



Arousals and Movements

Sleep Scoring and Staging



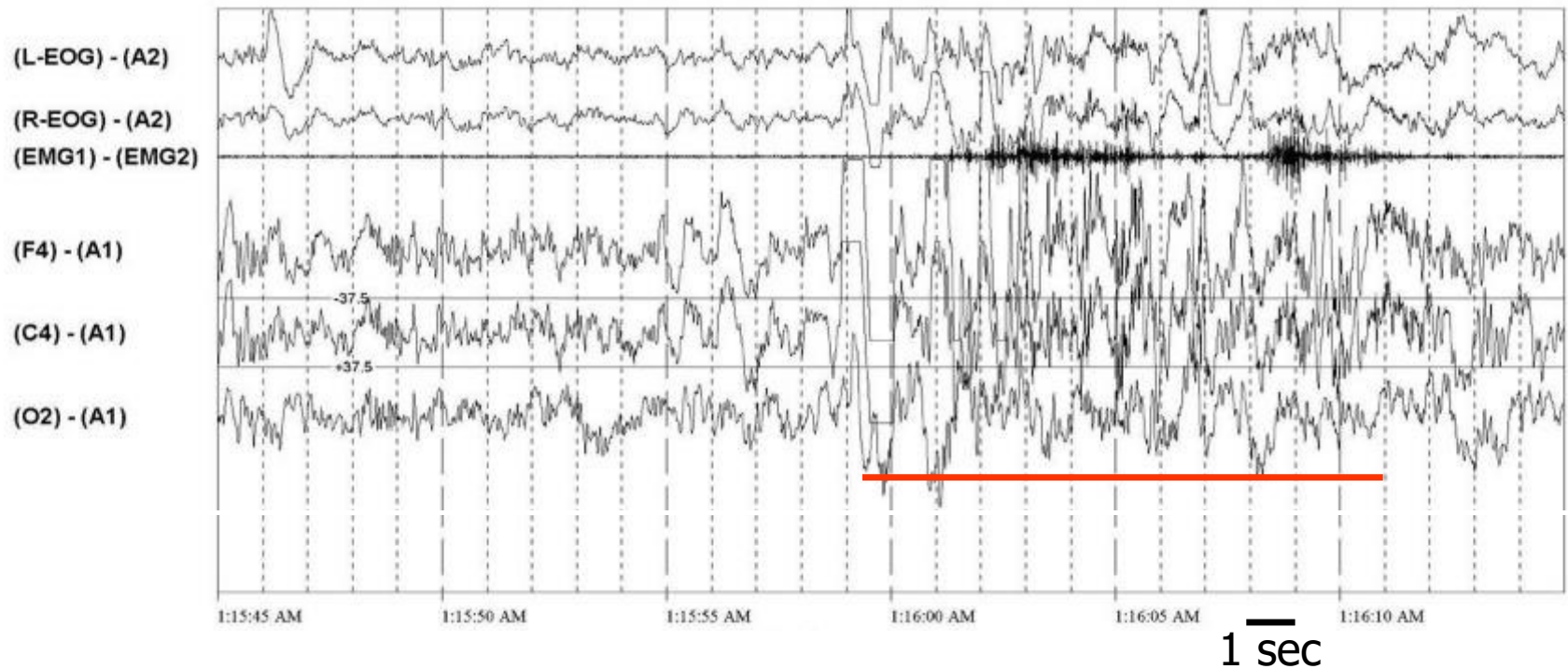
Arousals and Awakenings

- ❖ Brief arousals can be identified on the standard PSG and are characterized by abrupt changes in EEG frequency (suggestive of an awake state) and/or brief increases in EMG amplitude. The transient nature of these arousals leads to their being overlooked or to decisional uncertainties in the standard 30-second epoch sleep stage scoring system.
- ❖ Standard sleep stage scoring systems are intended to identify state (i.e. wake, REM, and NREM sleep) and not transient interruptions in state. Hence, a set of criteria to specifically and reliably identify the occurrence of transient arousals would be very useful for both clinical and theoretical purposes.

Arousals and Awakenings Rules

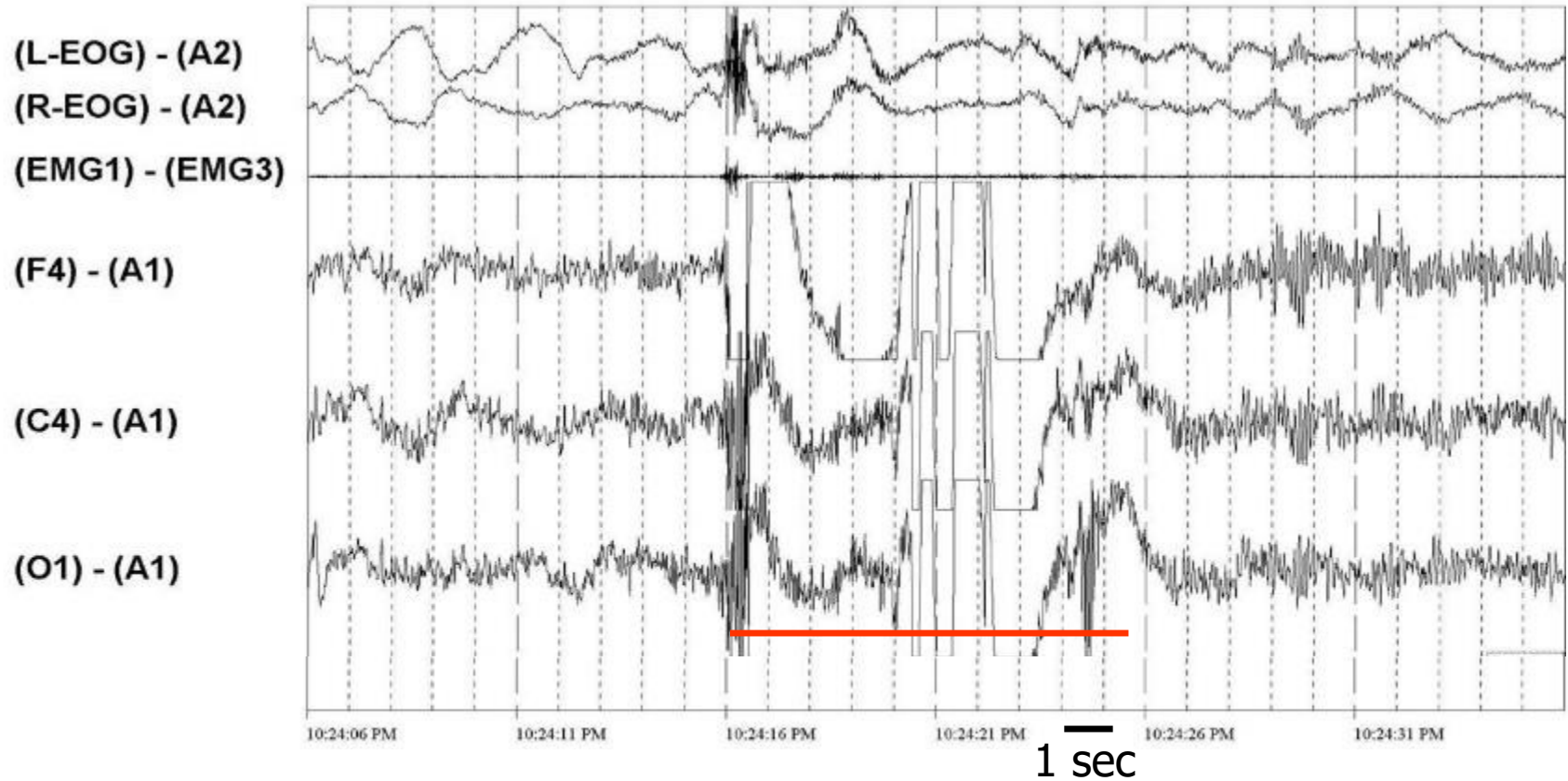
- I. Abrupt shift in EEG frequency to alpha, theta, and/or frequencies > 16 Hz (but not to spindles)
- II. Must arise from at least 10 seconds of prior stable sleep
- III. Must last for three seconds or more
- IV. In REM sleep, must have concurrent submental EMG increase lasting at least 1 second
- V. Score arousal if it immediately precedes a transition to stage W

Arousal Scoring 1



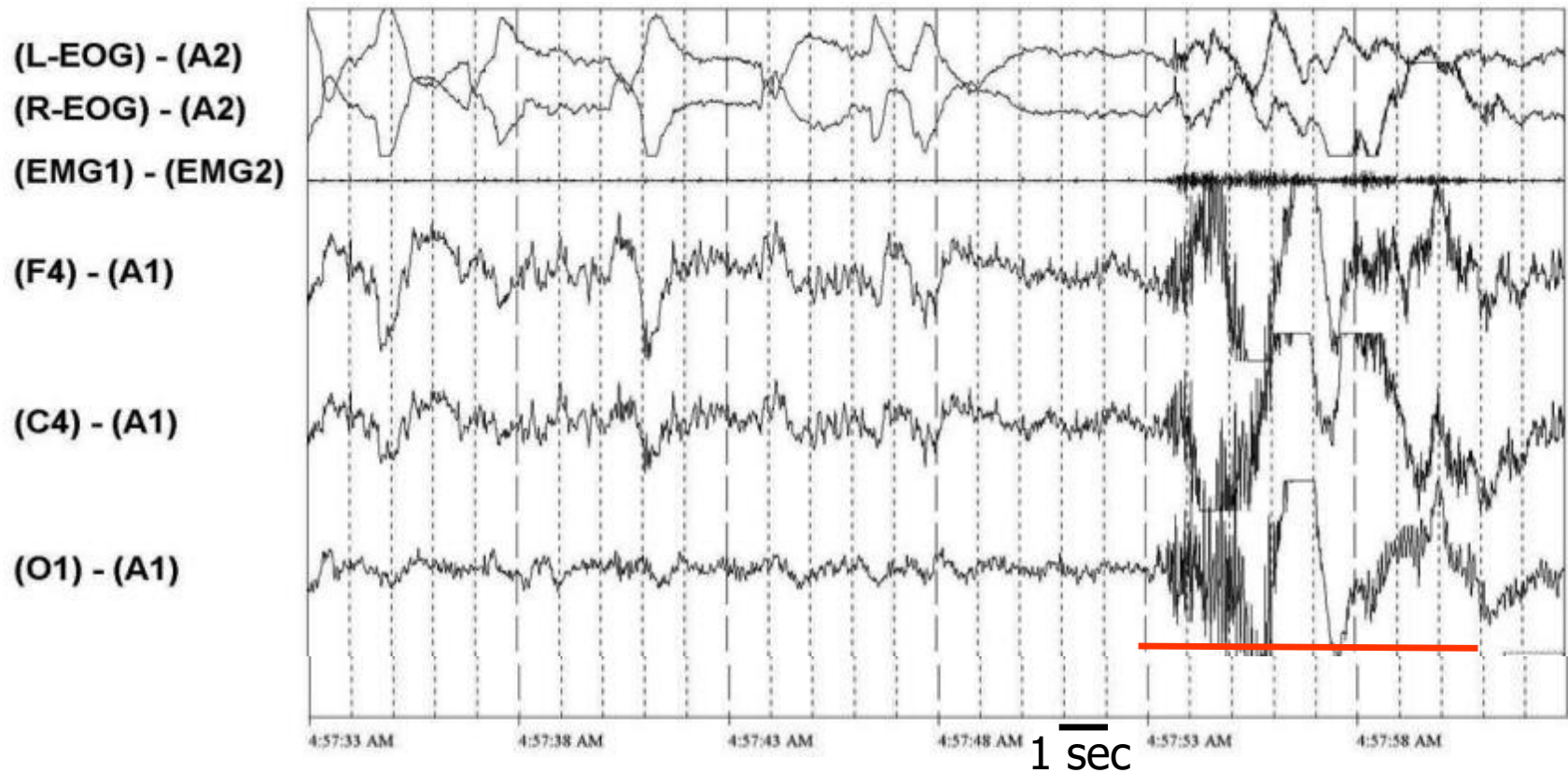
This slide shows a greater than three second EEG change with frequencies greater than 16 Hz and alpha activity (underlined in red). This EEG arousal also has increased EMG amplitude. There are greater than 10 seconds of sleep preceding this event, and it is scored as an arousal.

Arousal Scoring 2



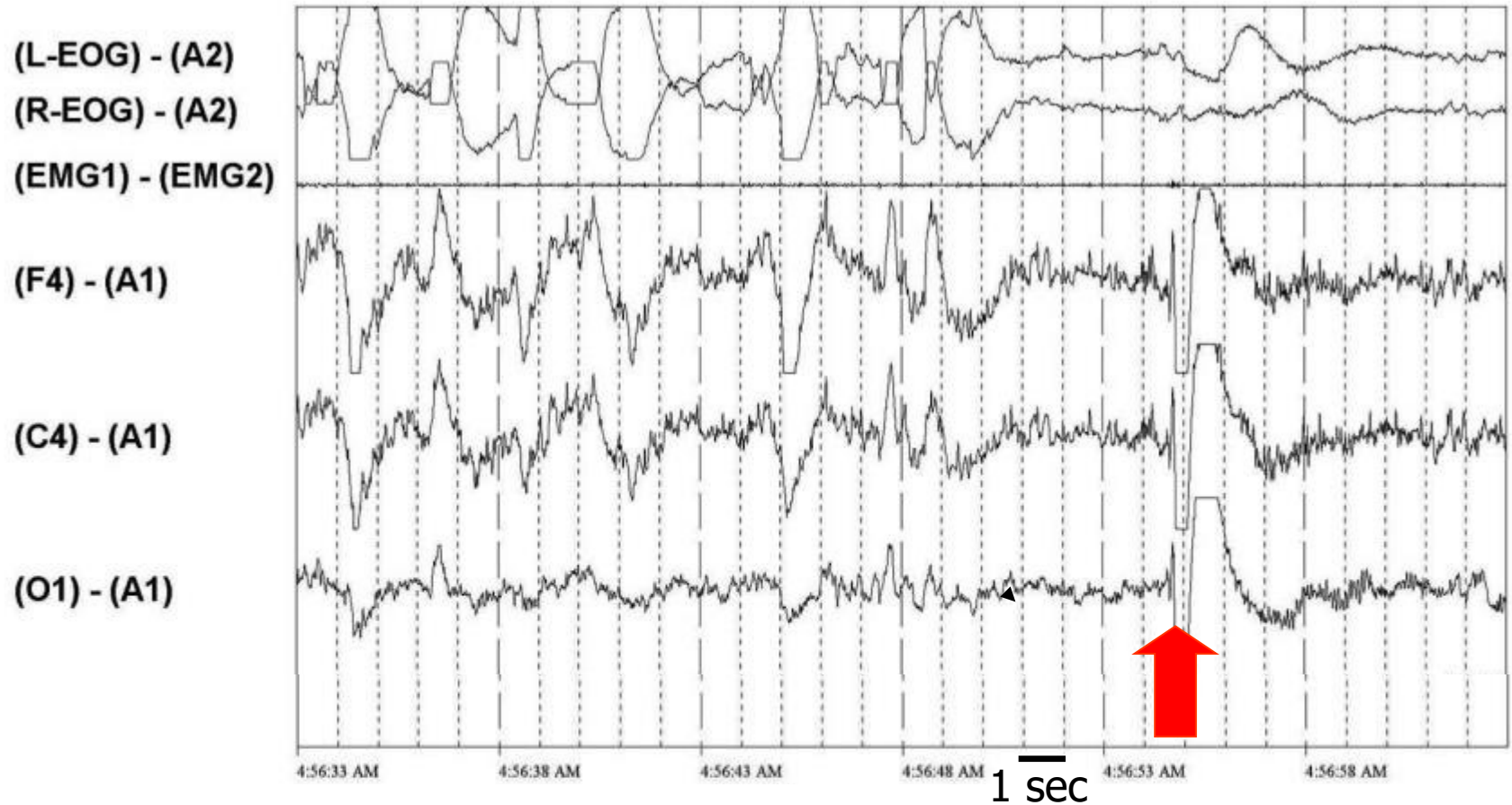
There is no sleep preceding the event underlined in red, above; therefore, it is not scored as an arousal. This epoch would be scored as W (wake).

Arousal Scoring 3



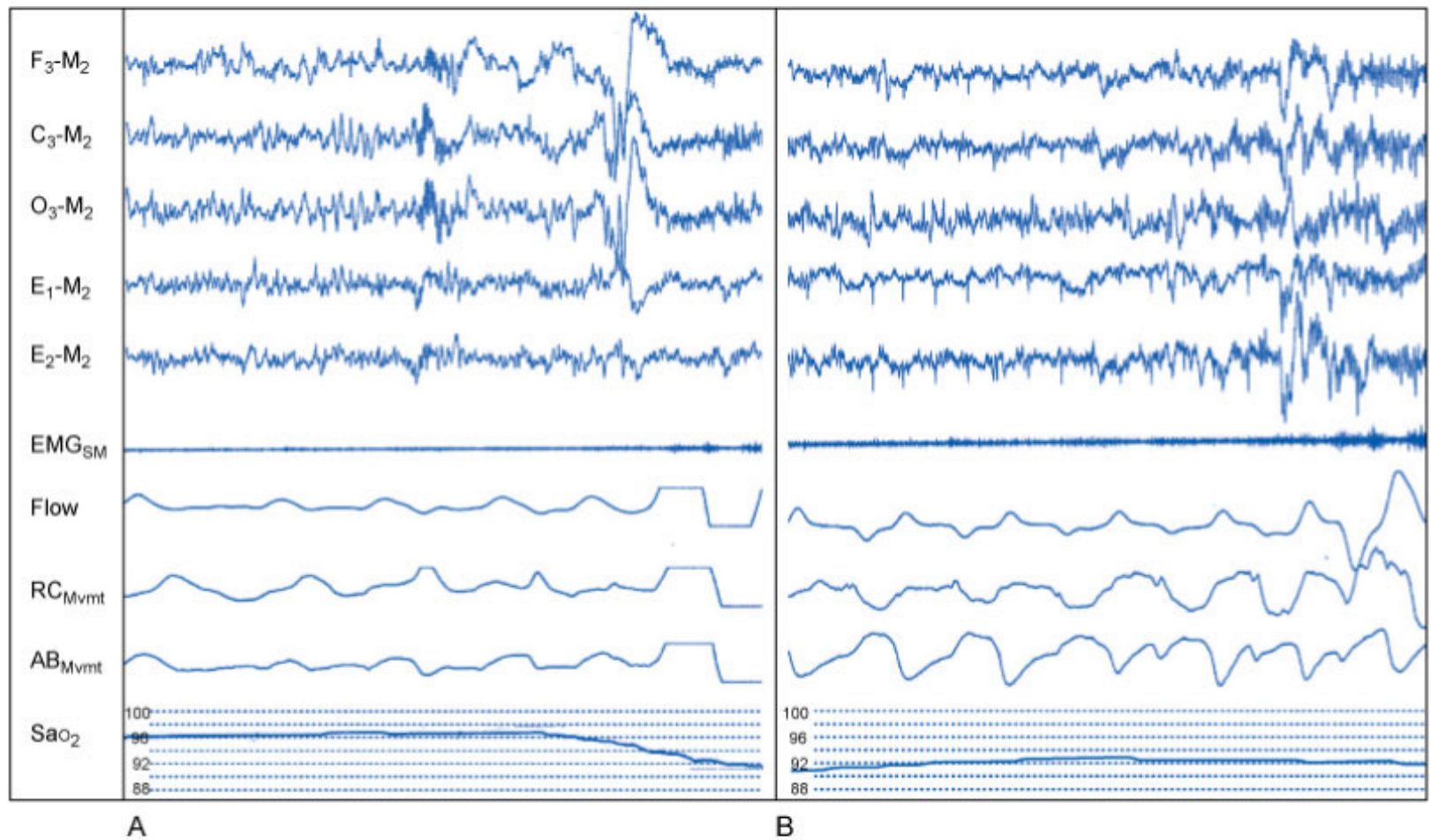
The EEG frequency change in this epoch of REM sleep is scored as an arousal (underlined in red). An arousal may be scored in REM only if there is an EEG frequency change for more than three seconds in duration and a concurrent increase in the submental EMG lasting at least one second, both of which are seen on these slide.

Arousal Scoring 4

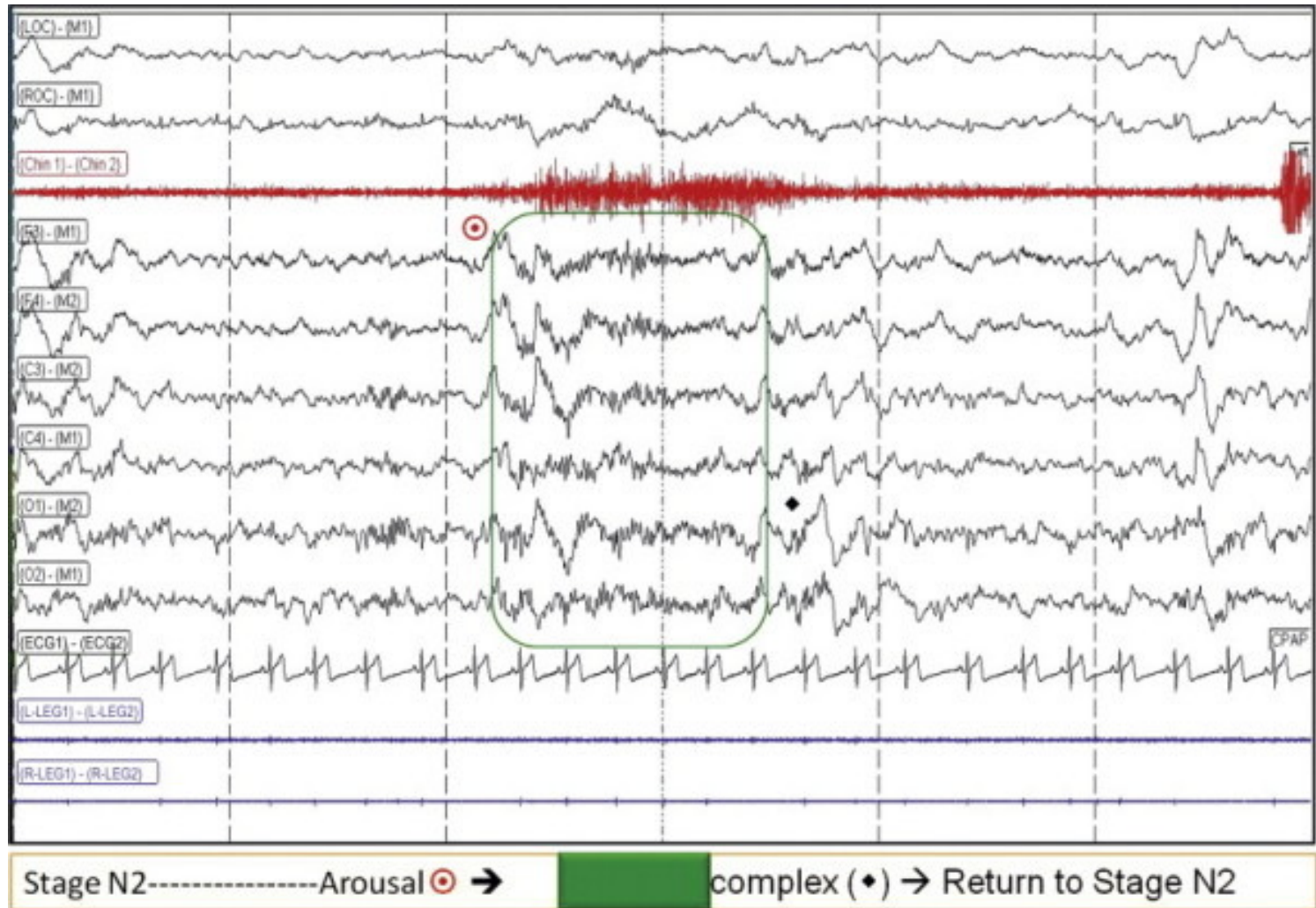


The EEG frequency change shown in this epoch of REM sleep (red arrow) is not accompanied by an increase in EMG amplitude and, thus, is not scored as an arousal.

Arousal Scoring 5



Arousal Scoring 6



Notes for Arousals

- Arousal scoring should incorporate info from frontal, central, and occipital derivations
- Arousal scoring can be improved by use of additional info in the recording such as respiratory events and/or additional EEG channels. But scoring arousals can't be based on this info alone.
- 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 arousal index.

Notes for Arousals

- The 10 seconds of stable sleep required prior to scoring an arousal may begin in the preceding epoch, including a preceding epoch scored as Wake.
- An arousal may still be scored if it immediately precedes a transition to Wake. Both the arousal and the transition to Wake are scored.
- Classifying arousals as related to respiratory or leg movement events, or occurring spontaneously, may be informative

Technical Specifications for Movement

- For monitoring leg movements, electrodes should be placed longitudinally and symmetrically in the middle of the anterior tibialis muscle 2-3 cm apart or $\frac{1}{3}$ the length of the anterior tibialis muscle, whichever is shorter.
- Both legs should be monitored, with separate channels for each leg strongly preferred.
- Use of 60 Hz notch filters should be avoided.
- Impedances need to be less than 10,000 Ohms.
 - Less than 5,000 Ohms is preferred but may be difficult to obtain.

Technical Specifications for Movement

- For monitoring movements of the upper limbs, electrodes should be placed longitudinally and symmetrically over the surface of the flexor digitorum superficialis or the surface of the extensor digitorum communis. Both arms should be monitored with separate channels for each arm strongly preferred
 - Recommended by AASM for diagnosis of REM behavior disorder (RBD)
 - Optional for standard studies
- For diagnosis of RBD, time-synchronized, audio-equipped video PSG is essential to document complex motor behaviors and vocalizations during REM. Diagnosis of RBD is based on demonstration of such episodes or a characteristic clinical history of dream enactment in addition to PSG evidence of REM sleep without atonia (RWA).

Technical Specifications for Movement

- Optional: For bruxism, in addition to the regular chin leads, additional masseter electrodes may be placed if clinically indicated.
- Optional: For rhythmic movement disorder, bipolar surface electrodes should be placed to record electrical activity of the large muscle groups involved.
 - Recommended: For diagnosis, time-synchronized video PSG is necessary to accurately characterize the disorder, in addition to PSG criteria.

Notes for Technical Specifications for Movement

- For accurate electrode placement, ask patient to activate the muscle.
 - Anterior tibialis: Raise foot toward head or flex foot up
 - Flexor digitorum superficialis: Bend (flex) only at base of fingers (avoid bending at distal two joints)
 - Extensor digitorum communis: Extend fingers back without moving their wrist
 - Masseter: Bite down
- Electrodes should be placed 2-3 cm apart no matter which muscles used.

Candidate Limb Movement Event

➤ Defined by:

- At least a portion must occur in an epoch of sleep
- Minimum duration of 0.5 seconds
- Maximum duration of 10 seconds
- Minimum amplitude = 8 μ V above resting EMG
 - Onset = Start of 8 μ V increase in EMG
 - Ending = Start of period lasting at least 0.5 seconds during which EMG does not exceed 2 μ V above resting

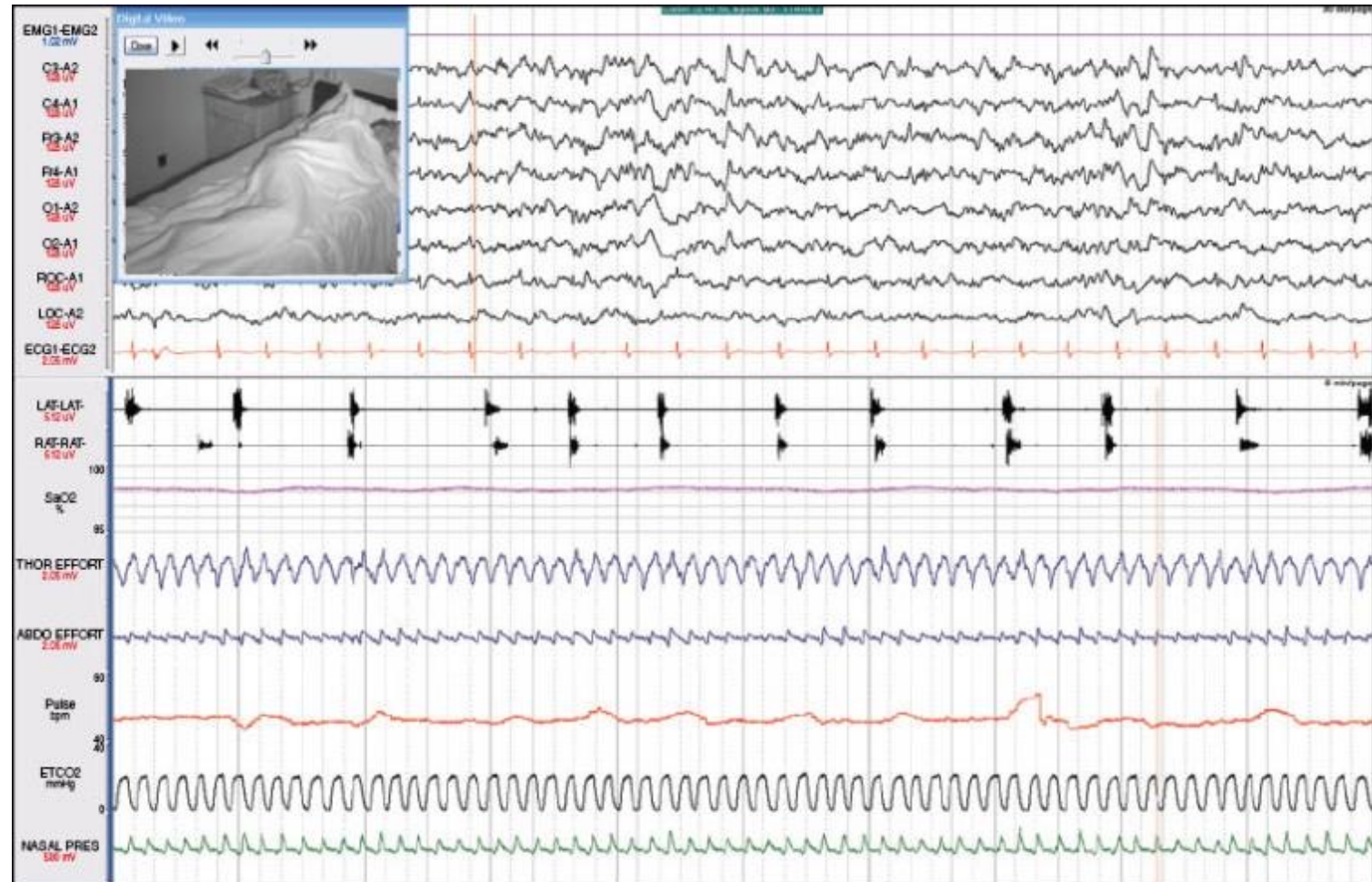
PLM Series

- Defined by:
 - Minimum of 4 LMs
 - Minimum period length between LMs = 5 seconds
 - Maximum period length between LMs = 90 seconds
 - Leg movements on 2 different legs separated by less than 5 seconds between movement onsets are counted as single leg movement
- An arousal and limb movement that occur in a PLM series should be considered associated with each other if they occur simultaneously, overlap, or when there is < 0.5 seconds between the end of one event and the onset of the other regardless of which is first.

PLM Series



PLM Series



Limb Movement Rules

- LM should not be scored if occurs 0.5 seconds prior to apnea, hypopnea, or RERA to 0.5 seconds following the event.
- When a period of wake < 90 seconds separates a series of LMs, this does not prevent LMs preceding wake from being included with subsequent LMs as part of PLM series.

Limb Movement Notes

- When PLMS occur with an interval of <10 seconds and each is associated with a ≥ 3 -second change in 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.

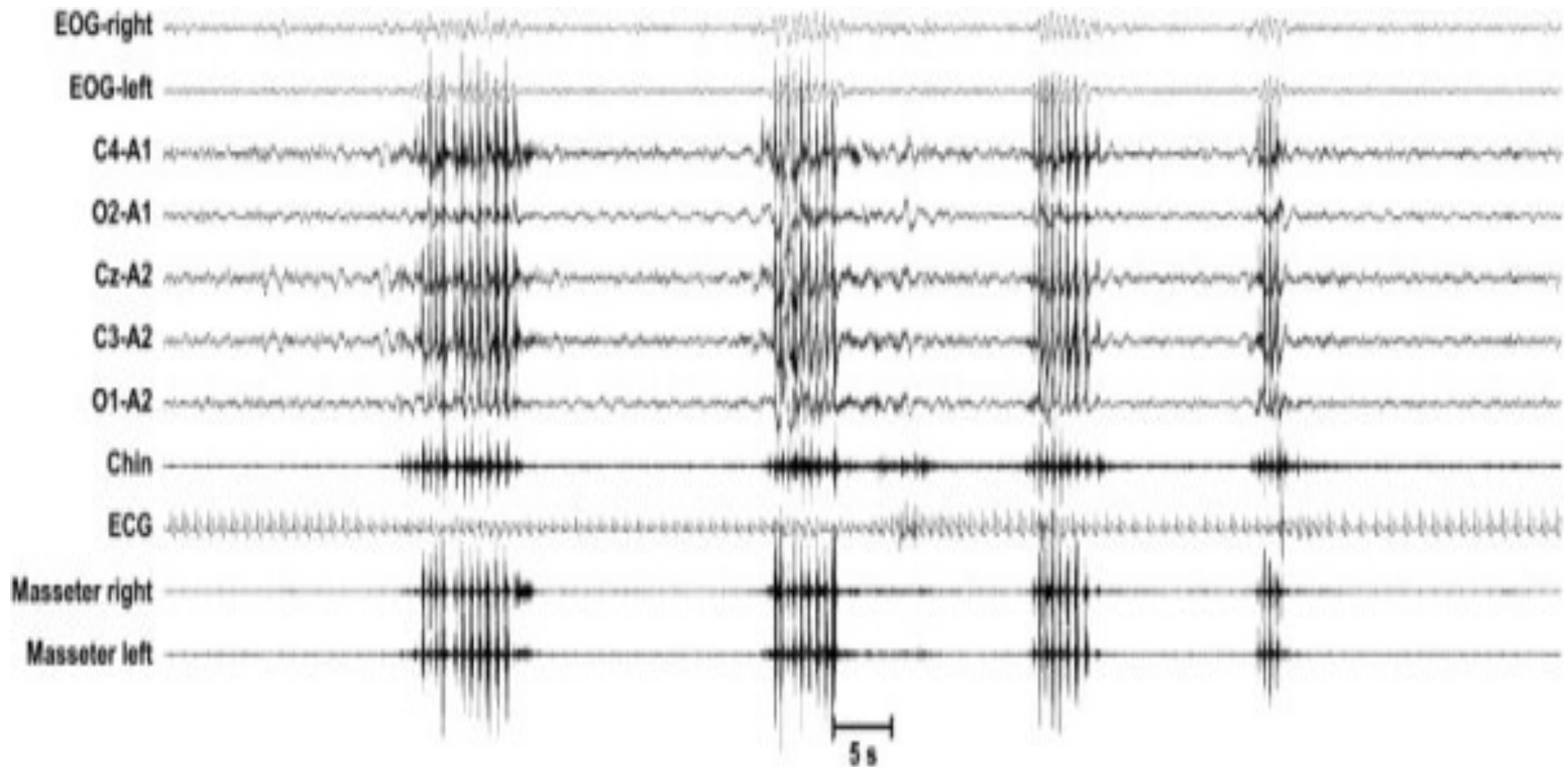
Bruxism

- Brief (phasic) or sustained (tonic) elevations of chin EMG at least twice the amplitude of background EMG
- Must be 0.25-2 seconds in duration and if at least 3 such elevations occur in regular sequence
- Sustained elevations of chin EMG are bruxism if greater than 2 seconds
- At least 3 seconds of stable background chin EMG must occur before new episode of bruxism can be scored
- Can be scored via video and audio in combo with PSG by min of 2 audible tooth grinding episodes in absence of epilepsy

Notes on Bruxism

- In sleep, jaw contraction frequently occurs. This contraction can take 2 forms: (1) sustained (tonic) jaw clenching contractions or (2) series of repetitive brief (phasic) muscle contractions termed rhythmic masticatory muscle activity (RMMA)
- Characteristic changes in masseter EMG are often more prominent than changes in chin EMG

Bruxism



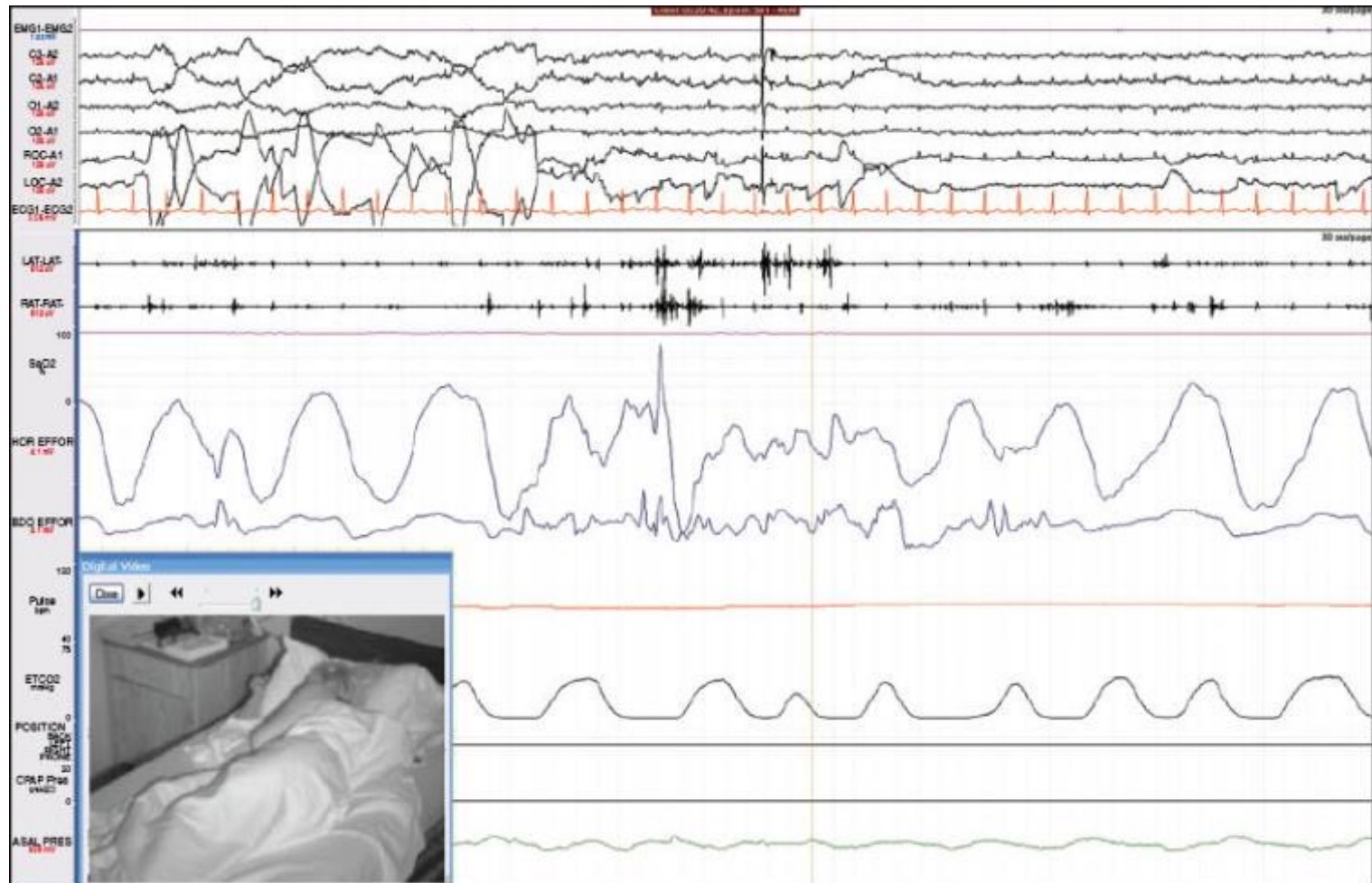
REM Without Atonia (RWA)

- Excessive sustained muscle activity (tonic activity) in REM:
 - Epoch of REM sleep with at least 50% duration having chin EMG amplitude at least 2 times greater than stage R atonia level (or lowest amplitude in NREM). Each segment must be greater than 5 seconds.
- Excessive transient muscle activity (phasic activity) in REM:
 - In 30 sec epoch of REM divided into 10 sequential, 3-sec mini-epochs, at least 5 (50%) of mini-epochs contain bursts of transient muscle activity
 - Bursts are 0.1 to 5 seconds in duration and at least 2 times as high in amplitude as the stage R atonia level (or lowest amplitude in NREM)

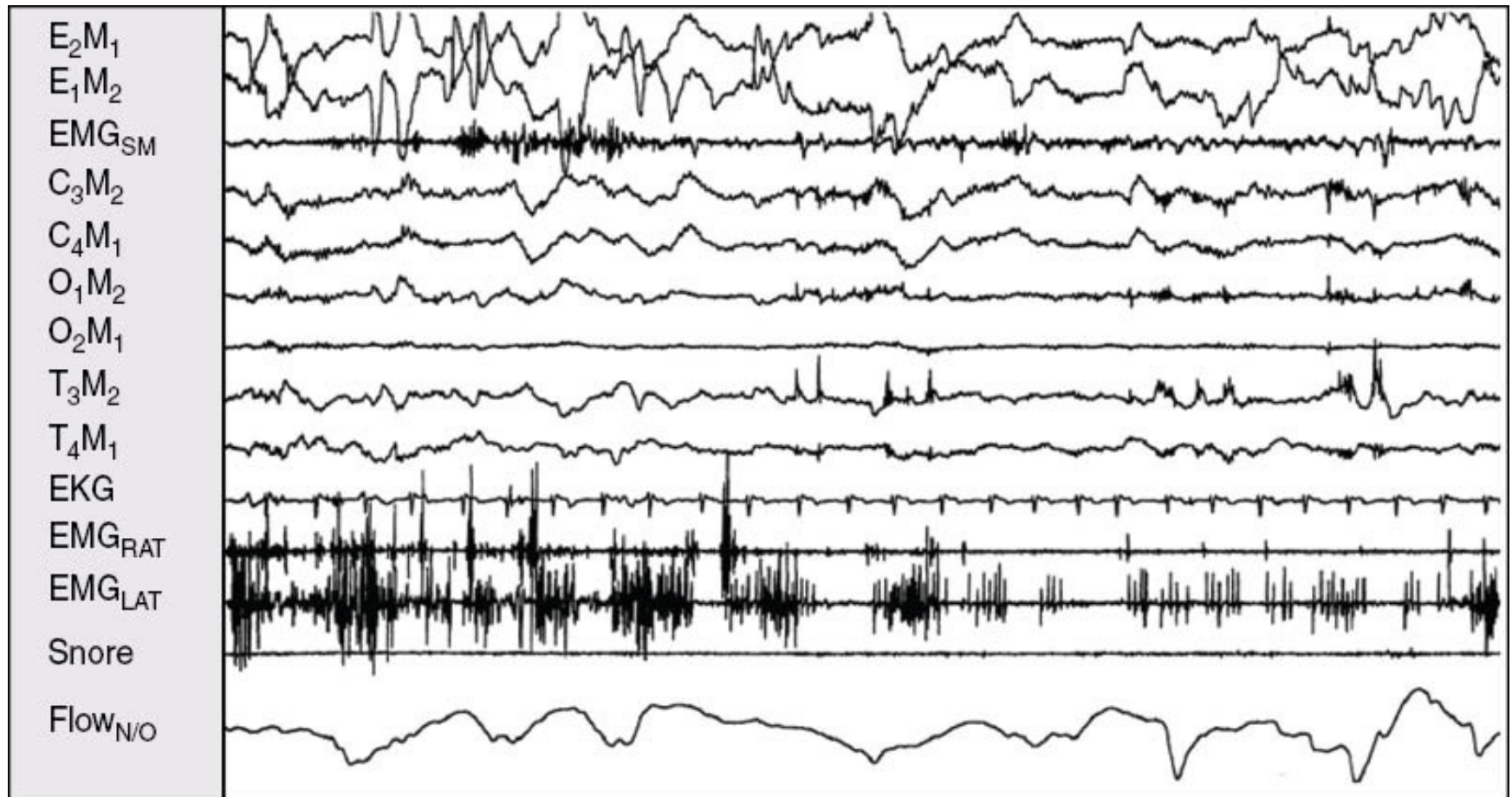
REM Without Atonia (RWA)

- Any chin activity
 - Activity with a minimum amplitude 2 times greater than stage R atonia level (or lowest amplitude in NREM) without regard to duration of the activity (including bursts of 5-15 seconds)
- If scoring, one of the following must be present:
 - Excessive sustained muscle activity in REM in chin EMG
 - Excessive transient muscle activity during REM in chin or limb EMG
 - At least 50% of 3 second mini-epochs contain any chin or limb activity (bursts of EMG activity 0.1 to 5 seconds in duration and at least 2 times as high in amplitude as stage R atonia (or lowest amplitude in NREM))
- If scoring, score the RWA index as the % of stage R epochs that meet the criteria for this rule

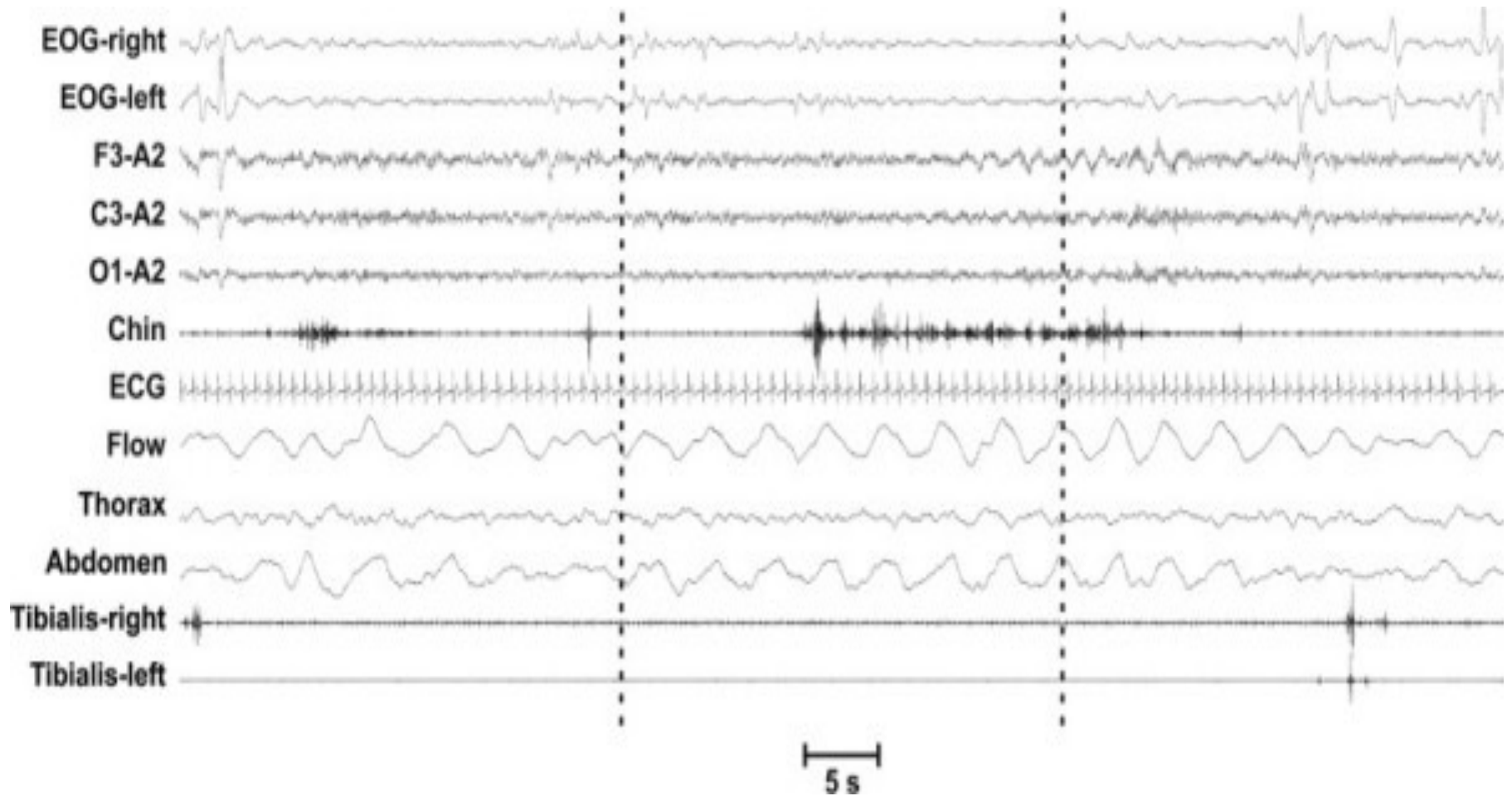
RWA



RWA



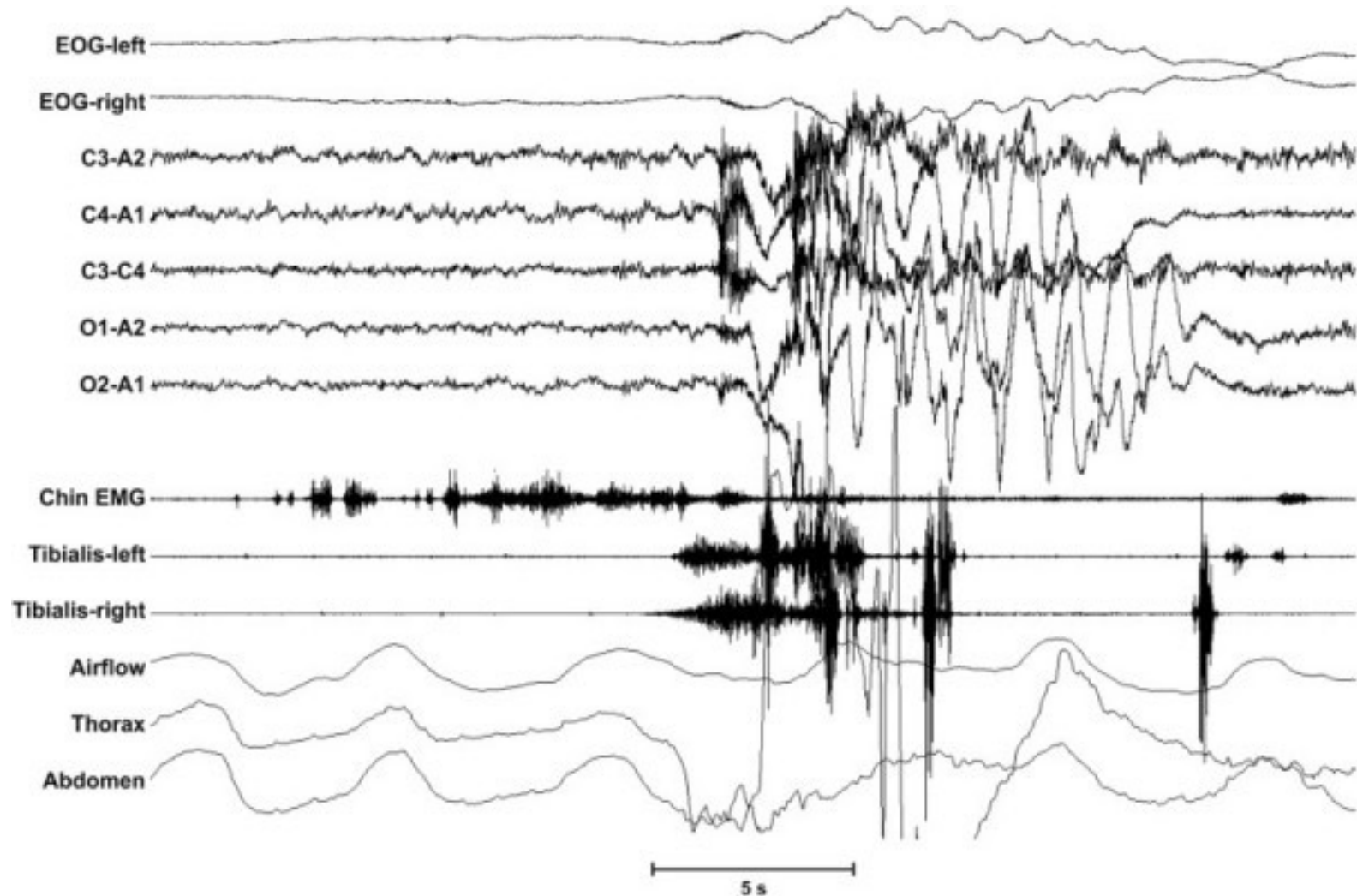
RWA



Rhythmic Movement Disorder

- Min frequency is 0.5 Hz
- Max frequency is 2 Hz
- Min number of movements for cluster = 4 movements
- Min amplitude of individual rhythmic burst is 2 times the background EMG
- Time-synchronized video PSG necessary for diagnosis

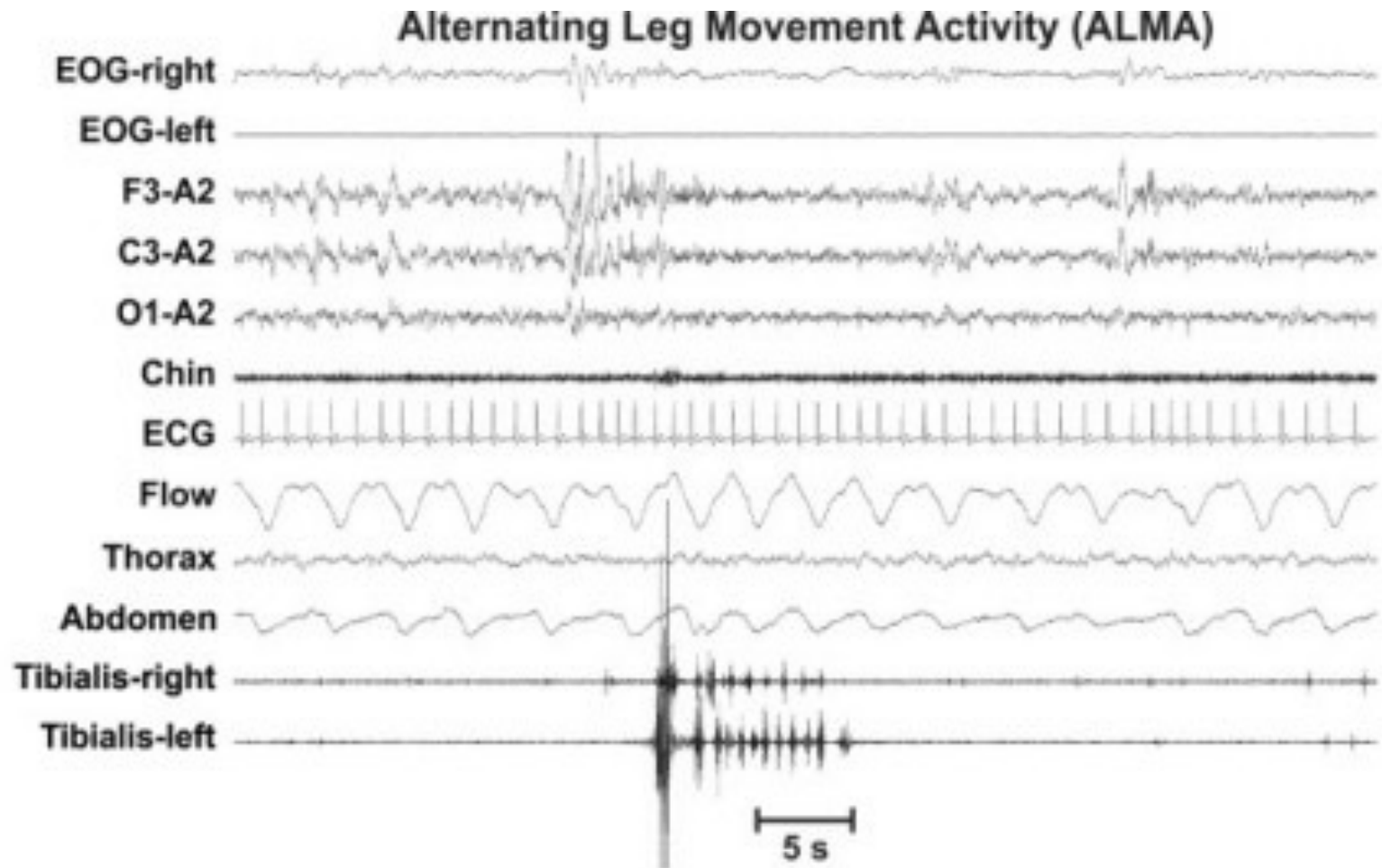
Rhythmic Movement Disorder



ALMA

- Minimum number of discrete and alternating EMG bursts of leg muscle activity for an ALMA series is 4 ALMAs
- Minimum frequency = 0.5 Hz
- Maximum frequency = 3 Hz
- Sequences occur during transition of wake to sleep or are associated with arousal
- Notes:
 - ALMAs alternate between legs
 - Usual range for duration = 100-500 msec
 - No reported clinical consequences

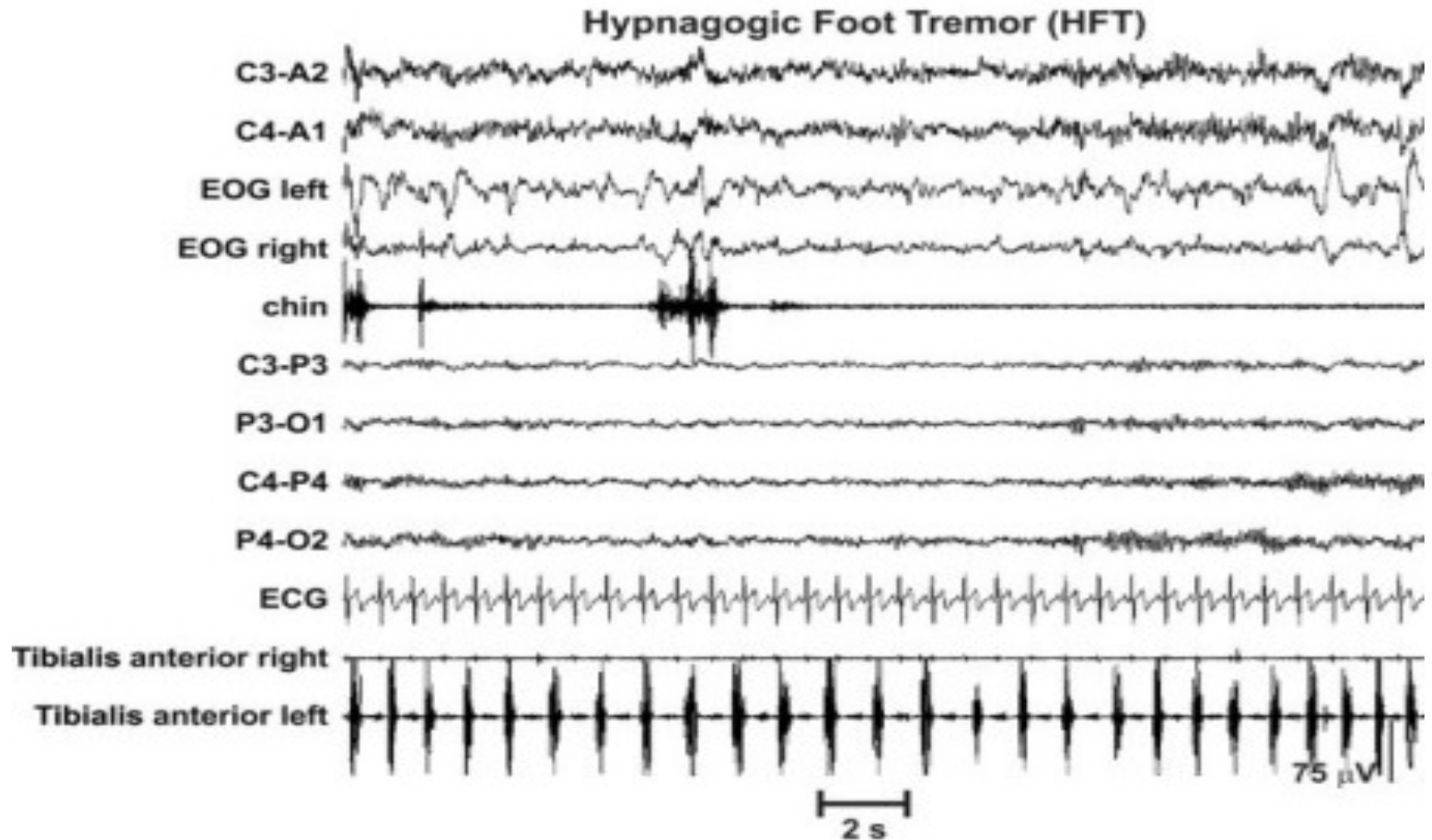
ALMA



Hypnagogic Foot Tremor

- Minimum number of EMG bursts needed for series = 4 HFT bursts
- Minimum frequency of EMG bursts = 0.3 Hz
- Maximum frequency of EMG bursts = 4 Hz
- Usual duration = 250-1,000 msec
- No reported clinical consequences

Hypnagogic Foot Tremor

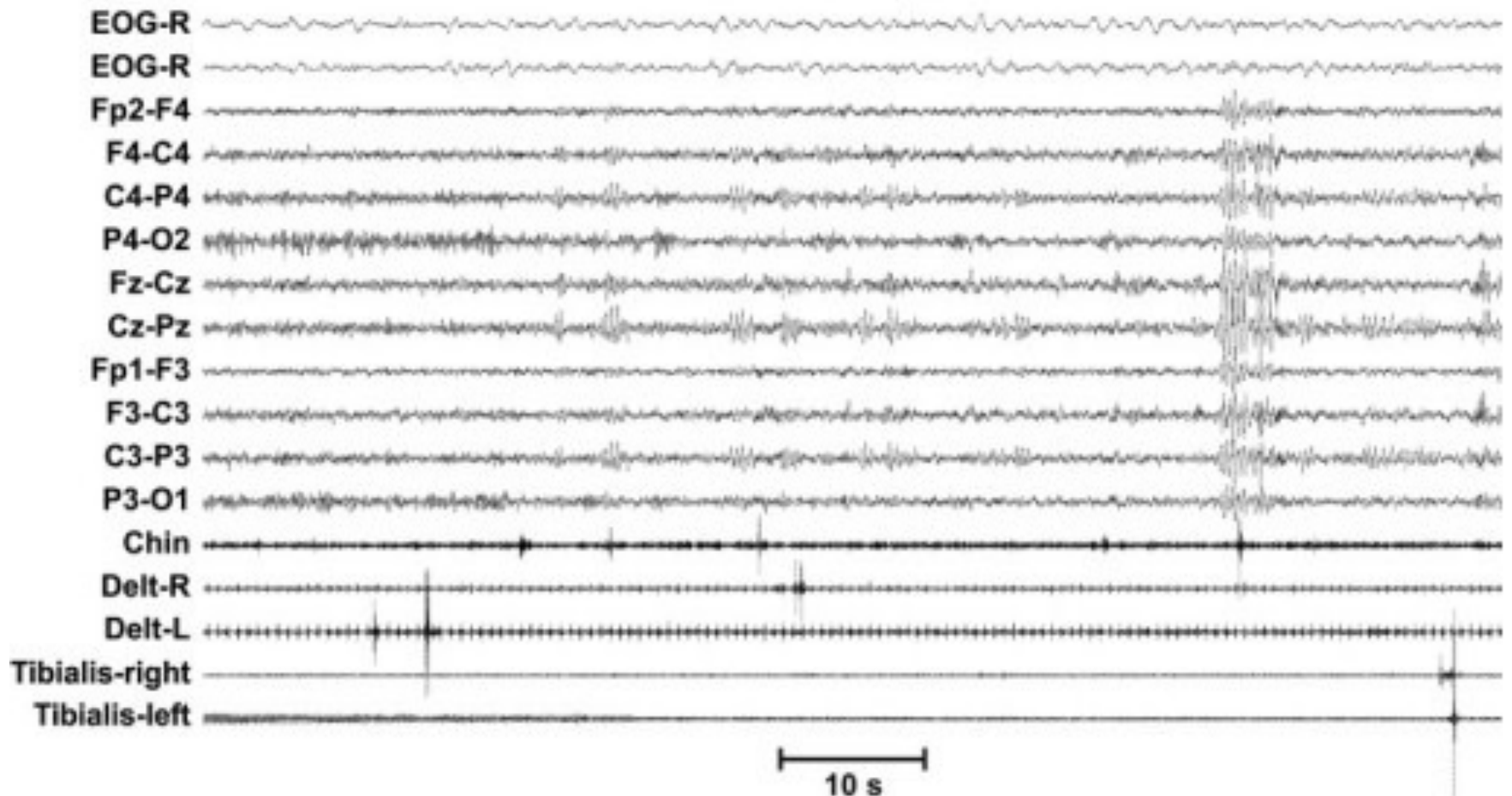


Excessive Fragmentary Myoclonus

- Usual max EMG burst duration = 150 msec
- At least 20 min of NREM sleep with EFM must be recorded
- At least 5 EMG potentials/minute must be recorded
- In most cases no visible movements are present
 - May just look like twitching of fingers, toes, and corner of mouth intermittently seen in REM
 - When visible movements present, EMG burst duration may be >150 msec

Excessive Fragmentary Myoclonus

Wakefulness/sleep transition



Excessive Fragmentary Myoclonus

