depicted.
A. Stage R is interrupted by an arousal followed by low-amplitude, mixed-frequency EEG **without slow eye movements.** Epoch 52 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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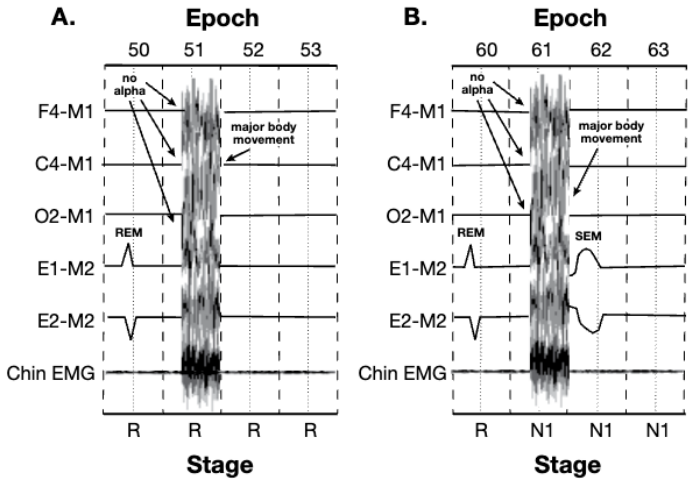


Figure 16. End of stage R due to a major body movement. The EEG is assumed to contain low-amplitude mixed-frequency activity unless otherwise depicted.
A. Epoch 52 continues as stage R as the EEG contains low-amplitude mixed-frequency activity, the chin EMG tone is low, and slow eye movements do NOT 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 section 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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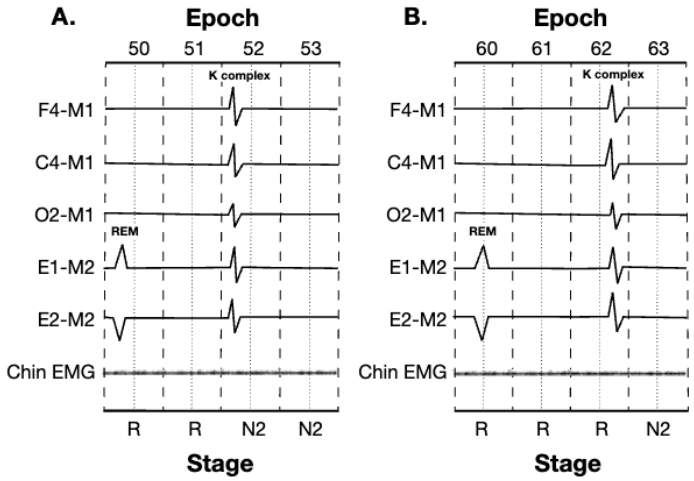


Figure 17. Transition from stage R to stage N2. The EEG is assumed to contain low-amplitude, mixed-frequency activity unless otherwise depicted.
A. Epoch 50 is definite stage R. Epoch 51 is scored as stage R by rule I.5 (continuation of stage R rule). Epoch 52 is an epoch of definite stage N2 given the 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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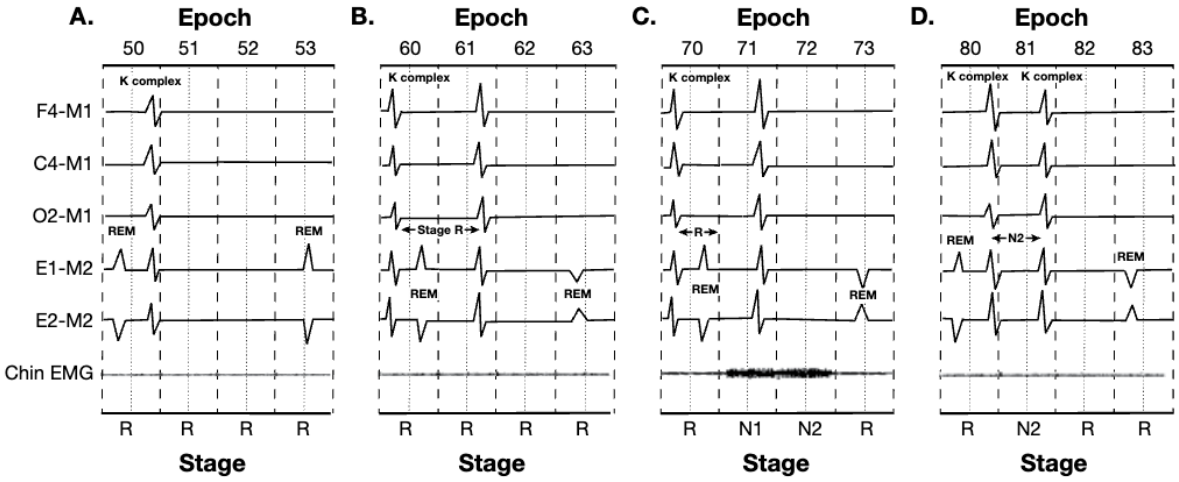


Figure 18. Mixture of REMs and K complexes.
A. Epoch 50 is scored as stage R as the majority of the epoch is considered stage R (rule I.7.c). Epochs 51 and 52 are scored as stage R by rule I.3.
B. Epochs 60 and 61 are scored as stage R as the majority of the epochs are considered stage R (rule I.7.c).
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.c) 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. If an arousal interrupts stage R, score the portion of the record **containing slow eye movements** with low-amplitude mixed-frequency EEG and no posterior dominant rhythm as stage N1 even if the chin EMG activity remains low (at stage R level). Continue to score stage N1 as long as there are slow eye movements until there is evidence for another stage, usually stage N2 (see rule G.2) or stage R (see rules 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. There is 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 in section 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. Some patients have spontaneous alpha mixed in with the low-amplitude and fast frequency waveforms. In some individuals, a greater amount of alpha frequency 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 rule 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 low-amplitude, mixed-frequency 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 stage R 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 posterior dominant rhythm (alpha rhythm) is present for part of the epoch (even <15 seconds duration), score as stage W.** RECOMMENDED
3. **If no posterior dominant rhythm (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 chapter 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. (see section I. Reference)

B. Technical Specifications

1. **See chapter IV. Sleep Staging Rules Part 1: Rules for Adults and chapter 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 ≥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 to 3 months post-term and are present in all infants by age 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. In addition to posterior slow waves of youth (PSW), the PDR in healthy children awake often contains medium amplitude intermixed slower EEG activity (typically <100 μV, 2.5–4.5 Hz). Intermixed delta-theta slowing in the PDR is a normal finding in EEGs of children ages 1–15 years and especially prominent in ages 5–7 years. The amount of intermixed slowing decreases and its frequency increases with increasing age. Intermixed slowing is "normal" when it is less than 120% the PDR amplitude, blocks with eye opening, and disappears with drowsiness.

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.

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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 on EEG that is low-amplitude, predominantly 4–7 Hz.

   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

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 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.

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F. Scoring Stage N2

1. **Same as adult rules in chapter IV. Sleep Staging Rules Part 1: Rules for Adults, section G.** [N1, N2, N3] RECOMMENDED

> **Note 1.** Sleep spindles are usually 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 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 adult rules in chapter IV. Sleep Staging Rules Part 1: Rules for Adults, section 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 adult rules in chapter IV. Sleep Staging Rules Part 1: Rules for Adults, section 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.

I. Reference

The following reference applies to content throughout chapter IV. Sleep Staging Rules Part 2: Rules for Children.

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. doi:10.5664/jcsm.26819

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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 full-term infants 0–2 months of age (37–48 weeks postmenstrual age).** RECOMMENDED
    a. Postmenstrual age (PMA) [formerly termed 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 PMA. Chronological age (or postnatal or legal age) is the time elapsed since birth (can be expressed in days, months, or years).
    b. At birth, an infant is classified as one of the following: pre-term (<37 weeks gestation); full-term (37–44 weeks); or post-term (born after 44 weeks). A neonate is a child during the first 28 days after birth; an infant is a child aged 1 to 12 months. (see section H. References, reference 2)
    c. Knowing an infant's PMA 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.
    d. For pre-term infants (<37 weeks PMA) refer to discussion in the Pediatric and Infant Scoring Task Force review paper. (see section H. References, reference 3)

B. Technical Specifications

1. **See chapter IV. Sleep Staging Rules Part 1: Rules for Adults and chapter 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.** [N2] RECOMMENDED

> **Note 1.** Since rudimentary sleep spindles first appear at 43 to 48 weeks PMA 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 2.** Behavioral characteristics are an essential component of infant sleep staging. When possible, every effort should be made to keep the video focused on patient's face and body to identify eye opening/closure and small movements.

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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 PMA):** [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 PMA 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.

Stages	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.

Stages	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	Stages
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, W
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.	W, R, rarely N
Waveforms of interest		
Sleep spindles	12 to 14 Hz, asynchronous, most prominent in midline central (CZ) and central derivations. Occur only in stage N sleep.	N

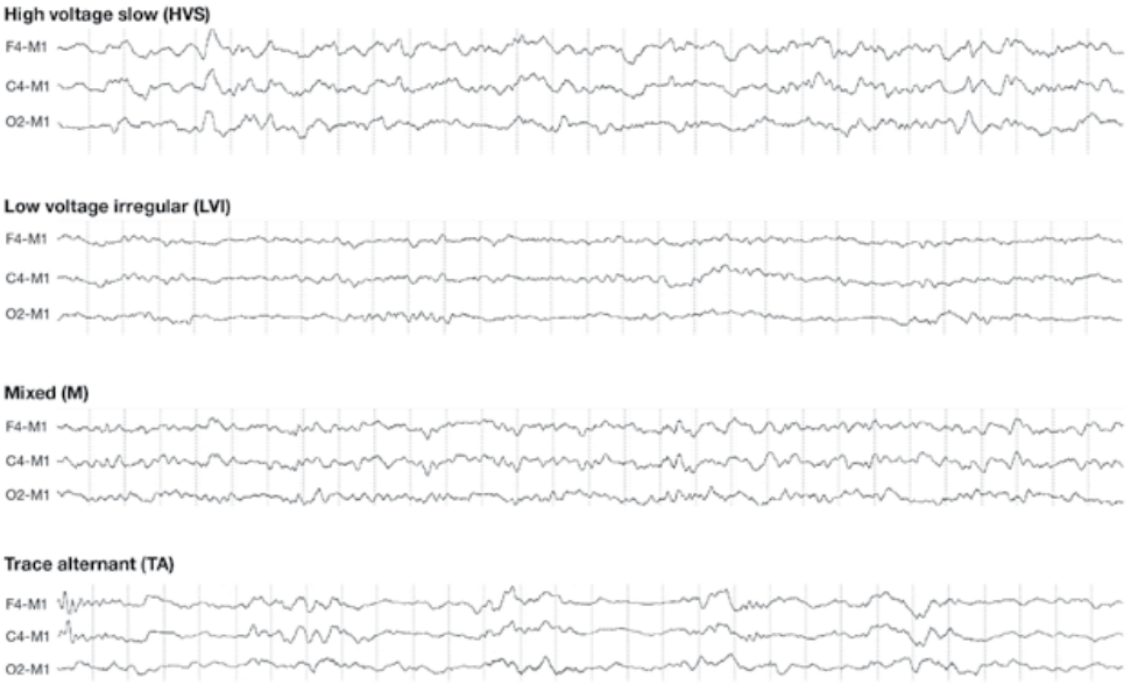


Figure 1. Sample 30 second tracings of EEG characteristics of sleep stages.

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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. [N12]

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.

Stages	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 (TMA): 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.

Stages	Chin EMG Patterns
Wake	Present, movement artifact
N	Present; could be lower than wake
R	Low, transient muscle activity may occur

Table 6. Summary of state characteristics from Tables 1 to 5. [N13]

Stages	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 [N14]	Low, TMA may occur

EM = eye movements, HVS = high voltage slow, LVI = low voltage irregular, M = mixed, REMs = rapid eye movements, TA = trace alternant, TMA = transient muscle activity

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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 chapter IV. Sleep Staging Rules Part 2: Rules for Children, section C, rule 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 stage 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 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 post menstrual age (PMA), is the predominant EEG pattern in stage N sleep at 40 weeks PMA and is unlikely to be seen after 44 weeks PMA. After 42 weeks PMA, interburst intervals (IBIs) of TA last only 1–2 seconds and the IBI is of higher amplitude. TA after 44 weeks PMA 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. Scanning eye movements can be seen as early as 2 weeks post-term.

Note 13. Stage T is scored when 3 NREM and 2 REM or 2 NREM and 3 REM characteristics are present.

Note 14. Epochs of sleep contiguous with and following an epoch of definite stage R should be scored as stage R.

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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] **(see 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]

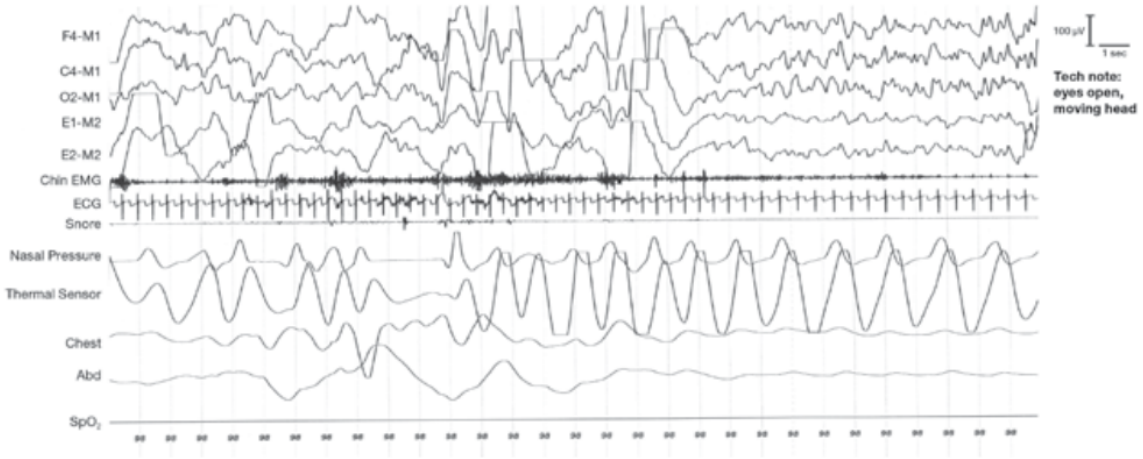


Figure 2. A 30 second tracing of stage W in an infant. EEG: mixed frequency pattern; EOG: REMs present; Chin EMG: present (high); Respiration: irregular; Behavior: eyes open, moving head. The thermal sensor is an oronasal flow sensor.

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Note 1. Stage W 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. Stage W 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, one of which must be regular respiration, for the majority of the epoch:** [N1, N2] **(see 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

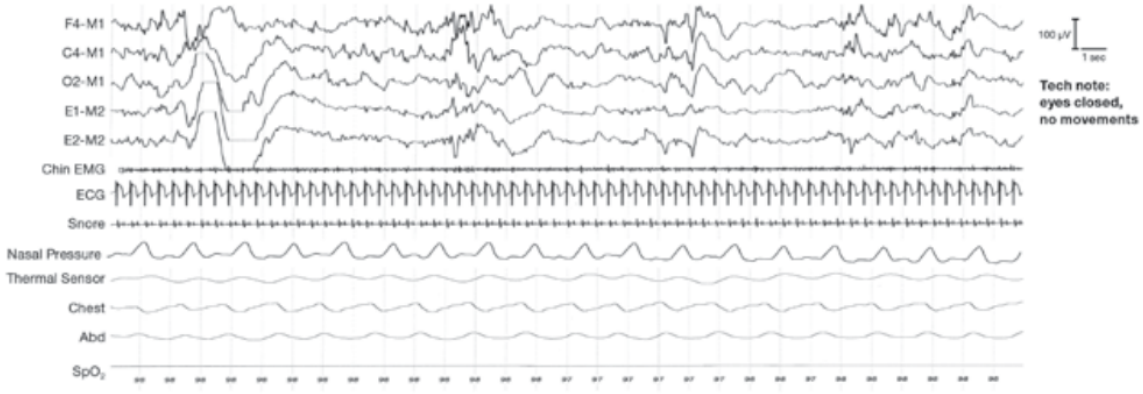


Figure 3. A 30 second tracing of stage N sleep in an infant. EEG: Trace alternant; EOG: no REMs; Chin EMG: present; Respiration: regular; Behavior: eyes closed, no movements. The thermal sensor is an oronasal flow sensor.

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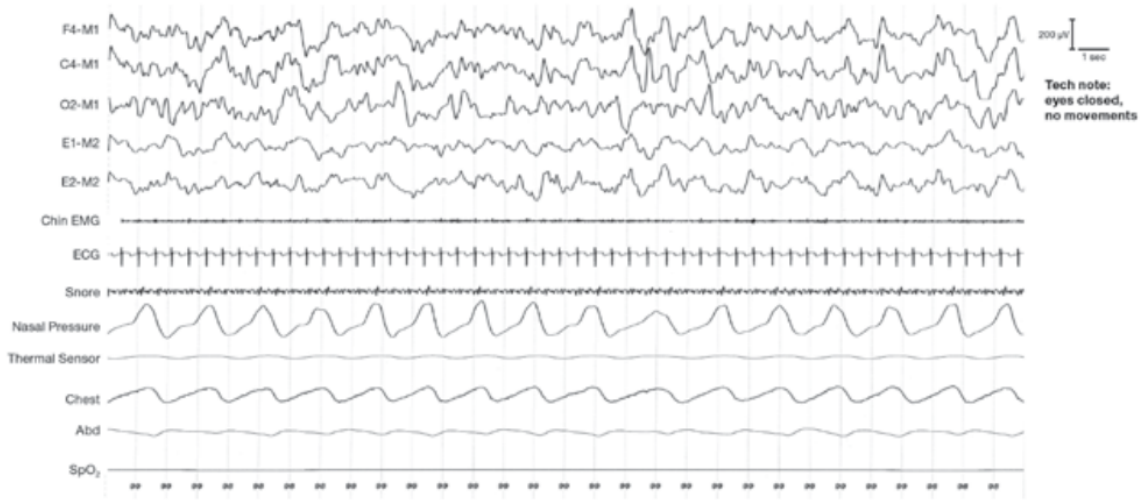


Figure 4. A 30 second tracing of stage N sleep in an infant. EEG: HVS; EOG: no eye movements; Chin EMG: present; Respiration: regular; Behavior: eyes closed, no movements. The thermal sensor is an oronasal flow sensor.

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Note 1. Chin EMG in stage N is variable; it is generally lower than stage W 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.

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F. Scoring Stage R

1. **Score stage R sleep (definite R) in epochs with four or more of the following criteria present, two of which must be irregular respiration AND rapid eye movements: [N1] (see 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 Rules)

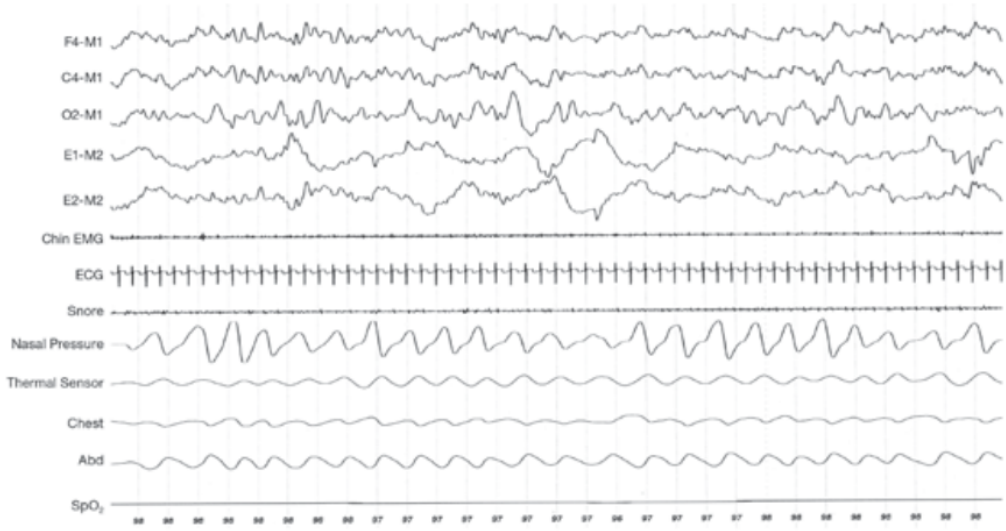


Figure 5. A 30 second tracing of stage R sleep in an infant. EEG: LVI; EOG: REMs; Chin EMG: low; Respiration: irregular; Behavior: eye movements noted with small movements of mouth. The thermal sensor is an oronasal flow sensor.

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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 if it contains either 3 NREM and 2 REM characteristics or 2 NREM and 3 REM characteristics. (see Table 6 and Figure 6)** RECOMMENDED

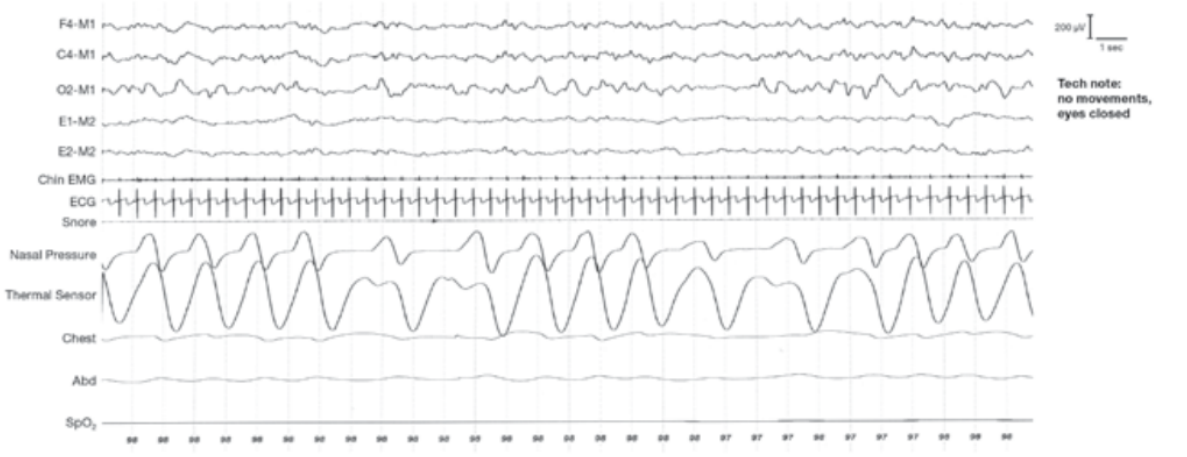


Figure 6. A 30 second tracing of Transitional (T) sleep in an infant. EEG: LVI; EOG: no REMs; Chin EMG: absent (low); Respiration: irregular; Behavioral: no movements, eye closed. Three characteristics of stage R (LVI, Chin EMG absent, irregular respiration) and two characteristics of NREM (no movement, 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 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 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. References

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

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2. Engle WA; American Academy of Pediatrics Committee on Fetus and Newborn. Age terminology during the perinatal period. *Pediatrics*. 2004;114(5):1362–1364. doi:10.1542/peds.2004-1915
3. 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. doi:10.5664/jcsm.26819
4. Grigg-Damberger MM. The visual scoring of sleep in infants 0 to 2 months of age. *J Clin Sleep Med*. 2016;12(3):429–445. doi:10.5664/jcsm.5600

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V. Arousal Rules

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 stage R requires a concurrent increase in submental EMG lasting at least 1 second.** [N1, N2, N3, N4] RECOMMENDED

2. **Score arousal if it immediately precedes a transition to stage W. That is, both the arousal and transition to wake are scored. (see Figure 1)** RECOMMENDED

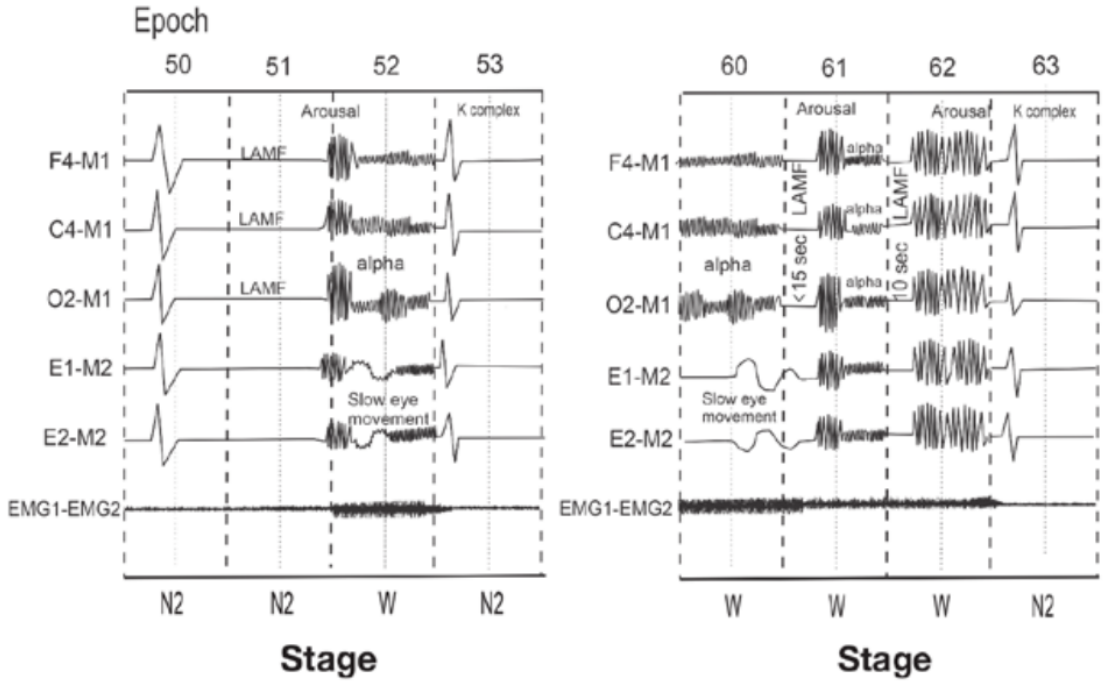


Figure 1. At the end of epoch 51, an arousal occurs and precedes an epoch of stage W. At the beginning of epoch 61, there are <15 seconds of sleep then an arousal is scored. Epoch 61 is scored stage W because most of the epoch is stage W. At the beginning of epoch 62, there are 10 seconds of sleep followed by an arousal that lasts for the remainder of the epoch. Thus, epoch 62 is scored as stage W. LAMF = low-amplitude mixed-frequency.

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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. Classifying arousals as related to respiratory or leg movement events, or occurring spontaneously, may be informative.

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VI. Cardiac Rules

A. Technical Specifications

1. **Use a single modified electrocardiograph Lead II on the torso with electrode placement as shown in Figure 1.** [N1, N2, N3, N4] RECOMMENDED

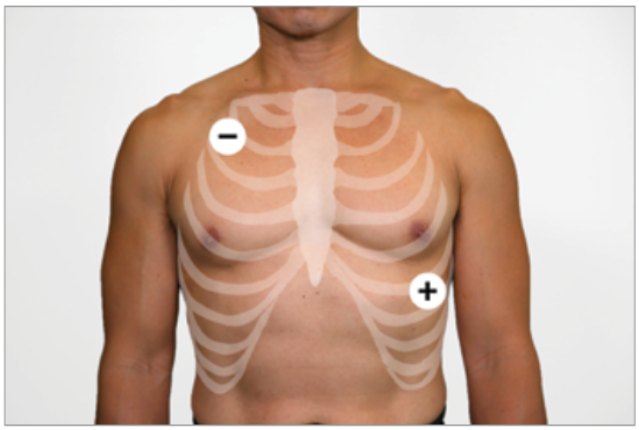


Figure 1. Diagram of Lead II placement on torso during cardiac recording. Illustration may not be to scale.

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2. **Use a single modified electrocardiograph Lead I on the torso with electrode placement as shown in Figure 2. If an artifact-free signal cannot be obtained using the modified Lead I, a modified Lead II must be placed.** [N5] OPTIONAL

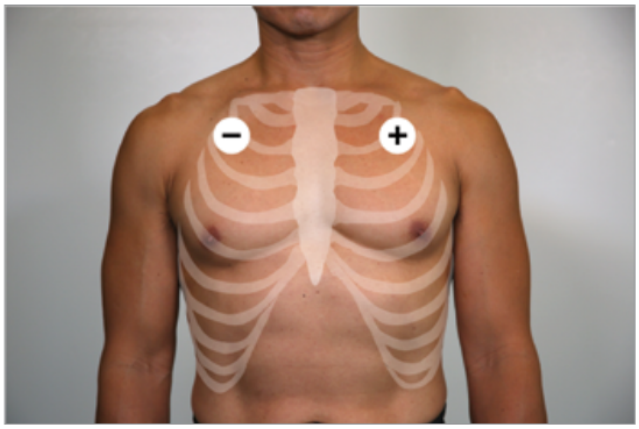


Figure 2. Diagram of Lead I placement on torso during cardiac recording. Illustration may not be to scale.

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

Note 2. Observing the ECG using a 10 or 15-second page duration may improve detection of arrhythmias.

Note 3. Lead II is typically derived from electrodes placed on the right arm and left leg, but the negative electrode can 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.

Note 5. Lead I is typically derived from electrodes placed on the right arm and left arm, but the negative electrode can be placed below the right clavicle at the mid-clavicular line and the positive electrode below the left clavicle at the mid-clavicular line.

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B. Scoring Cardiac Events [N1, N2, N3]

1. Score sinus tachycardia during sleep for a sustained (> 30 seconds) sinus heart rate of >90 beats per minute for adults. [N4, N5] RECOMMENDED
2. Score sinus bradycardia during sleep for a sustained (> 30 seconds) sinus heart rate of <40 beats per minute for ages 6 years through adult. [N5] RECOMMENDED
3. Score asystole for cardiac pauses during sleep >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 >100 per minute with QRS duration of ≥120 msec. RECOMMENDED
5. Score narrow complex tachycardia for a rhythm lasting a minimum of 3 consecutive beats at a rate >100 per minute with QRS duration of <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
7. Score second (identify as Mobitz I or Mobitz II) or third degree atrioventricular (AV) heart block. Mobitz I (Wenckebach) is suggested by the PR interval that becomes longer until a non-conducted P wave occurs. Mobitz II is suggested by the two fixed PR intervals prior to the non-conducted P wave. Third degree AV block (complete heart block) is suggested by complete AV dissociation with atrial (P waves) and ventricular (QRS complexes) activity being independent of each other. (see Figure 3, A-D) RECOMMENDED
8. Score cardiac pacemaker rhythm. The presence of cardiac paced rhythm will be manifested by sharp vertical spikes either immediately preceding the onset of P wave (atrial pacing) or QRS complex (ventricular pacing) or both on the ECG. (see Figure 3E) [N6] RECOMMENDED

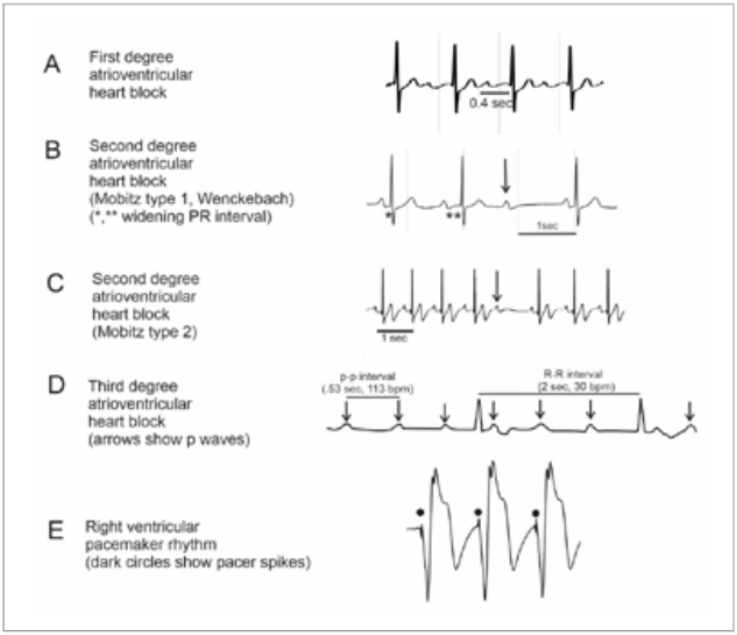


Figure 3.
Diagram of first (A; provided for illustrative purposes only), second (B-C), and third degree (D) atrioventricular heart block and cardiac pacemaker rhythm (E).

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Note 1. Reporting should occur only if the quality of the signal is sufficient for accurate identification, otherwise, a general description of the abnormality should be provided.

Note 2. Ectopic beats should be reported (e.g., sustained bigeminy or trigeminy, frequent premature atrial or ventricular contractions).

Note 3. Use of a single ECG lead is unreliable for detecting S-T segment and T wave abnormalities.

Note 4. Sinus rates vary according to age in children, with faster rates in young children that decrease with age as they approach adulthood. For typical sinus rates in children, see section C. References, references 1-3.

Note 5. Sustained sinus bradycardia or tachycardia is defined by more than 30 seconds of a stable rhythm to distinguish it from transient responses, such as those associated with sleep-disordered breathing events or arousals.

Note 6. Increasing the high frequency filter (HFF) on the display will aid in detecting atrial or ventricular pacing spikes.

C. References

The following references apply to content throughout chapter VI. Cardiac Rules.

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. doi:10.5664/jcsm.26816
2. Archbold KH, Johnson NL, Goodwin JL, et al. Normative heart rate parameters during sleep for children aged 6 to 11 years. *J Clin Sleep Med.* 2010; 6(1):47–50. doi:10.5664/jcsm.27709
3. Hedger-Archbold K, Sorensen ST, Goodwin JL, Quan SF. Average heart rates of Hispanic and Caucasian adolescents during sleep: longitudinal analysis from the TuCASA cohort. *J Clin Sleep Med.* 2014; 10(9):991–995. doi:10.5664/jcsm.4034

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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 one-third of the length of the anterior tibialis muscle, whichever is shorter. Both legs should be monitored for the presence of 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. (see Figure 1) RECOMMENDED

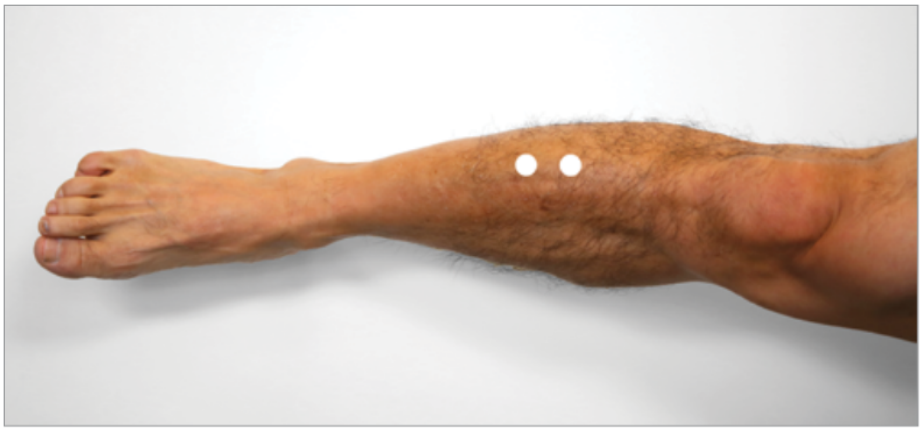


Figure 1. Placement of electrodes on the anterior tibialis muscle for monitoring leg movements. Illustration may not be to scale.

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

3. For monitoring movements of the upper limbs, surface electrodes should be placed longitudinally and symmetrically, so that they are 2–3 cm apart over the surface of the flexor digitorum superficialis (see Figure 2) or the surface of the extensor digitorum communis (see Figure 3). Both arms should be monitored. Separate channels for each arm are strongly preferred.
   a. Diagnosis of REM sleep behavior disorder (RBD) RECOMMENDED
   b. Standard studies OPTIONAL

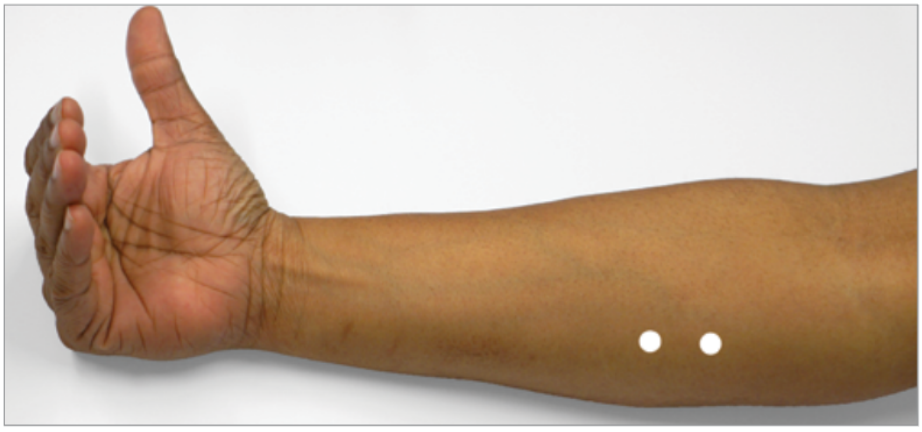


Figure 2. Placement of electrodes on the flexor digitorum superficialis for detecting transient muscle activity in REM sleep. Illustration may not be to scale.

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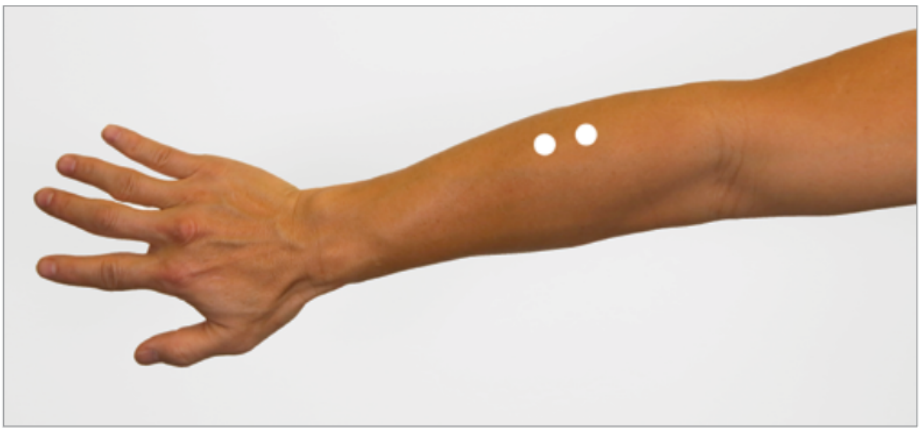


Figure 3. Placement of electrodes on the extensor digitorum communis for detecting transient muscle activity in REM sleep. Illustration may not be to scale.

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4. For diagnosis of RBD, time-synchronized, audio-equipped video PSG should be used 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 (RWA). RECOMMENDED

5. For detecting bruxism, in addition to the recommended placement of chin EMG electrodes as noted in chapter IV. Sleep Staging Rules Part 1: Rules for Adults, section 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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6. **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

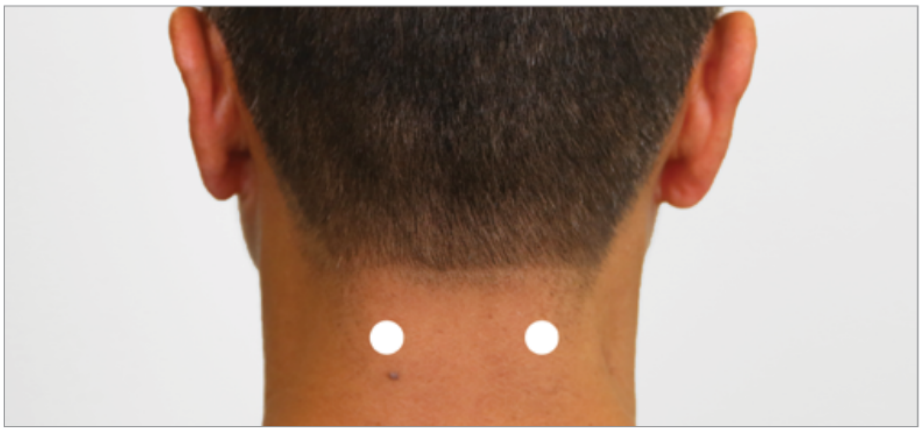


Figure 5. Placement of electrodes on the neck paraspinal muscles for monitoring rhythmic movement disorder. Illustration may not be to scale.

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

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 digitorum superficialis: patient should bend (flex) 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 candidate leg movement (LM) event for possible inclusion in a PLMS series:** [N1] RECOMMENDED

   a. The duration of the LM event is 0.5–10 seconds.
   b. The minimum amplitude of a LM event is an 8 μV increase in EMG voltage above resting EMG for at least 0.5 seconds.
   c. 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.
   d. 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.
   e. A portion of, or the entire, LM event occurs in an epoch scored as sleep.

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

   a. The minimum number of consecutive LM events needed to define a PLMS 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 PLMS series is 5–90 seconds.
   c. Leg movements on 2 different legs separated by <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)

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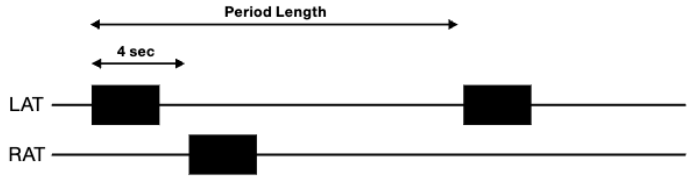


Figure 6. The first two LMs are counted as one leg movement since the time from onset to onset of the LMs in the left anterior tibial EMG channel (LAT) and right anterior tibial EMG channel (RAT) is less than 5 seconds. The period length to the next LM is measured from the onset of the first LM in the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

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3. **An arousal and a limb movement that occur in a PLMS 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

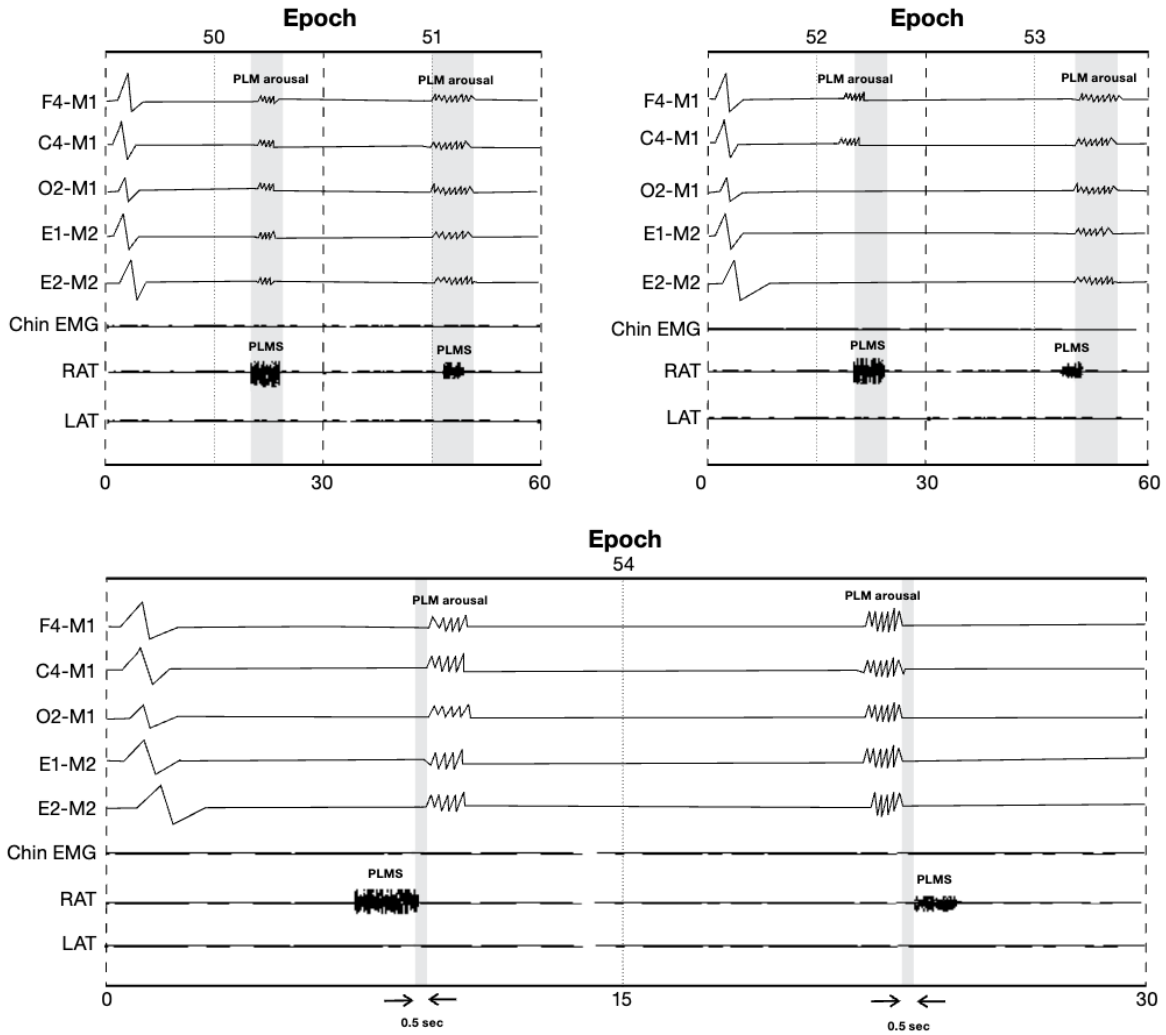


Figure 7. An arousal and LM occurring in a PLM series are considered to be associated if they occur simultaneously (epochs 50 and 51), overlap (epochs 52 and 53) or if the time from the end of one event to the start of the next is less than 0.5 seconds, regardless which event comes first (epoch 54).

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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 PLMS series. (see Figure 8)** RECOMMENDED

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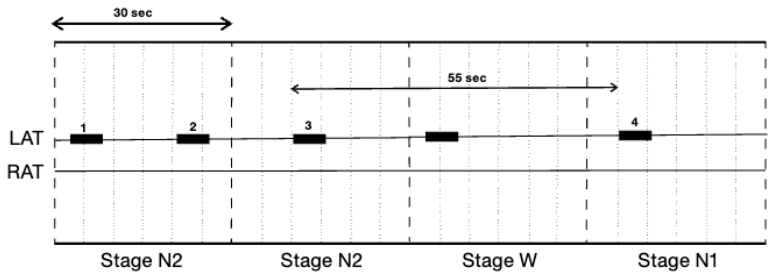


Figure 8. Five LMs are depicted. The fourth occurs in an epoch of wake and cannot be counted as a PLM in sleep. However, the other 4 LMs would be included in the same PLM series.

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Note 1. Rule B.1.c. defines a candidate 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 <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 PLMS associated with an arousal (and only one arousal) would be scored.

C. 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 >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 time synchronized video and audio in combination with polysomnography by a minimum of 2 audible tooth grinding episodes/night of polysomnography in the absence of associated epileptic discharges.

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.

D. Scoring REM Sleep Without Atonia (RWA)

Scoring RWA is OPTIONAL as noted in chapter II. Parameters to be Reported Part 1: Rules for Reporting Polysomnography, section 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 2 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 >5 seconds.

   Excessive transient muscle activity (phasic activity) in REM: [N2] In a 30-second epoch of stage R divided into 10 sequential

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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 2 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: Activity with a minimum amplitude 2 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 VII.D.1) RECOMMENDED
   b. Excessive transient muscle activity during REM in the chin or limb EMG (as defined in rule VII.D.1) RECOMMENDED
   c. At least 50% of 3 second mini-epochs contain any chin activity (as defined in rule VII.D.1) or limb EMG activity (bursts of EMG activity 0.1–5.0 seconds in duration and at least 2 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 RECOMMENDED

3. **If electing to score RWA, score the RWA index as the percent of stage R epochs that meet criteria in rule VII.D.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.D.2 qualifies as transient activity.

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

Note 3. Based on SINBAR (Sleep Innsbruck Barcelona) Group recommended criteria. (see section G. Reference)

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. Scoring 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.

F. Scoring Other Movement Disorders

1. **The following define alternating leg muscle activation (ALMA):** N1, N2 OPTIONAL
   a. The minimum number of discrete and alternating EMG bursts of right and left 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.
   d. The sequences occur during the transition of wake to sleep or are associated with arousal.

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2. **The following define hypnagogic foot tremor (HFT):** N3, N4 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.

3. **The following define excessive fragmentary myoclonus (EFM):** N5, N6, N7 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. The usual range for duration of a single movement of ALMA is 100–500 msec.

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

Note 3. The usual range for duration of hypnagogic foot tremor is 250–1,000 msec.

Note 4. HFT may simply be a benign movement phenomenon associated with characteristic EMG patterns as there have been no reported clinical consequences.

Note 5. EFM may be a benign movement phenomenon associated with a characteristic EMG pattern as there have been no reported clinical consequences.

Note 6. 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.

Note 7. In some cases, when visible movement is present, the EMG burst duration may be >150 msec.

G. Reference

The following reference applies to chapter VII. Movement Rules, section D.

1. Frauscher B, Iranzo A, Gaig C, et al. Normative EMG values during REM sleep for the diagnosis of REM sleep behavior disorder. Sleep. 2012;35(6):835–847. doi:10.5665/sleep.1886

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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 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 use 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-frequency and high-frequency 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-frequency filter setting of 25 to 40 Hz is used. Some polysomnography programs have an option for removal of ECG artifact from EMG signals.

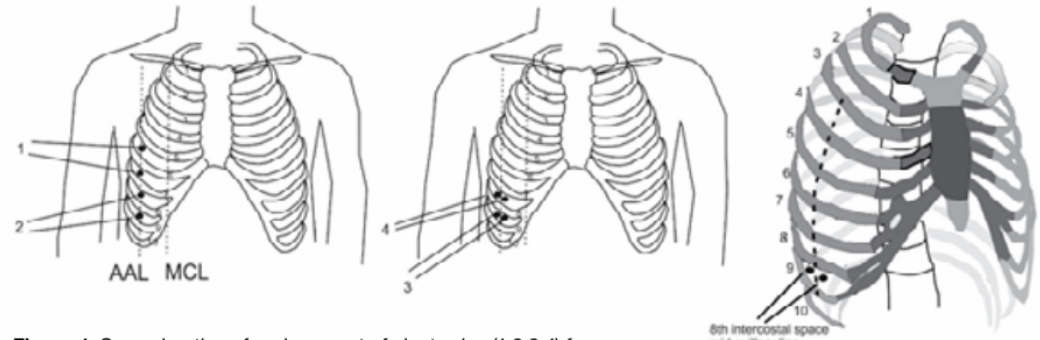


Figure 1. Several options for placement of electrodes (1,2,3,4) for recording the surface diaphragmatic/chest wall EMG are shown. AAL is the anterior axillary line, MCL the mid-clavicular line. Some sleep centers use electrodes above and below a rib and others use two electrodes in the same intercostal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

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Note 5. Monitoring snoring is optional as noted in chapter II. Parameters to be Reported Part 1: Rules for Reporting Polysomnography, section F.

Note 6. Monitoring hypoventilation is optional as noted in chapter II. Parameters to be Reported Part 1: Rules for Reporting Polysomnography, section F.

Note 7. 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 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 2 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 are receiving supplemental oxygen. It is crucial to obtain a plateau in the end-tidal waveform for the signal to be considered valid.

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B. Measuring Event Duration

1. For scoring an apnea, hypopnea, or respiratory effort-related arousal, 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. [N1, N2] (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 used. When the diagnostic study sensors fail or are inaccurate, alternative sensors may be used. (see rules A.2 and A.4 in this chapter) RECOMMENDED

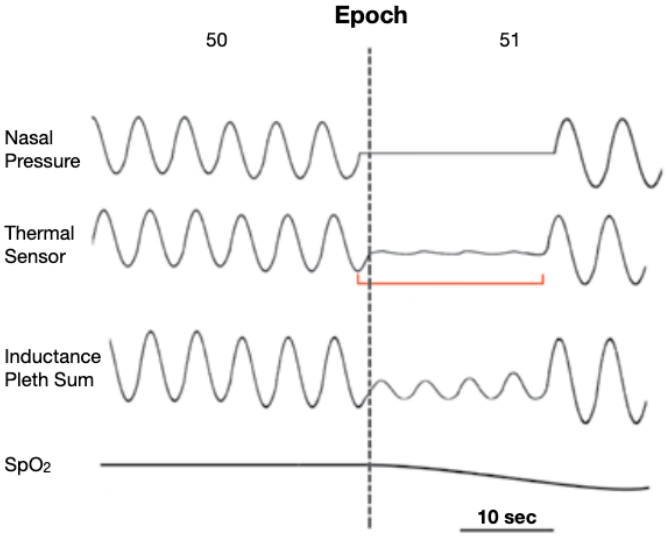


Figure 2. A respiratory event that should be scored as an apnea. The red bracket indicates the full duration of the apnea event.

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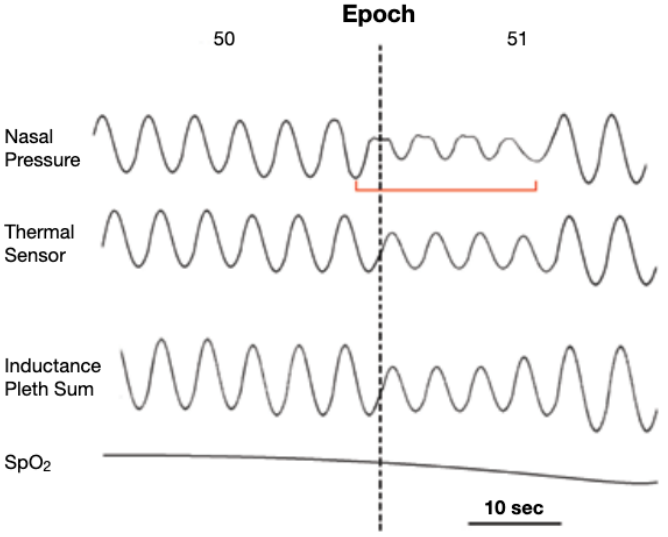


Figure 3. A respiratory event that should be scored as a hypopnea. The red bracket indicates the full duration of the hypopnea event.

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Note 1. The baseline breathing amplitude should take into consideration the mean amplitude of stable breathing during the 2 minutes preceding the event onset. In cases where breathing instability is present, then one should consider the mean amplitude of the three largest breaths prior to the onset of the event.

Note 2. 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%.

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)

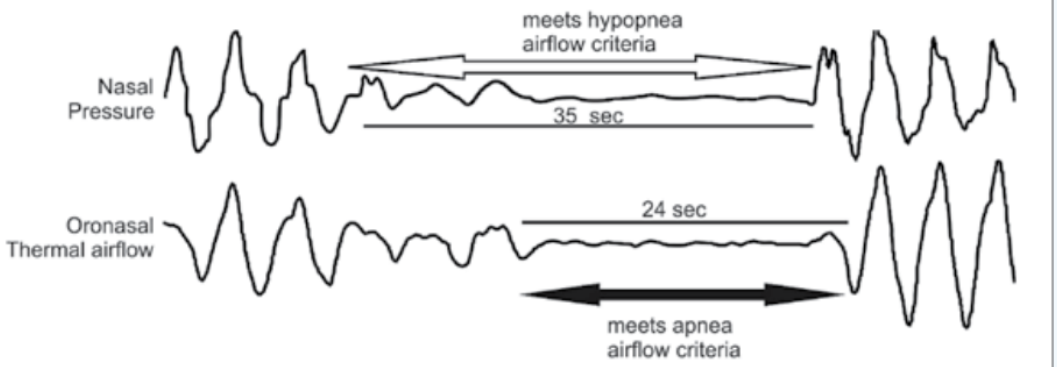


Figure 4. The longer duration, depicted by the white arrows in the nasal pressure channel, meets airflow criteria for a hypopnea, whereas the shorter duration, depicted by the black arrows in the oronnasal thermal airflow channel, meets airflow criteria for an apnea. The event would be scored as an apnea.

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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 because <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 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 rule A.2 in this chapter.

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

1.A Score a respiratory event as a hypopnea if ALL 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.

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

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.

Scoring hypopneas as central or obstructive events is OPTIONAL as noted in chapter II. Parameters to be Reported Part 1: Rules for Reporting Polysomnography, section F.

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 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 rule A.4 in this chapter.

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 Arousals

Scoring respiratory effort-related arousals is OPTIONAL as noted in chapter II. Parameters to be Reported Part 1: Rules for Reporting Polysomnography, section 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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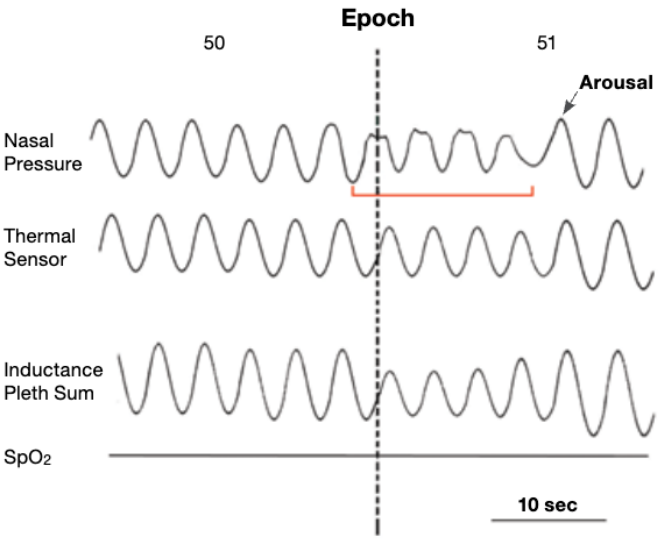


Figure 5. A respiratory event that should be scored as a respiratory effort-related arousal (RERA). The red bracket indicates the full duration of the RERA event.

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F. Scoring Hypoventilation

Monitoring hypoventilation is OPTIONAL as noted in chapter II. Parameters to be Reported Part 1: Rules for Reporting Polysomnography, section 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 rules A.9 and A.10 in this chapter for information on surrogate signals for monitoring hypoventilation.

Note 2. Use the following conversion factor 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 hypopneas separated by a crescendo and decrescendo change in breathing amplitude with a cycle length of ≥40 seconds. To be included, the hypopneas must have a symmetrical decrescendo crescendo pattern of tidal volume or flow.
   b. There are ≥5 central apneas and/or hypopneas per hour of sleep associated with the crescendo/decrescendo breathing pattern recorded over ≥2 hours of monitoring.

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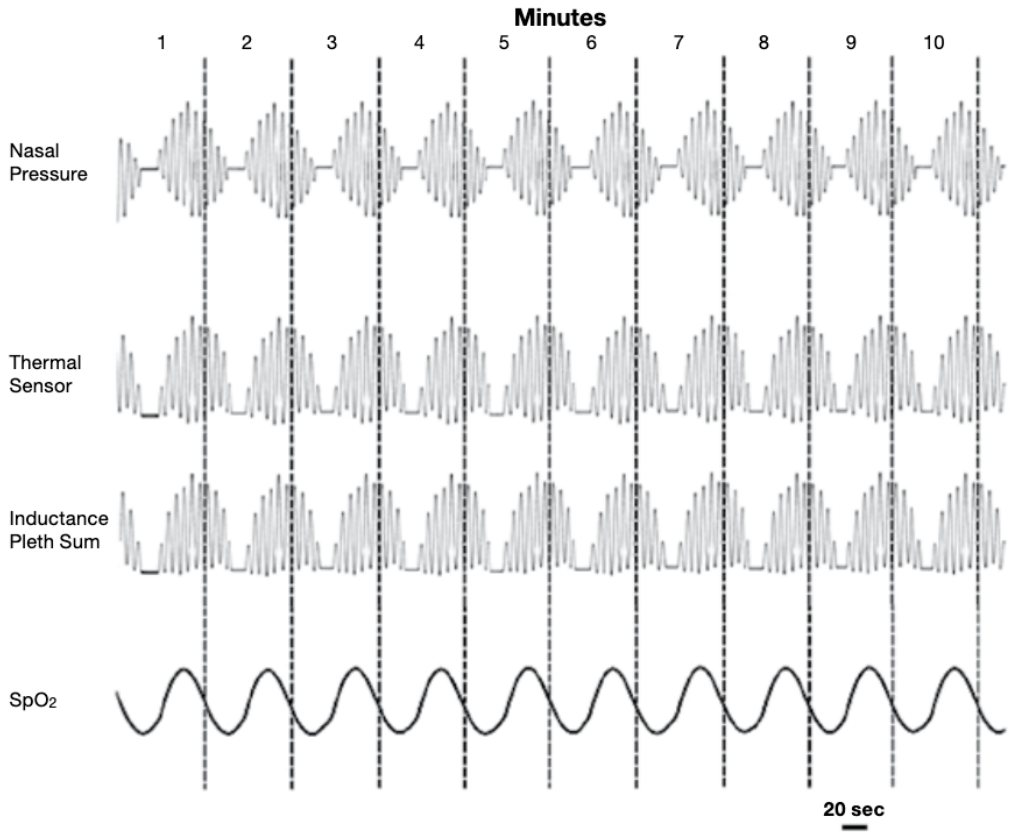


Figure 6. A respiratory event that should be scored as Cheyne-Stokes breathing due ≥3 consecutive apneas with crescendo and decrescendo breathing in between.

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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 and hypopneas that occur within a run of Cheyne-Stokes breathing should be scored as individual apneas or hypopneas as well.

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H. Special Circumstances for Scoring Respiratory Events

1. **When scoring respiratory events during a positive airway pressure (PAP) titration using a backup rate, score a respiratory event occurring during PAP device-triggered breaths as a central apnea if all of the following criteria are met: [N1] (see Figure 7)** 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.

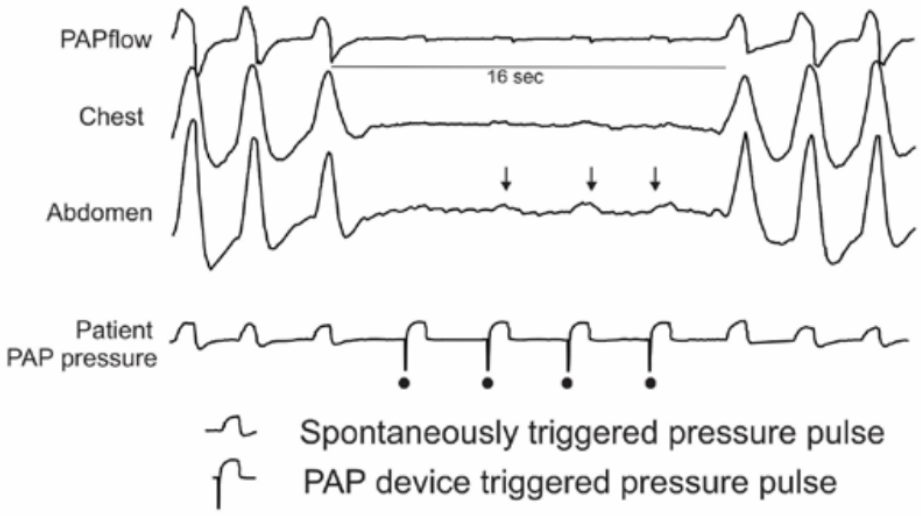


Figure 7. A central apnea during PAP device triggered pressure pulse. A reduction in PAP flow meeting criteria for an apnea is present. The patient PAP pressure is the pressure signal from the PAP device. The downward deflection (small circles) is an artifact introduced by the device to denote a device-triggered pressure pulse. The very small deflections in the chest and abdomen traces (arrows) are due to a very small amount of flow from the device-triggered pressure pulse and are not evidence of patient effort. One can also identify patient-triggered pressure pulses by the regular spacing (backup rate) and different morphology.

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Note 1. Laboratories should check with the manufacturer of the laboratory PAP device to determine the if the PAP pressure signal has an artifact denoting device-triggered breaths. Some devices have a separate channel with deflections marking device-triggered and cycled breaths.

I. Reference

The following reference applies to section D in chapter VIII. Respiratory Rules Part 1: Rules for Adults.

1. Malhotra RK, Kirsch DB, Kristo DA, et al; American Academy of Sleep Medicine Board of Directors. Polysomnography for obstructive sleep apnea should include arousal-based scoring: an American Academy of Sleep Medicine position statement. *J Clin Sleep Med*. 2018;14(7):1245–1247. doi:10.5664/jcsm.7234

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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; however, children ≥13 years with an adult body habitus may be scored using adult criteria.** [N1] RECOMMENDED

> **Note 1.** Historical 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 first edition of the AASM Scoring Manual in 2007. As of version 2.0 of the AASM Scoring Manual in 2012, the adult hypopnea rule D. 1 and pediatric hypopnea rules are similarly aligned, leading to 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 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 recommended, as noted in chapter II. Parameters to be Reported Part 1: Rules for Reporting Polysomnography, section F.

Note 5. Monitoring hypoventilation during diagnostic study is recommended and monitoring hypoventilation during PAP titration is optional, as noted in chapter II. Parameters to be Reported Part 1: Rules for Reporting Polysomnography, section 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 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 2 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 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 in Part 1: Rules for Adults, rules B.1 and B.2.** [N1, N2] RECOMMENDED

Note 1. For *alternative* apnea sensors see rule B.2 in this chapter.

Note 2. For *alternative* hypopnea sensors see rule B.4 in this chapter.

D. Scoring of Apneas

1. **Score a respiratory event as an apnea when ALL the following criteria are met:** [N1, N2, N3, N4, N5] 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 2 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 2 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. For infants <1 year of age, the decrease in heart rate requirement adjusts to less than 60 beats per minute for 15 seconds due to higher baseline heart rates.

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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.** 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 2.** 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) even if a portion of the respiratory event is on an epoch scored as wake. 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 3.** For *alternative* apnea sensors see rule B.2 in this chapter.
>
> **Note 4.** 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 5.** 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 chapter II. Parameters to be Reported Part 1: Rules for Reporting Polysomnography, section F.

1. **Score a respiratory event as a hypopnea if ALL 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 rule B.4 in this chapter.
>
> **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 Arousals

Scoring respiratory effort-related arousals is OPTIONAL as noted in chapter II. Parameters to be Reported Part 1: Rules for Reporting Polysomnography, section 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 2 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 rules B.9 and B.10 in this chapter for information on surrogate signals for monitoring hypoventilation.
>
> **Note 2.** Use the following conversion factor 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.

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I. Special Circumstances for Scoring Respiratory Events

1. **When scoring respiratory events during a positive airway pressure (PAP) titration using a backup rate, score a respiratory event occurring during PAP device-triggered breaths as a central apnea if all of the following criteria are met:** [N1] **(see Figure 1)** 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.

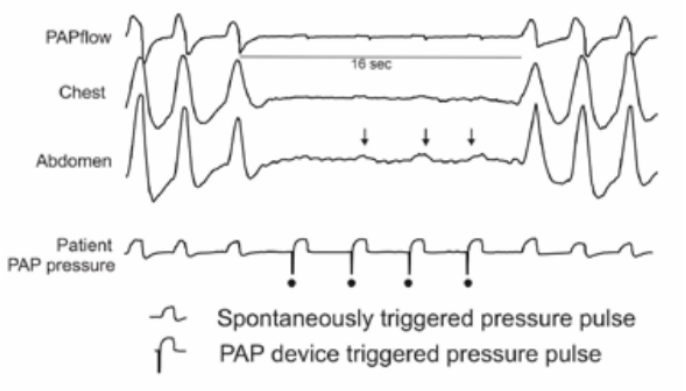


Figure 1. A central apnea during PAP device triggered pressure pulse. A reduction in PAP flow meeting criteria for an apnea is present. The patient PAP pressure is the pressure signal from the PAP device. The downward deflection (small circles) is an artifact introduced by the device to denote a device-triggered pressure pulse. The very small deflections in the chest and abdomen traces (arrows) are due to a very small amount of flow from the device-triggered pressure pulse and are not evidence of patient effort. One can also identify patient-triggered pressure pulses by the regular spacing (backup rate) and different morphology.

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Note 1. Laboratories should check with the manufacturer of the laboratory PAP device to determine if the PAP pressure signal has an artifact denoting device-triggered breaths. Some devices have a separate a channel with deflections marking device-triggered and cycled breaths.

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

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

A. General Parameters to be Reported [N1]

1. Type of device	RECOMMENDED
2. Type of airflow sensor [N2]	RECOMMENDED
3. Type of respiratory effort sensor (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 as noted in section F of this chapter.

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) (including wake and artifact)	RECOMMENDED
4. Monitoring time (MT) [N1] (time used to calculate respiratory event index) [N2]	RECOMMENDED
5. Heart rate	
5a. Average heart rate	RECOMMENDED
5b. Highest heart rate	OPTIONAL
5c. Lowest heart rate	OPTIONAL
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
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

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9. Central apnea index (CAI) = (# central apneas × 60) / MT in min [N3]	OPTIONAL
10. A measure of oxygen saturation (one of these three parameters) [N4]	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%] [N5]	
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 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. Central apnea index (CAI) derived on HSAT may differ from an equivalent parameter derived during PSG due to the use of MT, rather than TST, and reduced quality of respiratory effort signal during unattended studies.

Note 4. Reporting all three parameters may provide important information for the clinician.

Note 5. 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) (including wake and artifact)	RECOMMENDED
4. Total sleep time (TST) [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
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

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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 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
6. Recommendation for management that meets AASM clinical practice guidelines and practice parameters	RECOMMENDED
7. Chain of custody (if applicable)	OPTIONAL

E. Technical and Digital Specifications: HSAT Equipment Recording Features

1. FDA approval or clearance of device	RECOMMENDED
2. Unique identifier for each unit	RECOMMENDED
3. Must meet minimum definition for CPT codes 95800, 95801, or 95806 (or equivalent G codes) [N1]	RECOMMENDED
4. Ability to record oximetry	RECOMMENDED
5. Ability to record a measure of heart rate	RECOMMENDED
5a. Average heart rate	RECOMMENDED
5b. Highest heart rate	OPTIONAL

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5c. Lowest heart rate	OPTIONAL
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]

1.A If sleep is NOT recorded, score a respiratory event as a hypopnea if ALL 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.

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

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.

2.A If sleep IS recorded, score a respiratory event as a hypopnea if ALL 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]

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

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 (using EEG) is recorded.

I. References

The following references apply to content throughout chapter IX. Home Sleep Apnea Test (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. doi:10.5664/jcsm.27032
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. doi:10.5664/jcsm.1328

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

Part 2: HSAT Utilizing Peripheral Arterial Tonometry (PAT)

A. General Parameters to be Reported

1.	Type of device	RECOMMENDED
2.	Sleep/wake and REM sleep 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 sleep, 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)	
	6a. pAHI based on ≥3% oxygen desaturation	RECOMMENDED
	6b. pAHI based on ≥4% oxygen desaturation	OPTIONAL
7.	Oxygen desaturation index (ODI) ≥3% or ≥4% = (# oxygen desaturations ≥3% or ≥4% × 60) / MT in min [specify measure of desaturation of ≥3% or ≥4%]	OPTIONAL

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

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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
6.	Recommendation for management that meets AASM clinical practice guidelines and practice parameters	RECOMMENDED
7.	Chain of custody (if applicable)	OPTIONAL

D. Technical and Digital Specifications: HSAT Equipment Recording Features

1.	FDA approval or clearance 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 AHI used for in-laboratory 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)

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.

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F. References

The following references apply to content throughout chapter IX. Home Sleep Apnea Test (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. doi:10.5664/jcsm.27032
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. doi:10.5664/jcsm.1328

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X. Update Process

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 American Academy of Sleep Medicine (AASM) is committed to using 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, to further clarify existing rules and notes, and 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.

Supplemental Resources

When a new version of the AASM Scoring Manual is released, an accompanying summary of changes document is published on the AASM website to outline what has changed from the previous version. In addition, a frequently asked questions (FAQ) document is available online that includes additional information for common questions. This FAQ resource is updated when a new version of the manual is released and when new questions warrant inclusion.

In instances where an error is found in a published version of the AASM Scoring Manual, an erratum will be added online for users to access the correction.

Previous Versions and Release Dates

- Version 2.6: January 2020
- 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 Part 1: Rules for Reporting 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.1–5	Movement events. No evidence. Consensus agreement of Scoring Manual Committee (SMC*) and approved by the AASM Board of Directors.	CONSENSUS
F.1–27	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 and 3 additions and approval from 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

II. Parameters to be Reported Part 2: Rules for Reporting MSLT and MWT		
A.1–4	General parameters. No evidence. Consensus agreement of SMC and approved by the AASM Board of Directors.	CONSENSUS
B.1–5	Patient parameters. No evidence. Consensus agreement of SMC and approved by the AASM Board of Directors.	CONSENSUS
C.1–6	Sleep scoring data. No evidence. Consensus agreement of SMC and approved by the AASM Board of Directors.	CONSENSUS
D.1–2	MSLT summative data. No evidence. Consensus agreement of SMC and approved by the AASM Board of Directors.	CONSENSUS
E.1	MWT summative data. No evidence. Consensus agreement of SMC and approved by the AASM Board of Directors.	CONSENSUS

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III. Technical and Digital Specifications		
A.1–5	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. Ability to display raw data. Consensus agreement of SMC and approved by the AASM Board of Directors.	CONSENSUS
B.1–7	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 SMC 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

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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
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 SMC and approved by the AASM Board of Directors.	CONSENSUS
F.5	Limited evidence. Consensus agreement of SMC and approved by the AASM Board of Directors.	CONSENSUS
F.6	Limited evidence. Consensus agreement of SMC 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 SMC 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 SMC 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 SMC and approved by the AASM Board of Directors.	CONSENSUS
I.4	Limited evidence. Consensus agreement of SMC 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
I.6	Stage R ending. Inferred from other rules. Limited evidence. Consensus agreement of Visual Task Force approved by Steering Committee.	CONSENSUS

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I.7	Limited evidence. Consensus agreement of SMC 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
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 SMC 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

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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 Rules

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 the Steering Committee.	ADJUDICATION
A.2	Arousal preceding transition to stage W. No evidence. Consensus agreement of SMC and approved by the AASM Board of Directors.	CONSENSUS

VI. Cardiac Rules

A.1	Single lead II. No evidence. Consensus agreement by Cardiac Task Force approved by Steering Committee.	CONSENSUS
A.2	Single lead I. No evidence. Consensus agreement of SMC and approved by the AASM Board of Directors.	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
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
B.7	Atrioventricular heart block. Consensus agreement of SMC and approved by the AASM Board of Directors.	CONSENSUS
B.8	Cardiac pacemaker rhythm. Consensus agreement of SMC and approved by the AASM Board of Directors.	CONSENSUS

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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	Monitoring movements of upper limbs for diagnosis of RBD and for standard studies. Consensus agreement of SMC and approved by the AASM Board of Directors.	CONSENSUS
A.4	Recommended video PSG for diagnosis of RBD. Consensus agreement of Scoring Manual Editorial Board and approved by the AASM Board of Directors.	CONSENSUS
A.5	Optional masseter electrodes. Consensus agreement of Scoring Manual Editorial Board and approved by the AASM Board of Directors.	CONSENSUS
A.6	Optional electrode placement for monitoring RMD. Consensus agreement of Scoring Manual Editorial Board and approved by the AASM Board of Directors.	CONSENSUS
A.7	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. 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.b-d	Leg movements. Evidence level 5. Consensus agreement by Movements Task Force, approved by Steering Committee.	CONSENSUS
B.1.e	Leg movements. Consensus agreement of SMC and approved by the AASM Board of Directors.	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
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.a–b	Bruxism phasic bursts. Evidence level 5. Consensus agreement by Movements Task Force, approved by Steering Committee.	CONSENSUS
C.1.a,c	Bruxism tonic bursts. Evidence level 5. Consensus agreement by Movements Task Force, approved by Steering Committee.	CONSENSUS
C.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

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C.1.d	Bruxism episodes. Evidence level 5. Consensus agreement by Movements Task Force, approved by Steering Committee.	CONSENSUS
C.1.e	Bruxism scoring. Evidence level 2 and evidence level 5. Consensus agreement by Movements Task Force, approved by Steering Committee.	STANDARD
D.1	Definitions for REM sleep without atonia. Consensus agreement of SMC and approved by the AASM Board of Directors.	CONSENSUS
D.2–3	Rule for REM sleep without atonia. Consensus agreement of SMC and approved by the AASM Board of Directors.	CONSENSUS
E.1.a–b	Rhythmic movement disorder (RMD) frequency. Evidence level 4. Consensus agreement by Movements Task Force, approved by Steering Committee.	CONSENSUS
E.1.c–d	Rhythmic movement disorder (RMD). No evidence. Consensus agreement by Movements Task Force approved by Steering Committee.	CONSENSUS
F.1	The minimum duration of the muscle bursts for ALMA was removed due to concerns by the technical panel and Movements Task Force Chair and adjudication by the Steering Committee.	CONSENSUS
F.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
F.1.d	Alternating leg muscle activation (ALMA). Consensus agreement of SMC and approved by the AASM Board of Directors.	CONSENSUS
F.2.a–c	Hypnagogic foot tremor (HFT). Evidence level 2 Consensus agreement by Movements Task Force; approved by Steering Committee	GUIDELINE
F.3.a–c	Excessive fragmentary myoclonus (EFM). Evidence level 4. 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 SMC (SMC).	CONSENSUS
A.2.a–c	*Alternative* airflow sensors for apnea detection. Consensus agreement by Respiratory Task Force approved by SMC.	CONSENSUS
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

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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
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
D.1A.a–c D.1B.a–c	Hypopnea amplitude, duration and minimum oxygen desaturation criterion. Consensus agreement of SMC and approved by the AASM Board of Directors.	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 SMC 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 SMC.	CONSENSUS
B.1	*Recommended* airflow sensor for apnea detection. Consensus agreement by Respiratory Task Force approved by SMC.	CONSENSUS

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B.2.a–c	*Alternative* airflow sensors for apnea detection. Consensus agreement by Respiratory Task Force approved by SMC.	CONSENSUS
B.2.d–e	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–e	*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
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 SMC and approved by the AASM Board of Directors.	CONSENSUS

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IX. Home Sleep Apnea Test (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
D.1–7	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

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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 SMC 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 SMC and approved by the AASM Board of Directors.	CONSENSUS

IX. Home Sleep Apnea Test (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.1–7	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

Alternating leg muscle activation (ALMA): Consists of brief activation of the anterior tibialis in one leg alternating with similar activation in the other leg during sleep or arousals from sleep. There is frequently no reported movement, but ALMA is recorded as an incidental finding on polysomnography.

Any chin electromyography (EMG) activity: Activity with a minimum amplitude two times greater than the stage R sleep atonia level (or lowest amplitude in NREM sleep, if no stage R sleep 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 specified in the apnea scoring rules for adults (chapter VIII, part 1, rule C.1) and children (chapter VIII, part 2, rule D.1). Apneas are classified as obstructive, mixed, or central based on the pattern of respiratory effort.

Apnea-hypopnea index (AHI): Total number of apneas and hypopneas scored × 60 divided by total sleep time (TST).

Asystole: An interruption of cardiac rhythm lasting more than 3 seconds for ages 6 years through adulthood.

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

Beta waves: An electroencephalography (EEG) rhythm consisting of >13 Hz activity.

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

Cardiac pacemaker rhythm: Sharp vertical spikes either immediately preceding the onset of P wave (atrial pacing) or QRS complex (ventricular pacing) or both on the electrocardiography (ECG).

Central hypopnea: A respiratory event meeting all criteria for a hypopnea (see chapter VIII, part 1, rule D.1 for adults and chapter VIII, part 2, rule E.1 for children) and 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 that occurs during the event but not during pre-event breathing.

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

Chronological age (also known as postnatal or legal age): The time elapsed since birth (can be expressed in days, months, or years).

Delta waves: An electroencephalography (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., electroencephalography [EEG], electrooculography [EOG], chin electromyography [EMG] derivations).

Excessive fragmentary myoclonus: Limb electromyography (EMG) activity characterized by small movements of the corners of the mouth, fingers, or toes, or by no visible movement at all. This incidental polysomnographic finding is associated with no known clinical consequence.

Excessive sustained muscle activity (tonic activity) in REM: An epoch of stage R sleep with at least 50% of the duration of the epoch having a chin electromyography (EMG) amplitude at least two times greater than the stage R sleep atonia level (or lowest amplitude in NREM sleep, if no stage R sleep 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 sleep 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 electromyography (EMG). In REM sleep without atonia, 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 sleep atonia level (or lowest amplitude in NREM sleep, if no stage R sleep 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 post menstrual age.

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

Hypnagogic foot tremor (HFT): Trains of electromyography (EMG) activity of the lower limb during the transition between wake and sleep or during light NREM sleep (stage N1 and N2) with a specified frequency. HFT is seen as an incidental finding on polysomnography conducted for other indications.

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 sleep.

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

Hypopnea: A reduction in airflow with the minimum amplitude and duration as specified in the hypopnea rules for adults (chapter VIII, part 1, rule D.1) and children (chapter VIII, part 2, rule E.1). The reduction in airflow must be accompanied by a ≥3% desaturation or an arousal (adults: chapter VIII, part 1, rule D.1A; children: chapter VIII, part 2, rule E.1).

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 electroencephalography (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 chapter V. Arousal Rules).

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

Low chin electromyography (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 electroencephalography (EEG) for more than half an epoch to the extent that the sleep stage cannot be determined.

Mixed voltage: Includes high voltage slow (HVS) and low voltage polyrhythmic electroencephalography (EEG) components; these are intermingled with little periodicity. The amplitude is lower than seen in the HVS pattern.

Mobitz I (Wenckebach): Suggested by the PR interval that becomes longer until a non-conducted P wave occurs.

Mobitz II: Suggested by the two fixed PR intervals prior to the non-conducted P wave.

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 at a rate >100 per minute with QRS duration of <120 msec.

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.

Obstructive hypopnea: A respiratory event meeting all criteria for a hypopnea (see chapter VIII, part 1, rule D.1 for adults and chapter VIII, part 2, rule E.1 for children) and during which there is evidence of snoring, increased inspiratory flattening of the nasal pressure or PAP device flow signal compared to baseline breathing, and/or associated thoracoabdominal paradox that occurs during the event but not during pre-event breathing.

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

Periodic breathing: A breathing rhythm in children with ≥3 episodes of central pauses in respiration lasting >3 seconds separated by no more than 20 seconds of normal breathing.

Periodic limb movements of sleep (PLMS): 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.

Polyvinylidene fluoride (PVDF) sensor: Polyvinylidene fluoride 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.

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

Post menstrual age (formerly termed conceptional age, CA): Gestational age (GA) at birth plus the number of weeks postpartum.

Posterior dominant rhythm (PDR; also known as alpha rhythm): The dominant reactive electroencephalography (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

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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 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.

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 posterior dominant rhythm (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.

PVDFsum: The electrical sum of signals recorded from the thoracic and abdominal polyvinylidene fluoride (PVDF) sensors (belts).

Rapid eye movements (REMs): Eye movements recorded in the electrooculography (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 electrooculography (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 or as the child visually scans the environment.

REM sleep behavior disorder (RBD): A parasomnia characterized by repeated episodes of sleep-related vocalization or complex motor behaviors documented by video-polysomnography to occur during REM sleep or are presumed to occur during REM sleep based on clinical history of dream enactment. Polysomnographic recording should also demonstrate REM sleep without atonia.

Respiratory effort-related arousal (RERA): 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.

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

RIPsum: The electrical sum of the signals from the thoracic and abdominal respiratory inductance plethysmography (RIP) sensors; excursions in the signal are an estimate of tidal volume.

Sawtooth waves: An electroencephalography (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.

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.

Sleep-related bruxism: Repetitive jaw-muscle activity characterized by grinding or clenching of the teeth in sleep that results in abnormal tooth wear and/or transient morning jaw muscle pain or fatigue or temporal headache.

Sleep-related rhythmic movement disorder (RMD): Repetitive, stereotyped, and rhythmic motor behaviors that occur predominantly during drowsiness or sleep and involve large muscle groups. The behaviors result in interference with normal sleep, significant impairment in daytime function, and/or self-inflicted bodily injury or likelihood of injury if preventative measures are not used.

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 sleep.

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: An epoch of stage R sleep with at least 50% of the duration of the epoch having a chin electromyography (EMG) amplitude greater than the lowest amplitude 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 waves: An electroencephalography (EEG) rhythm consisting of 4–7.99 Hz activity.

Third degree atrioventricular (AV) block (complete heart block): Suggested by complete AV dissociation with atrial (P waves) and ventricular (QRS complexes) activity being independent of each other.

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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 in a term infant) alternating with periods of lower amplitude (25–50 μV) 4–7 Hz theta activity (range 4–12 seconds).

Transient muscle activity (TMA): Short irregular bursts of electromyography (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 electrooculography (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.

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 at a rate >100 per minute with QRS duration ≥120 msec.

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