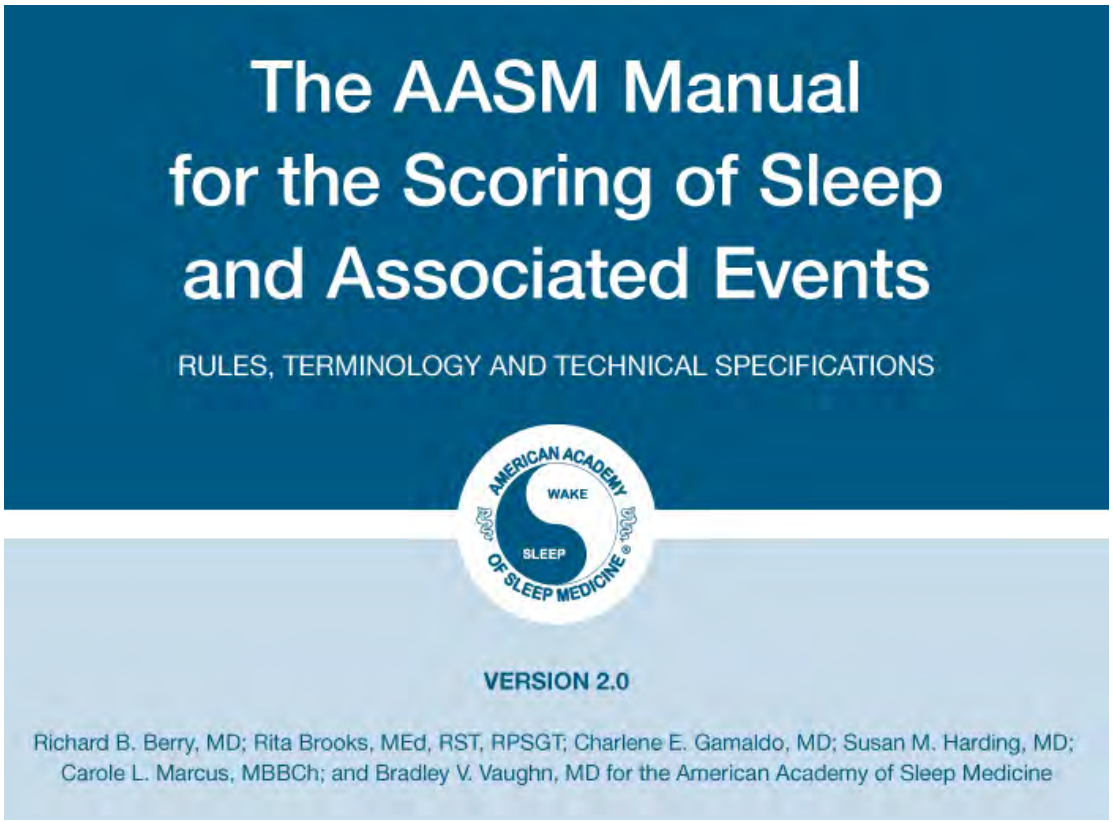

Berry RB, Brooks R, Gamaldo CE, Harding SM, Marcus CL, Vaughn BV and Tangredi MM for the American Academy of Sleep Medicine. The AASM Manual for the Scoring of Sleep and Associated Events: Rules, Terminology and Technical Specifications, Version 2.0. www.aasmnet.org, Darien, Illinois: American Academy of Sleep Medicine, 2012.

General Scoring of Sleep Stages

1. The following terminology should be used for the stages of sleep in adults:[N1] RECOMMENDED

a. Stage W (Wakefulness)

b. Stage N1 (NREM 1)

c. Stage N2 (NREM 2)

d. Stage N3 (NREM 3)

e. Stage R (REM)

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 2 or more stages coexist during a single epoch, assign the stage comprising the greatest portion of the epoch.

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

WAKE

1. Score in accordance with the following definitions: RECOMMENDED

Alpha rhythm: Trains of sinusoidal 8-13 Hz activity recorded over the occipital region with eye closure, 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 subject reads.

Rapid eye movements (REM): 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 subjects scan the environment.

Slow eye movements (SEM): Conjugate, reasonably regular, sinusoidal eye movements with an initial deflection usually lasting >500 msec.

2. Score epochs as stage W when more than 50% of the epoch has alpha rhythm over the occipital region. RECOMMENDED

3. Score epochs without visually discernible alpha rhythm as stage W if ANY of the following are present: RECOMMENDED

a. Eye blinks at a frequency of 0.5-2 Hz

b. Reading eye movements

c. Irregular, conjugate rapid eye movements associated with normal or high chin muscle tone

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

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

Note 3. The EOG during wakefulness may demonstrate rapid eye blinks at a frequency of about 0.5-2 Hz. As drowsiness develops, the frequency of blinking slows, and eye blinks may be replaced by slow eye movements, even in the presence of continued alpha 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.

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 usually lasting >500 msec.

Low-amplitude, mixed-frequency EEG activity: Low-amplitude, predominantly 4-7 Hz activity.

Vertex sharp waves (V waves): Sharply contoured waves with duration <0.5 seconds maximal over the central region and distinguishable from the background activity.

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.)

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

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

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

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

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

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

Scoring Stage N2

1. Score in accordance with the following definitions: RECOMMENDED

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

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

2. Begin scoring stage N2 (in absence of criteria for N3) if EITHER OR BOTH of the following occur during the first half of that epoch or the last half of the previous epoch:N1,N2,N3,N4 RECOMMENDED

a. One or more K complexes unassociated with arousals

b. One or more trains of sleep spindles

3. 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: RECOMMENDED

a. K complexes unassociated with arousals

b. Sleep spindles

4. End stage N2 sleep when ONE of the following events occurs:N5,N6 RECOMMENDED

a. Transition to stage W

b. An arousal (change to stage N1 until a K complex unassociated with an arousal or a sleep spindle occurs) (see Figure 4)

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 criteria under heading J) (see Figure 5)

d. Transition to stage N3

e. Transition to stage R

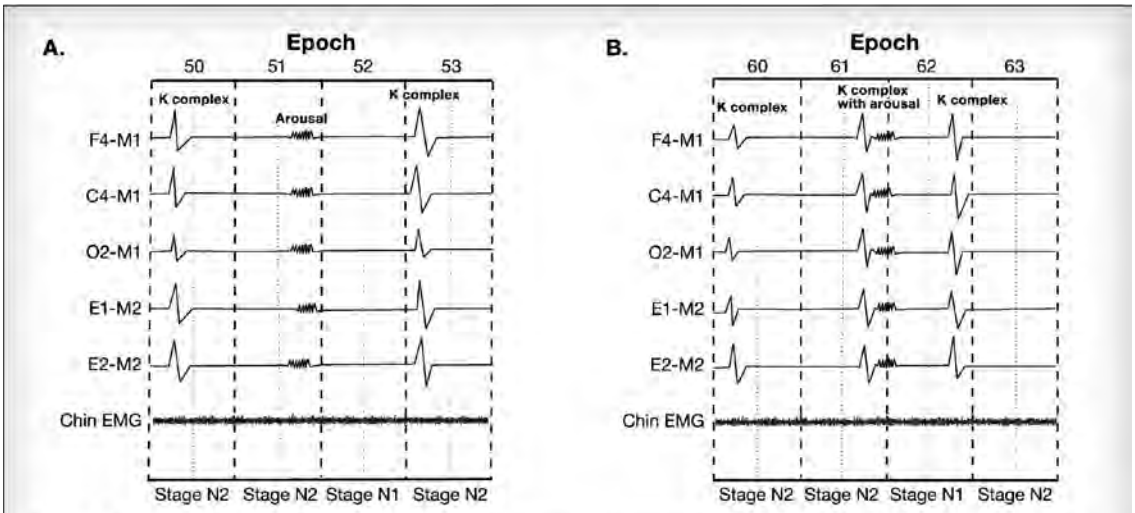

Figure 4. End of stage N2 sleep due to an arousal. The EEG is assumed to contain low-amplitude, mixed-frequency activity unless otherwise depicted.
A. Epoch 50 is scored as stage N2 as a K complex unassociated with an arousal occurs in the first half of the epoch. Epoch 51 is scored as stage N2 according to the rule for continuation of stage N2 (G.3) and the fact that the arousal occurs in the second half of the epoch. That is, the majority of Epoch 51 is considered to be stage N2. Epoch 52 is scored as stage N1 (rule G.4.b) as the epoch contains no K complexes or sleep spindles. Epoch 53 is scored as stage N2 as a K complex unassociated with an arousal occurs in the first half of the epoch.
B. A K complex associated with an arousal in the last part of Epoch 61 interrupts an episode of stage N2 sleep. Epoch 62 is NOT scored as stage N2 as the K complex in the last half of the preceding epoch is associated with an arousal. Epoch 62 is scored as stage N1 as the next K complex appears in the second half of the epoch. Epoch 63 is scored as stage N2 as a K complex occurs in the last half of the preceding epoch.

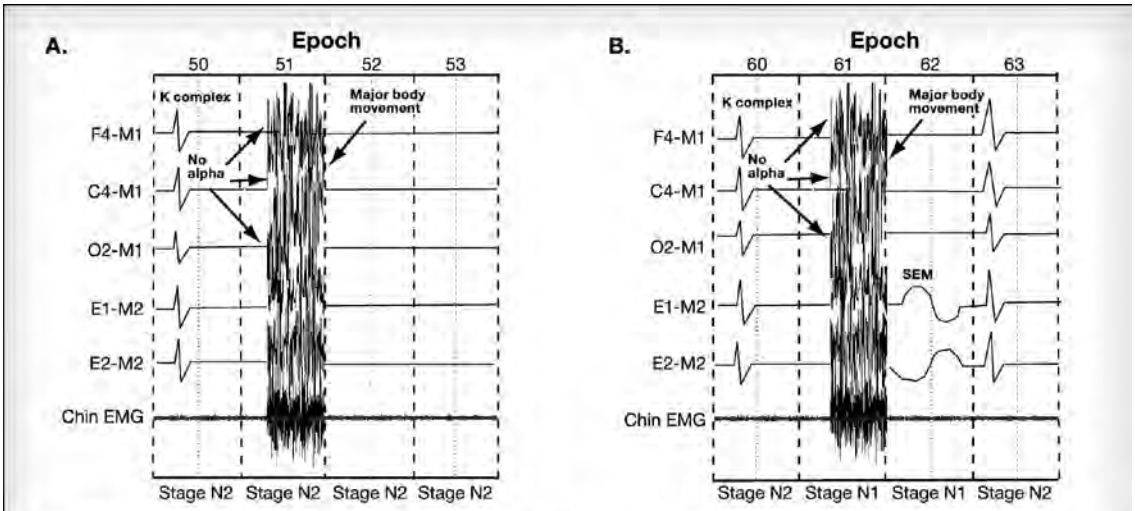

Figure 5. End of stage N2 due to a major body movement. The EEG is assumed to contain low-amplitude, mixed-frequency activity unless otherwise depicted.
A. Epoch 52 continues to be scored as stage N2 as the major body movement is NOT followed by slow eye movements. Epoch 51 is scored according to the major body movement rules (J). As the epoch does not contain alpha activity and an epoch of stage W does not precede or follow the epoch, the major body movement epoch 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.4.c). Epoch 63 is scored as stage N2 as a K complex unassociated with an arousal occurs in the first half of the epoch.

Note 1. An epoch of stage N2 meeting criteria in rule G.2 is termed definite stage N2.

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

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

Note 4. Although sleep spindles and frequency changes associated with arousals are more typically noted in the central and occipital derivations respectively, these events should be used to score sleep even if they are only noted in the frontal derivations.

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

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

Scoring Stage N3

1. Score in accordance with the following definition:N1 RECOMMENDED

Slow wave activity: Waves of frequency 0.5 Hz-2 Hz and peak-to-peak amplitude >75 µV, measured over the frontal regions

2. Score stage N3 when ≥20% of an epoch consists of slow wave activity, irrespective of age.N2,N3,N4 RECOMMENDED

Note 1. K complexes would be considered slow waves if they meet the definition of slow wave activity.

Note 2. Sleep spindles may persist in stage N3 sleep.

Note 3. Eye movements are not typically seen during stage N3 sleep.

Note 4. 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.

Scoring Stage R

1. Score in accordance with the following definitions: RECOMMENDED

Rapid eye movements (REM): Conjugate, irregular, sharply peaked eye movements with an initial deflection usually lasting <500 msec.

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: 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 muscles and scalp). The activity is maximal in association with rapid eye movements.

2. Score stage R sleep in epochs with ALL of the following phenomena:N1,N2,N3 RECOMMENDED

a. Low-amplitude, mixed-frequency EEG

b. Low chin EMG tone

c. Rapid eye movements

3. Continue to score stage R sleep, even in the absence of rapid eye movements, for epochs following one or more epochs of stage R as defined in rule I.2 above, IF the EEG continues to show low-amplitude, mixed-frequency activity without K complexes or sleep spindles AND the chin EMG tone remains low for the majority of the epoch.N4 (see Figure 6) RECOMMENDED

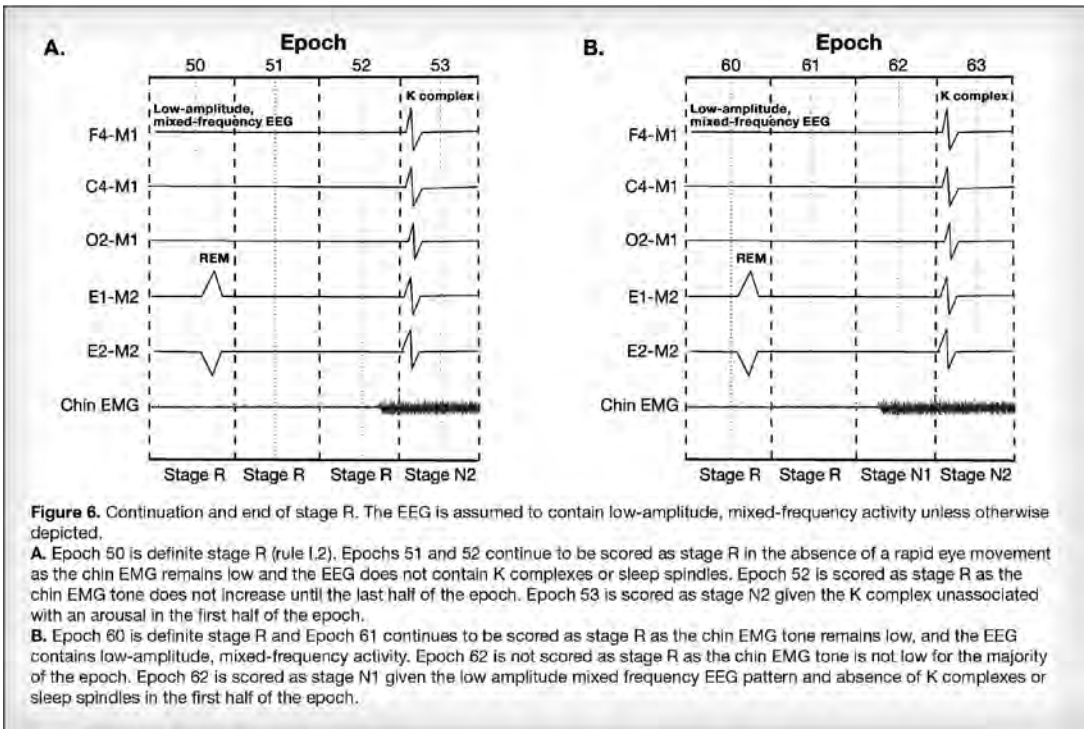

Figure 6. Continuation and end of stage R. The EEG is assumed to contain low-amplitude, mixed-frequency activity unless otherwise depicted.
A. Epoch 50 is definite stage R (rule I.2). Epochs 51 and 52 continue to be scored as stage R in the absence of a rapid eye movement as the chin EMG remains low 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 the K complex 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 EMG tone remains low, and the EEG contains low-amplitude, mixed-frequency activity. Epoch 62 is not scored as stage R as the chin EMG 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 absence of K complexes or sleep spindles in the first half of the epoch.

Stop 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 7)

c. An arousal occurs followed by low-amplitude, mixed-frequency EEG and slow eye movements (Score the epoch as stage N1; if there are no slow eye movements and chin EMG tone remains low, continue to score as stage R) (see Figure 8)

d. A major body movement followed by slow eye movements and low-amplitude, mixed-frequency EEG without non-arousal associated K complexes or sleep spindles (Score the epoch following the major body movement as stage N1; if no slow eye movements and the EMG tone remains low, continue to score as stage R; the epoch containing the body movement is scored using the criteria under heading J) (see Figure 9)

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 10)

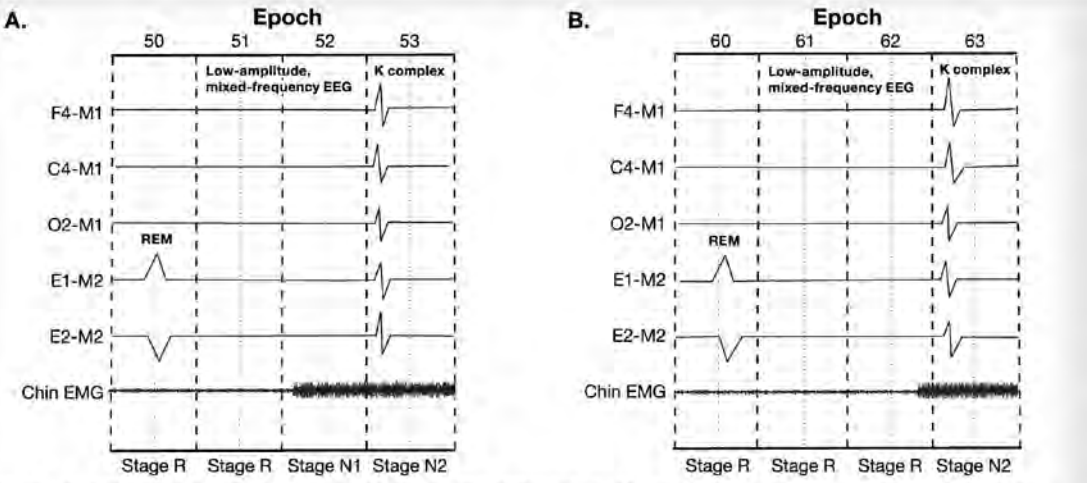

Figure 7. End of stage R due to increased chin EMG tone. The EEG is assumed to contain low-amplitude, mixed-frequency activity unless otherwise depicted.
A. Epoch 52 is not scored as stage R as the chin EMG tone is not low for the majority of the epoch. The epoch is scored as stage N1 based on the low-amplitude, mixed-frequency EEG pattern and the absence of K complexes or sleep spindles in the first half of the epoch.
B. Epoch 62 continues to be scored as stage R as the chin EMG tone does not increase until the last half of the epoch. That is, the majority of the epoch meets criteria for continuation of stage R.

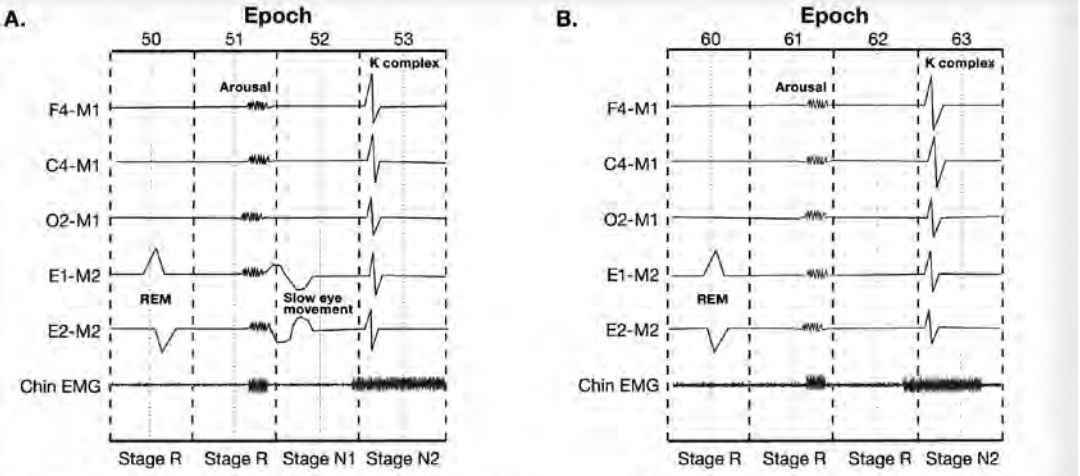

Figure 8. End of stage R due to an arousal. The EEG is assumed to contain low-amplitude, mixed-frequency activity unless otherwise depicted.
A. Stage R is interrupted by an arousal followed by slow eye movements and low-amplitude, mixed-frequency EEG. Thus, epoch 52 is scored as stage N1.
B. Stage R is interrupted by an arousal followed by low-amplitude, mixed-frequency EEG without slow eye movements. Epoch 62 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. Compare the effects of an arousal interrupting stage R with one interrupting stage N2 (Figure 4).

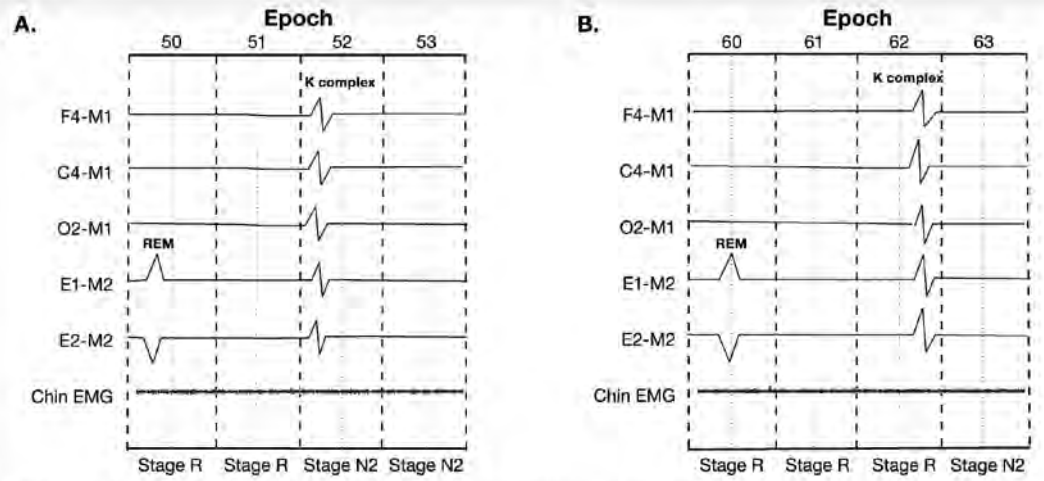

Figure 10. Transition from Stage R to stage N2. The EEG is assumed to contain low-amplitude, mixed-frequency activity unless otherwise depicted.
A. Epoch 50 is definite stage R. Epoch 51 continued as stage R as the EEG activity is low-amplitude, mixed frequency and the chin tone remains low (at the stage R level). Epoch 52 is stage N2 as a K complex unassociated with an arousal occurs in the first half of the epoch.
B. Epoch 60 is definite stage R. Stage R continues in Epochs 61 and 62 because the chin tone remains low and the EEG contains low amplitude mixed frequency activity until the K complex occurs in the second half of Epoch 63. Epoch 62 is stage N2 by the stage N2 rule (G.2)

Score epochs at the transition between stage N2 and stage R as follows: N1,N2,N3,N4,N5,N6 RECOMMENDED

a. In between epochs of definite stage N2 and definite stage R, score an epoch with a distinct drop in chin EMG in the first half of the epoch to the level seen in stage R as stage R even in the absence of rapid eye movements, if ALL of the following criteria are met: (see Figure 11)

i. Absence of non-arousal associated K complexes

ii. Absence of sleep spindles

b. In between epochs of definite stage N2 and definite stage R, score an epoch with a distinct drop in chin EMG in the first half of the epoch to the level seen in stage R as stage N2 if ALL of the following criteria are met: (see Figure 12A)

i. Presence of non-arousal associated K complexes or sleep spindles

ii. Absence of rapid eye movements

c. In between epochs of definite stage N2 with minimal chin EMG tone and definite stage R without further drop in chin EMG tone, score epochs as stage R even in the absence of rapid eye movements, if ALL of the following are met: (see Figure 12B)

i. Absence of non-arousal associated K complexes

ii. Absence of sleep spindles

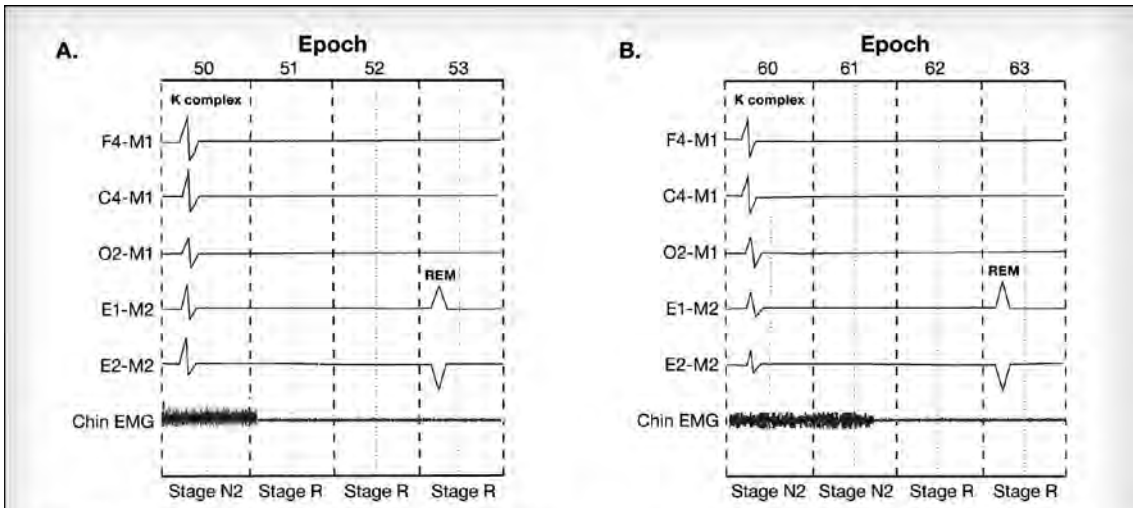

Figure 11. Transition between stage N2 and stage R. The EEG is assumed to contain low-amplitude, mixed frequency activity unless otherwise noted.
A. Epoch 50 is definite stage N2 (G.2). Epoch 53 is definite stage R. Epochs 51 and 52 are scored as stage R as the EEG contains low-amplitude, mixed frequency activity and the chin tone is low (at the stage R level) even though no rapid eye movements are present (G.5.a).
B. Epoch 60 is definite stage N2. Epoch 62 is definite stage R. Epoch 61 is scored as stage N2 as the chin tone does not fall to the REM level until the last half of the epoch. Epoch 62 is scored as stage R as the EEG contains low-amplitude, mixed frequency activity and the chin tone is low (at the stage R level) even though no rapid eye movements are present (rule I.5.a)

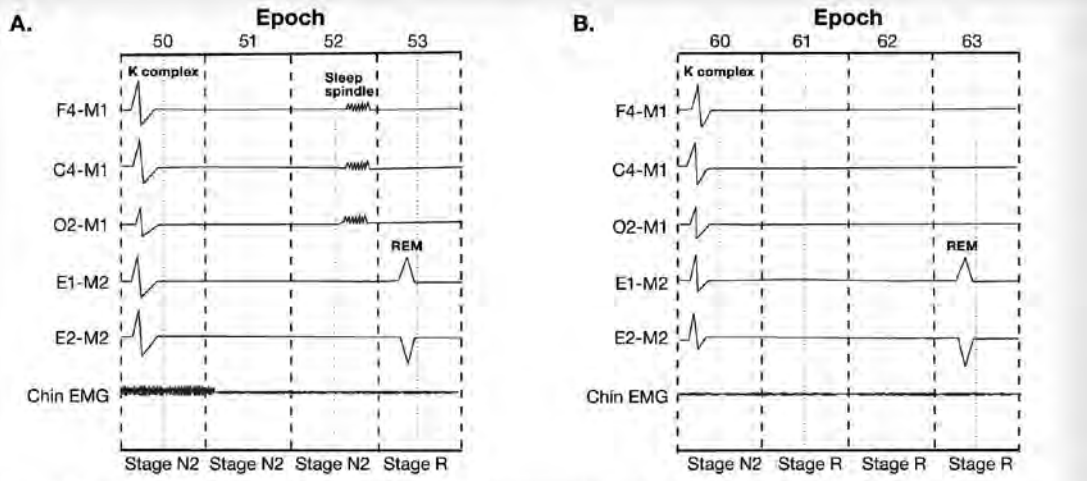

Figure 12. Transition between stage N2 and stage R. The EEG is assumed to contain low-amplitude, mixed-frequency activity unless otherwise depicted.
A. Epoch 50 is definite stage N2 and Epoch 53 definite stage R. The chin EMG tone is low (at the REM level) in both Epochs 51 and 52, and no rapid eye movements are present. A sleep spindle occurs in the last half of Epoch 52 suggesting that stage N2 continues through epoch 52 (rule I.5.b).
B. Epoch 60 is definite stage N2 and Epoch 63 definite stage R. Epochs 61 and 62 have a low-amplitude, mixed-frequency EEG and low chin tone and are scored as stage R.

Note 1. Epochs defined by rule I.2 are called epochs of definite stage R. Such epochs usually do not contain K complexes or sleep spindles. However, especially in the first REM sleep period of the night, K complexes or sleep spindles may be interspersed among epochs of what otherwise appears to be stage R sleep. Epochs defined by rule I.2 are scored as stage R even in the presence of K complexes or sleep spindles. In the absence of rapid eye movements, epochs containing sleep spindles or K complexes are not scored as stage R even if they contain low chin EMG tone.

Note 2. Definite stage N2 refers to epochs defined by G.2. The epoch contains one or both of the following: one or more sleep spindles or one or more K complexes in the first half of the epoch, and the epoch does not meet criteria for stage N3.

Note 3. Low-amplitude, mixed-frequency activity in stage R resembles that seen in stage N1. In some individuals, a greater amount of alpha activity can be seen in stage R than in stage N1. The alpha frequency in stage R often is 1-2 Hz slower than during wakefulness.

Note 4. 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 5. There are no rules specifically dealing with stage N1-R transitions. Stage R sleep will only commence when rapid eye movements are seen in association with low muscle tone and the typical EEG.

Note 6. At times, especially in the first REM sleep period of the night, K complexes or sleep spindles may be interspersed among epochs of what otherwise appears to be stage R sleep. The above rules indicate that epochs with rapid eye movements should be scored as stage R even in the presence of K complexes or spindles. However, if rapid eye movements are absent, subsequent epochs with K complexes or spindles should be scored as stage N2, even if chin muscle tone remains low.

Scoring Epochs with Major Body Movements

1. Score in accordance with the following definition: RECOMMENDED

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

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

3. If no alpha rhythm is discernible, but an epoch scorable 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

Scoring Arousals

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

Note 1. Arousal scoring should incorporate information from both the occipital and central 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.

Scoring Cardiac EventsN1,N2

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

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

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

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

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

6. Score atrial fibrillation if there is an irregularly irregular ventricular rhythm associated with replacement of consistent P waves by rapid oscillations that vary in size, shape, and timing. RECOMMENDED

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

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

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

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

Scoring Periodic Limb Movements in Sleep (PLMS)

1. The following define a significant leg movement (LM) event:N1,N2,N3,N4 RECOMMENDED

a. The minimum duration of a LM event is 0.5 seconds.

b. The maximum duration of a LM event is 10 seconds.

c. The minimum amplitude of a LM event is an 8 µV increase in EMG voltage above resting EMG.

d. The timing of the onset of a LM event is defined as the point at which there is an 8 µV increase in EMG voltage above resting EMG.

e. The timing of the ending of a LM event is defined as the start of a period lasting at least 0.5 seconds during which the EMG does not exceed 2 µV above resting EMG.

2. The following define a PLM series:N5,N6 RECOMMENDED

a. The minimum number of consecutive LM events needed to define a PLM series is 4 LMs.

b. The minimum period length between LMs (defined as the time between onsets of consecutive LMs) to include them as part of a PLM series is 5 seconds.

c. The maximum period length between LMs (defined as the time between onsets of consecutive LMs) to include them as part of a PLM series is 90 sec.

d. Leg movements on 2 different legs separated by less than 5 seconds between movement onsets are counted as a single leg movement.

Note 1. An LM should not be scored if it occurs during a period from 0.5 seconds preceding an apnea, hypopnea, RERA or sleep-disordered-breathing event to 0.5 seconds following.

Note 2. Surface electrodes should be placed longitudinally and symmetrically around the middle of the muscle so that they are 2-3 cm apart or 1/3 of the length of the anterior tibialis muscle, whichever is shorter. Both legs should be monitored for the presence of the leg movements. Separate channels for each leg are strongly preferred. Combining electrodes from the 2 legs to give 1 recorded channel may suffice for some clinical settings, although it should be recognized that this strategy may reduce the number of detected LMs. Movements of the upper limbs may be sampled if clinically indicated.

Note 3. The movement rule A.1 defines a significant leg movement event by absolute increase in 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 4. Use of 60 Hz (notch) filters should be avoided. Impedances need to be less than 10,000 Ω. Less than 5,000 Ω is preferred but may be difficult to obtain. Sensitivity limits of -100 and +100 µV (upper/lower) are preferred.

Note 5. An arousal and a PLM should be considered associated with each other when there is <0.5 seconds between the end of one event and the onset of the other event regardless of which is first.

Note 6. When two periodic limb movements occur with an interval of less than 10 seconds and each is associated with a 3 second arousal, only the first arousal should be scored although both limb movements may be scored. In this scenario, the arousal index and PLMS arousal index, but not the PLMS index, would be influenced by not scoring the second "arousal."

Scoring Alternating Leg Muscle Activation (ALMA)

1. The following define ALMA:N1,N2,N3 OPTIONAL

a. The minimum number of discrete and alternating EMG bursts of leg muscle activity needed to score an ALMA series is 4 ALMAs.

b. The minimum frequency of the alternating EMG bursts in ALMA is 0.5 Hz.

c. The maximum frequency of the alternating EMG bursts in ALMA is 3.0 Hz.

Note 1. ALMAs alternate between legs.

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

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

Scoring Hypnagogic Foot Tremor (HFT)

1. The following define HFT:N1,N2 OPTIONAL

a. The minimum number of EMG bursts needed to make a train of bursts in a HFT series is 4 HFT bursts.

b. The minimum frequency of the EMG bursts in a HFT is 0.3 Hz.

c. The maximum frequency of the EMG bursts in a HFT is 4.0 Hz.

Note 1. The usual range for duration of hypnagogic foot tremor is 250-1000 msec.

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

Scoring Excessive Fragmentary Myoclonus (EFM)

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

a. The usual maximum EMG burst duration seen in fragmentary myoclonus is 150 msec.

b. At least 20 minutes of NREM sleep with EFM must be recorded.

c. At least 5 EMG potentials per minute must be recorded.

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

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

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

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 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 EMG activity are scored as bruxism if the duration is more than 2 seconds.

d. A period of at least 3 seconds of stable background chin EMG must occur before a new episode of bruxism can be scored.

e. Bruxism can be scored reliably by audio in combination with polysomnography by a minimum of 2 audible tooth grinding episodes per night of polysomnography in the absence of epilepsy.

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

Note 2. In addition to the recommended placement of chin EMG electrodes as noted in adult visual rules section IV.C, additional masseter electrodes may be placed at the discretion of the investigator or clinician.

Scoring PSG Features of REM Sleep Behavior Disorder (RBD)

1. Score in accordance with the following definitions: RECOMMENDED

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

Excessive transient muscle activity (phasic activity) in REM sleep: In a 30-second epoch of REM sleep divided into 10 sequential, 3-second mini-epochs, at least 5 (50%) of the mini-epochs contain bursts of transient muscle activity. In RBD, excessive transient muscle activity bursts are 0.1-5.0 seconds in duration and at least 4 times as high in amplitude as the background EMG activity.

2. The polysomnographic characteristics of RBD are characterized by EITHER or BOTH of the following features:N1,N2,N3,N4 RECOMMENDED

a. Sustained muscle activity in REM sleep in the chin EMG

b. Excessive transient muscle activity during REM in the chin or limb EMG

Note 1. Time-synchronized, audio-equipped video PSG demonstrating dream enactment or a characteristic clinical history are necessary to make the diagnosis of RBD in addition to polysomnographic evidence of REM sleep without atonia or excessive transient muscle activity in REM sleep.

Note 2. Transient muscle activity and occasional accompanying visible twitching of small muscle groups are a normal phenomenon seen in REM sleep (see adult visual rules section IV.I). When larger muscle groups are involved, this activity is not associated with large, overt muscular activity acting across large joints. When smaller muscle groups are involved, the movement often involves the distal muscles of the hands and face or the corners of the mouth. Transient muscle activity may be excessive in RBD.

Note 3. The sustained muscle activity or the excessive transient muscle activity observed in REM sleep may be interrupted by superimposed (usually dream-enacting) behaviors of RBD.

Note 4. In normal individuals there is an atonia seen in REM sleep in the chin and anterior tibialis EMG. In this state the baseline amplitude of the EMG signal decreases markedly. This atonia of REM sleep is lost to a considerable extent in RBD, with variable frequency, and as a result, the EMG baseline amplitude is often higher. In this situation, the EMG can be said to be in a tonic rather than atonic state.

Scoring the PSG Features of Rhythmic Movement Disorder

1. The following define the polysomnographic characteristics of rhythmic movement disorder:N1,N2 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.

Note 1. Bipolar surface electrodes should be placed to record electrical activity of the large muscle groups involved.

Note 2. Time-synchronized video PSG, in addition to polysomnographic criteria, is necessary to make the diagnosis of rhythmic movement disorder.

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. RIPsum (calibrated or uncalibrated) RECOMMENDED

c. 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) 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 PCO2, transcutaneous PCO2 or end-tidal PCO2.N5,N6 RECOMMENDED

10. For detection of hypoventilation during PAP titration, use arterial PCO2, or use transcutaneous PCO2.N5,N6 RECOMMENDED

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

Note 2. RIP stands for respiratory inductance plethysmography. 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. Monitoring snoring is optional as noted in Parameters to be Reported II.F.

Note 5. Monitoring hypoventilation is optional as noted in Parameters to be Reported II.F.

Note 6. a.Clinical judgment is essential when assessing the accuracy of end-tidal PCO2 and transcutaneous PCO2 readings. The values should not be assumed to be accurate surrogates of the arterial PCO2 when the values do not fit the clinical picture.

b. The transcutaneous PCO2 sensor should be calibrated with a reference gas according to the manufacturer's recommendations and when the accuracy of the reading is doubtful. Of note, the value of the transcutaneous PCO2 typically lags behind changes in the arterial PCO2 by two minutes or more.

c. The end-tidal PCO2 often malfunctions or provides falsely low values in patients who have marked nasal obstruction, profuse nasal secretions, are obligate mouth breathers, or who are receiving supplemental oxygen It is crucial to obtain a plateau in the end-tidal waveform for the signal to be considered valid.

Measuring Event Duration

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

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

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

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 1) 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.

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

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

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

Scoring of Hypopneas

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

1. Score a respiratory event as a hypopnea if ALL of the following criteria are met:N1,N2,N3 (see Figure 2) 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.

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

a. Snoring during the event

b. Increased inspiratory flattening of the nasal pressure or PAP device flow signal compared to baseline breathing

c. Associated thoracoabdominal paradox 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. Snoring during the event

b. Increased inspiratory flattening of the nasal pressure or PAP device flow signal compared to baseline breathing

c. Associated thoracoabdominal paradox occurs during the event but not during pre-event breathing

Note 1. If necessary, the number of hypopneas using a definition requiring a ≥30% drop in flow for ≥10 seconds that is associated with ≥4% desaturation may additionally be reported to qualify a patient for PAP reimbursement (eg. Medicaid or Medicare patients).

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

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

Scoring Respiratory Effort-Related Arousal

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

1. If electing to score respiratory effort-related arousals, score a respiratory event as a respiratory effort-related arousal (RERA) if there is a sequence of breaths lasting ≥10 seconds characterized by increasing respiratory effort or by flattening of the inspiratory portion of the nasal pressure (diagnostic study) or PAP device flow (titration study) waveform leading to arousal from sleep when the sequence of breaths does not meet criteria for an apnea or hypopnea. (see Figure 3)

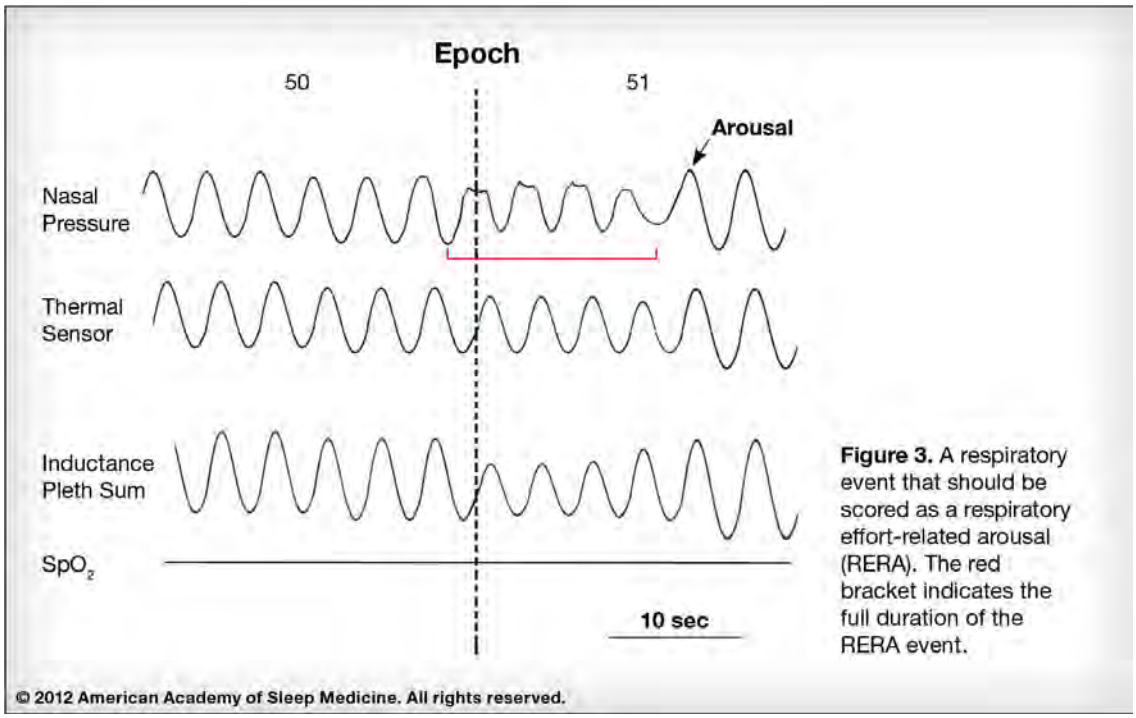

Figure 3. A respiratory event that should be scored as a respiratory effort-related arousal (RERA). The red bracket indicates the full duration of the RERA event.

Scoring Hypoventilation

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

1. If electing to score hypoventilation, score a respiratory event as hypoventilation during sleep if EITHER of the below occur:N1 RECOMMENDED

a. There is an increase in the arterial PCO2 (or surrogate) to a value >55 mmHg for ≥10 minutes.

b. There is ≥10 mmHg increase in arterial PCO2 (or surrogate) during sleep (in comparison to an awake supine value) to a value exceeding 50 mmHg for ≥10 minutes.

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

Scoring Cheyne-Stokes Breathing

1. Score a respiratory event as Cheyne-Stokes breathing if BOTH of the following are met: (see Figure 4)N1,N2 RECOMMENDED

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

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

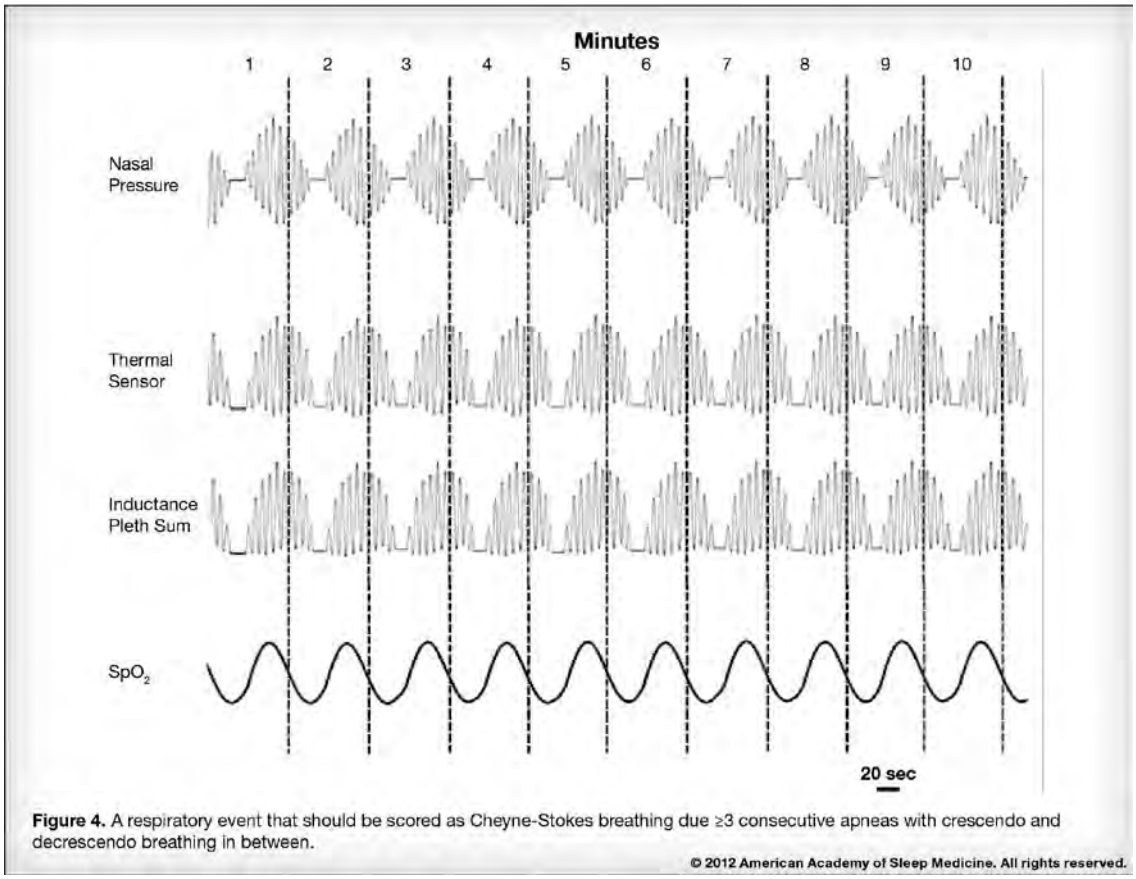

Figure 4. A respiratory event that should be scored as Cheyne-Stokes breathing due ≥3 consecutive apneas with crescendo and decrescendo breathing in between.

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

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

Glossary of Terms

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

Alpha rhythm: 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.

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

Atrial fibrillation: An irregularly irregular ventricular rhythm associated with replacement of consistent P waves by rapid electrical oscillations.

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

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

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

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

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

Delta frequency: An EEG rhythm consisting of 0-4 Hz activity. (See definition of slow wave activity.)

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

Dominant posterior rhythm: An EEG pattern with frequency appropriate to age which is observed over the occipital regions during relaxed wakefulness with eyes closed and attenuates with eye opening or attention.

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

Eye blinks: EOG events consisting of conjugate vertical eye movements at a frequency of 0.5-2 Hz present in wakefulness with the eyes open or closed.

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

Hypnagogic hypersynchrony: An EEG pattern consisting of paroxysmal runs or bursts of diffuse high amplitude sinusoidal 75 to 350 μV, 3-4.5 Hz waves which begin abruptly, are usually widely distributed but often maximal over the central, frontal, or frontocentral scalp regions.

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

Hypoventilation: A specified period of increased PCO2 of >50 mm Hg in children or >55 mg Hg in adults, or a rise of PCO2 during sleep of ≥10 mm Hg that exceeds 50 mm Hg for a specified period of time in adults.

K complex: An EEG event consisting of a well delineated negative sharp wave immediately followed by a positive component standing out from the background EEG with total duration ≥0.5 seconds, usually maximal in amplitude over the frontal regions.

Low-amplitude, mixed-frequency activity: An EEG pattern consisting of low amplitude, predominantly 4-7 Hz activity.

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

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.

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

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

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

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

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

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

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

Rapid eye movements: Eye movements recorded in the EOG derivations consisting of conjugate, irregular, sharply peaked eye movements with an initial deflection usually lasting <500 msec. Rapid eye movements may be noted during stage W or stage R.

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

REM Sleep Behavior Disorder: A parasomnia characterized by relative atonia during REM and associated with potentially harmful dream-enacting behaviors.

Respiratory effort related arousal: A sequence of breaths characterized by increasing respiratory effort (esophageal manometry); inspiratory flattening in the nasal pressure or PAP device flow channel; or an increase in end-tidal PCO2 (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 inductance plethysmography (RIP): A technology that uses alternating current in belts surrounding the thorax and abdoment to generate a signal based on changes in the inductance of belts during breathing. The band inductance depends on the cross-sectional area encircled by the band.

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

Rhythmic anterior theta activity: An EEG pattern consisting of runs of 5-7 Hz rhythmic theta activity maximal over the frontal or frontocentral regions.

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

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

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

Sleep onset: The start of the first epoch scored as any stage other than stage W.

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

Slow eye movements: EOG events consisting of conjugate, reasonably regular, sinusoidal eye movements with an initial deflection usually lasting >500 msec. Slow eye movements may be present during drowsy wakefulness or stage N1.

Slow wave activity: Waves measured over the frontal regions with a frequency of 0.5-2 Hz and a peak-to-peak amplitude >75 μV.

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

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

Theta rhythm: An EEG rhythm consisting of 4-7 Hz activity.

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. The activity is maximal in association with rapid eye movements.

Vertex sharp waves (V waves): An EEG pattern consisting of sharply contoured waves with duration <0.5 seconds maximal over the central region and distinguishable from the background activity.

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