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EXECUTIVE SUMMARY

The American Academy of Sleep Medicine (AASM) manual for the scoring of sleep and associated events provides guidelines for polysomnography recording and interpretation which have been valuable in standardising practice particularly in North America. Since this was published in 2007 a number of studies have addressed the impact of the new rules on scoring and subsequent diagnosis. This commentary draws on these studies and some factors unique to Australasian sleep laboratories in providing recommendations for the application of the AASM rules in Australasian sleep centres. Underlying this commentary is an acceptance that the application must, wherever possible, remain consistent with the AASM rules to enable direct comparison with research from North America. Where no comment or clarification is made on a particular issue, the AASM rules should apply. This commentary applies specifically to adult laboratories, a separate paediatric document is to be provided.

Recording and Technical Specifications

• The use of the AASM minimal recording frequencies for physiological signals is adequate for clinical purposes.
• Use of alternate sensors is not recommended without evidence to confirm that measurements are not different to AASM recommended sensors. Examples include piezo sensors for limb movement or snoring.
• Sound pressure meters capable of measuring in decibels are preferred to microphones.
• Methods of measurement of events during positive airway pressure studies are included.

Recording and Scoring of Sleep and Arousal

• Central, occipital and frontal EEG derivations are recommended. A backup central derivation should be used but laboratories may examine their own practice to determine if backup occipital or frontal leads are required.
• AASM rules for scoring sleep should be adopted. The changes will have a modest effect, likely increasing N1 at the expense of N2. There may be a small decrease in R.
• Clarifications are provided for the definition of respiratory, limb movement and spontaneous arousals and the temporal association between events.
• Only arousals occurring in sleep epochs should be counted in deriving an arousal index.

Recording and Scoring of Respiratory Events

• Clarifications to the event duration rules for respiratory events are provided.
• The use of a thermal sensor for apnoea detection and nasal pressure sensor for hypopnoea detection is recommended.
• The AASM alternative hypopnoea definition should be adopted. The AASM recommended definition is overly conservative and may fail to recognise important physiological events.
• The scoring and reporting of Respiratory Effort Related Arousals (RERAs) is considered desirable as they may assume increasing importance given that the AASM hypopnoea definition may fail to count events of lesser severity.
• AHI (apnoea-hypopnoea index) should be reported as the sum of apnoea and hypopnoea and RDI (respiratory disturbance index) as the sum of apnoea, hypopnoea and RERAs.
• Only respiratory events occurring in sleep epochs should be counted in deriving AHI or RDI.
• Respiratory events during positive airway pressure studies should be measured and scored using the pressure signal from the CPAP mask. Signals derived from the PAP machine such as airflow and leak should be validated against standard measures before accepting them as a suitable substitute.

Additional considerations

• A revision of normative data and severity criteria for all polysomnographic indices is urgently required as a result of the adoption of the AASM rules. This should recognise the uncertainty of measurement associated with inter-scorer concordance and provide a lower or upper limit of normal.
• Use of fully automated scoring cannot be recommended at this time because the trained scorer is able to assimilate many subtle issues into a report.
INTRODUCTION AND SCOPE

In 2004 the American Academy of Sleep Medicine (AASM) began an exercise to revise the rules for scoring of polysomnography. Three years later and after a comprehensive review of the literature to 2004, the new AASM guidelines were published. The task was undertaken by a series of expert groups with reviews published in a single issue of the Journal of Clinical Sleep Medicine in 2007.

In her review of the guidelines Grigg-Damberger commented on the principles underlying the discussions in task force groups. The principles seem inherently sensible and form the basis of the current review:

“I perceived driving themes were in the principles of simplicity, ease of implementation, likelihood of improving interscorer reliability, and avoidance of radical changes unless there was sufficient evidence to proceed otherwise, whereas at the same time emphasizing that the rules contained in the Manual were subject to revision and evolutionary improvements with debate, the passage of time, and accumulation of further evidence.”

The intent of this review is to place the AASM guidelines in the Australasian context and to recommend a framework by which Australasian laboratories can draw on the considerable work done by the AASM to achieve greater consistency across laboratories. In the process information from some later studies has been used to examine the impact of the AASM rules and used, where possible, to either support or refute suppositions that were made as part of the AASM rules.

It is self-evident that the Australasian Sleep Association (ASA) and the Australasian Sleep Technologists Association (ASTA) do not have the resources nor should they attempt to perform a separate analysis from that undertaken by AASM. Such an analysis would be unlikely to achieve the scientific rigour or comprehensive coverage of the AASM document. This analysis also recognises the importance of maintaining compatibility with the AASM guidelines such that there can be confidence that studies performed in Australasian laboratories are able to be published in the International literature. It is therefore accepted that the outcome of any review will be the adoption of the majority of the AASM recommendations except where it is considered that gains could be made by minor modifications, corrections or clarifications. The gains may be in terms of simplification, more efficient use of resources or improved standardisation. The current recommendations are primarily aimed at the clinical sleep laboratory rather than the research sleep laboratory. Where research is the primary purpose of the polysomnography, researchers would be wise to consider the acceptance of their research in journals originating in North America and complete compliance with the AASM guidelines may be desirable.

The scoring criteria that have caused the most contention since the publication of the rules are clearly the rules related to scoring of respiratory events. The AASM rules for scoring respiratory events incorporate major changes to respiratory scoring rules. However, rather than resolving discrepancies that existed between research studies which predominantly used the “Chicago” criteria and the rules of the Medicare and Medicaid Services, they have created two rule sets with substantially different outcomes which are likely to result in continuing confusion. The clarification of this situation for Australian and New Zealand laboratories is one of the main reasons for the preparation of this consensus document.

In the discussion which follows brief summaries of the changes associated with the AASM rules are given but the reader is referred to the AASM Manual for a comprehensive description. In addition, where this document is silent the AASM guidelines should be assumed to apply.

A supplementary document addresses the application of the AASM guidelines in paediatric sleep studies.
SOURCES OF INFORMATION

This document draws upon previous reviews of the AASM guidelines\textsuperscript{10,14,15,16} in addition to a number of studies published since 2007.

RECORDING SPECIFICATIONS

The AASM manual is the first comprehensive attempt to define criteria for digital polysomnography including minimal and desirable sampling rates, low- and high-frequency filter settings, resolution requirements for computer screens and video card resolution. The guidelines also provide guidance on the measurement of electrode impedance and data file storage which are likely to have little impact on the scoring of sleep or sleep related events.\textsuperscript{6,17}

Summary of recording parameters

The AASM recommended sampling rates are shown below.

<table>
<thead>
<tr>
<th>Sampling Rates</th>
<th>Desirable</th>
<th>Minimal</th>
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<tbody>
<tr>
<td>EEG</td>
<td>500Hz</td>
<td>200Hz</td>
</tr>
<tr>
<td>EOG</td>
<td>500Hz</td>
<td>200Hz</td>
</tr>
<tr>
<td>EMG</td>
<td>500Hz</td>
<td>200Hz</td>
</tr>
<tr>
<td>ECG</td>
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<td>200Hz</td>
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<tr>
<td>Airflow</td>
<td>100Hz</td>
<td>25Hz</td>
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<tr>
<td>Oximetry</td>
<td>25Hz</td>
<td>10Hz</td>
</tr>
<tr>
<td>Nasal Pressure</td>
<td>100Hz</td>
<td>25Hz</td>
</tr>
<tr>
<td>PAP Pressure*</td>
<td>100Hz</td>
<td>25Hz</td>
</tr>
<tr>
<td>Oesophageal Pressure</td>
<td>100Hz</td>
<td>25Hz</td>
</tr>
<tr>
<td>Piezo Movement Sensors*</td>
<td>100Hz</td>
<td>25Hz</td>
</tr>
<tr>
<td>Body Position</td>
<td>1Hz</td>
<td>1Hz</td>
</tr>
<tr>
<td>Snoring Sounds (microphone)</td>
<td>500Hz</td>
<td>200Hz</td>
</tr>
<tr>
<td>Snoring Sounds (Piezo sensor)*</td>
<td>100Hz</td>
<td>25Hz</td>
</tr>
<tr>
<td>Snoring Sounds (Decibel meter)*</td>
<td>25Hz</td>
<td>10Hz</td>
</tr>
<tr>
<td>Rib Cage and Abdominal Movements</td>
<td>100Hz</td>
<td>25Hz</td>
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<th>Low Frequency Filter</th>
<th>High Frequency Filter</th>
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<tr>
<td>EEG</td>
<td>0.3Hz</td>
<td>35Hz</td>
</tr>
<tr>
<td>EOG</td>
<td>0.3Hz</td>
<td>35Hz</td>
</tr>
<tr>
<td>EMG</td>
<td>10Hz</td>
<td>100Hz</td>
</tr>
<tr>
<td>ECG</td>
<td>0.3Hz</td>
<td>70Hz</td>
</tr>
<tr>
<td>Respiration</td>
<td>0.1Hz</td>
<td>15Hz</td>
</tr>
<tr>
<td>PAP Pressure*</td>
<td>0.1Hz</td>
<td>15Hz</td>
</tr>
<tr>
<td>Snoring (microphone)</td>
<td>10Hz</td>
<td>100Hz</td>
</tr>
<tr>
<td>Snoring Sounds (Piezo sensor)*</td>
<td>0.1Hz</td>
<td>15Hz</td>
</tr>
<tr>
<td>Snoring Sounds (Decibel meter)*</td>
<td>DC coupled</td>
<td>DC coupled</td>
</tr>
<tr>
<td>Piezo Movement Sensors*</td>
<td>0.3Hz</td>
<td>35Hz</td>
</tr>
</tbody>
</table>

*Sensors not included in the AASM recommendations

While there can be little argument that the recommended sampling frequencies are adequate for the purpose, there is no evidence that the use of lower sampling frequencies, the minimum frequencies in Table 1 for example, would result in a difference which is clinically meaningful. In fact, at these frequencies and using traditional screen displays of 30 seconds, the ability to discriminate signals will be limited by the screen resolution rather than the sampling frequency. The maximum frequency that can be displayed on a 30sec screen at the recommended 1600x1200 resolution is approximately 50Hz. There are a number of advantages to minimising the sampling frequency. These include smaller file size, more convenient data storage, improved data retrieval rates and faster data review speeds.
In the absence of a convincing argument to support the higher sampling rates, the use of the AASM minimal settings is recommended.

Additional methods and alternative sensors not included in AASM guidelines

Microphones for snoring sound

The AASM guidelines recommend a sampling frequency of 500Hz to record snoring sound. This implies that they recommend the use of a microphone to record snoring sounds but they do not give specific guidance on their use. A microphone may be placed adjacent to the patient or attached to the patient. When placed adjacent to the patient, it is most important that the distance between the patient and the microphone be fixed to ensure consistent and comparable snoring noises. The microphone should be positioned such that reflected noise is minimised. Microphones provide qualitative signals which are not directly related to sound volume and hence are less desirable than sound pressure meters (see below) for the recording of snoring. Placement of the microphone on the patient in the region of the larynx or trachea, although used in some laboratories, may record breathing sounds other than snoring, which is undesirable.

Piezo sensors for snoring sound

An alternative sensor for the detection of snoring is the piezo snore sensor which responds to vibratory movements detected near the upper airway. Piezo snore sensors are attached to the patient in a location adjacent to the upper airway which vibrates when a snoring sound occurs. They respond rapidly to movement associated with snoring with frequencies in the range of 5Hz to 50Hz. Because they rely on vibration rather than sound, they do not suffer from the same issues as a microphone relating to distance or placement. Piezo sensors provide qualitative signals which are not directly related to sound volume and hence are less desirable than sound pressure meters for the recording of snoring.

Ambient sound pressure level - decibel meters – for snoring sound

Decibel (sound level) meters are in common use in Australasian sleep laboratories. Sound level meters measure the ambient sound pressure level within the bedroom and provide a quantitative validated measure of the sound which can be compared with environmental noises. The use of these devices to monitor snoring sounds offers some advantages over the microphones assumed within the AASM guidelines. In particular, sound level meters can be calibrated, provide a signal which is quantitative and is largely independent of the position of the sensor relative to the patient. The device does not need to be attached to the patient. The output of the device is an analogue signal which may be recorded on a conventional PSG system. Conversely a microphone is nonlinear, not easily calibrated, requires signal processing and may suffer from ceiling effects which fail to adequately discriminate high levels of sound.

Recommendation – Recording Snoring Sound

AASM make no recommendation of the sensor to be used for detection of snoring. The quantitative output of an ambient sound level meter is preferred to a microphone for the recording of sound and is recommended.

Appropriate recording parameters for a sound level meter are:
- Placed approximately 1.2m from patient head
- Minimum sampled decibel level <40dB (preferred 30dB)
- Maximum sampled decibel level >90db (preferred 100dB)
• A-weighted sound filter setting (dBA)
• Time constant <150 ms
• Digital acquisition sampling rate minimum 10Hz with no filter
• Calibrated with a 94dB sound source

Recommendation - Positive airway pressure (PAP) measurements

Measurement of respiration during PAP titration is essential to determine treatment efficacy. This measurement is not included in the AASM guidelines but is covered by Kushida et al. in a comprehensive review of clinical guidelines for the titration of PAP.21

The most common method for recording respiration is by measuring pressure changes in the patient’s PAP mask. A calibrated pressure transducer allows measurement of the absolute pressure delivered to the mask with fluctuations which reflect the respiration of the patient. Kushida et al. recommend that this pressure signal be referenced to pressure measured at the PAP pump which they claim gives a differential pressure which better reflects the fluctuations due to respiration. The use of a square-root transformation of the pressure signal is optional and unlikely to add significantly to the sensitivity, specificity or reliability of event scoring.

Kushida et al. discuss the additional use of a conventional nasal pressure transducer for the detection of events during PAP studies. They acknowledge the difficulty of obtaining a good PAP mask seal if a nasal pressure cannula is used but do not discount its use as an alternative to the pressure at the mask. Notwithstanding, unless a PAP mask is modified to accommodate such a cannula, the problems arising are likely to outweigh any advantage over the measurement of mask pressure.

The use of an oronasal thermal sensor inside the mask is not recommended by AASM. They correctly conclude that the sensor is inadequate to detect hypopnoeic events (see below) and discount its use to improve the sensitivity for detection of apnoea. Where this practice is employed it is important that the oronasal thermal sensor is not used as the primary measurement of respiration but may provide useful additional information where the mask pressure signal is equivocal. There is no evidence to support the use of a nasal pressure sensor or oronasal thermal sensor in addition to mask pressure to better quantify respiratory flow disturbance during PAP studies.

A number of PAP machines provide signals which reflect PAP pressure, PAP flow and PAP mask leak. These signals often appear to be of superior quality to the pressure signal derived from the mask as they can adjust for machine generated variation such as reduced pressures on expiration. These signals have not been appropriately validated and should only be used in conjunction with another primary measurement of respiration during PAP treatment. A laboratory intending to use these as the primary source should validate the particular device against a primary measure such as mask pressure.

Digital specifications for recording all PAP signals should be identical to those for respiratory signals, ie sampling frequency 25Hz, low frequency filter 0.1Hz, high frequency filter 15Hz.

Piezo Movement Sensors

The AASM do not recognise the use of piezo sensors placed on the leg to detect limb movement. These sensors produce a voltage when deformed by muscle movement and are commonly used in Australia and New Zealand as an alternative to EMG.

Digital specifications for recording limb movements from piezo strain gauge are sampling frequency 100Hz, low frequency filter 0.1Hz, high frequency filter 15Hz.
Evidence supporting their use and calibrating them against anterior tibialis EMG is required. Until that time, their use is not recommended due to lack of evidence showing equivalence to the recommended anterior tibialis EMG sensors.

Plethysmographic signal from oximetry

The recording of the plethysmographic waveform derived from the pulse oximeter should be considered because it provides an independent measure of oximeter signal quality and may be useful in deciding whether falls in oxygen saturation are real or an artefact due to poor oximetry signals. The waveform need not be displayed in the PSG presented to clinicians but should be available for scorers, if required.

TECHNICAL SPECIFICATIONS

The AASM manual makes a number of recommendations related to digital PSG recording, digital analysis and PSG display and data manipulation. They encompass requirements for the manufacturers of equipment and inform the choices laboratories make when a digital PSG system is being selected. The specifications could be considered to be over-sophisticated for a routine clinical laboratory but with modern computer systems should pose no difficulty for manufacturers.

The specifications do not fully address the presentation of the digital waveforms to the scorer which can impact on scoring and scoring reliability. Whilst the guidelines recommend a minimum screen resolution of 1600x1200 pixels they do not recommend a minimum screen size. It is suggested that the effective screen size for scoring should be at least 30cm horizontally and vertically to allow 16 channels to be displayed with a minimum size of approximately 2cm. Larger screen sizes and increased resolution may be desirable for paediatric studies. Importantly, scorers must be consistent in their use of horizontal and vertical window size to ensure that amplitude dependent decisions such as EEG amplitude are consistently applied.

EEG MEASUREMENT

New EEG montages including frontal derivations, combined with the existing central and occipital derivations, are recommended by AASM. The recommended derivations are:

- F4-M1, F3-M2
- C4-M1, C3-M2
- O2-M1, O1-M2

Where M1 and M2 is the recommended nomenclature for left and right mastoid processes (previously called A1 and A2).

The AASM recommended lead placements are justified as follows:

- Central leads – generalised EEG activity including sleep spindles
- Occipital leads – alpha activity and sleep onset
- Frontal leads – for the detection of K-complexes and slow-wave activity

The AASM also allow the alternative placement of Fz-Cz, Cz-Oz and C4-M1 but offer no explanation of why it may be necessary to use this montage. There seems no reason to adopt these in preference to the commonly used recommended derivations.

Occipital Lead Placement

Occipital leads are recommended by AASM. It is generally accepted that alpha activity is more easily detected in the occipital leads. As alpha activity is associated with wake, improved detection of alpha activity is likely to change the distribution between wake and sleep which could have clinical consequences, although a recent study failed to show consistent significant differences. The placement of occipital leads is also likely to lead to
the detection of more arousals and result in the scoring of more N1 sleep (see below) but overall is likely to have a small impact on diagnosis and clinical decision making. Nevertheless for compatibility with AASM, the use of an occipital lead placement (O2-M1) is recommended.

**Frontal Lead Placement**

Frontal leads are recommended by AASM. Some studies have indicated that the use of frontal leads improves the sensitivity of detecting cortical arousals following obstructive respiratory events.\(^{23,24}\) These findings were not supported in a subsequent study of children\(^{25}\) nor in a recent study comparing the AASM recommended montage against an abbreviated montage which excluded occipital and frontal leads.\(^{22}\) Clearly the information from these studies is inconsistent which may reflect the uncertainty of measurement associated with the relatively poor inter-scorer concordance in scoring arousals. The AASM scoring rules for arousals (see below) do not require information from frontal leads to be incorporated, however, in subsequent discussion the AASM added that if an event such as an arousal or sleep spindle were detected only in the frontal lead then these features should be used to score sleep.\(^{26}\) The use of frontal leads for improved detection of K complexes and slow-wave activity may aid in differentiation of stages of sleep but is unlikely to have a major impact on clinical decision making.\(^{22}\) Nevertheless for compatibility with AASM, the use of a frontal lead placement (F4-M1) is recommended.

**Backup Leads**

The AASM manual recommends placement of backup leads at C3, F3, O1 and M2 to provide signals in the case of failure of the primary leads. Given that the vast majority of full polysomnography is conducted in an attended setting, the loss of a signal should be relatively easily discovered and appropriate remedial action taken. Each laboratory should examine its own practice but in general it is expected that periods of unscoreable signals from the primary derivations would be rare except where the common M2 lead has been displaced. To overcome this it is recommended that a single backup using the C3-M2 derivation be employed routinely. Where it is anticipated that signal loss may be significant, for example in young children, the use of all backup leads should be considered.

Recommended EEG derivations are:
- C4-M1 with C3-M2 as a backup
- O2-M1
- F4-M1

**EOG MEASUREMENT**

The AASM document includes a recommended EOG montage which is very similar to that of Rechtschaffen and Kales\(^{27}\). The recommended placement is:
- E1-M2 with the E1 electrode placed one centimetre below the left outer canthus
- E2-M2 with the E2 electrode placed one centimetre above the right outer canthus.

An alternative derivation requiring a frontal lead is also considered acceptable but is unlikely to offer any clinically significant advantage and should not be used.

**CHIN EMG MEASUREMENT**

The AASM document includes a recommended chin EMG montage which is very similar to that of Rechtschaffen and Kales. They recommended electrode placement in the midline 1cm above the inferior edge of the mandible referenced to another electrode either:
- 2cm below the inferior edge of the mandible and 2 cm to the right of the midline; or
- 2cm below the inferior edge of the mandible and 2 cm to the left of the midline.

In young children and in other situations where precise placement according to AASM rules may not be possible, some variation of placement is possible without adversely affecting
measurements which are, in general, relative to signals recorded during other stages of sleep. The use of two chin EMG signals does not assist in the scoring of sleep but does provide a backup signal in the event of failure. Each laboratory should examine their own practice to decide whether the use of the backup signal is warranted.

**ECG MEASUREMENT**

A single modified lead II placement is recommended for ECG with one electrode below the right clavicle and the other on the 6th or 7th left intercostal space on the midline of the patient’s left side. If clinically relevant other ECG derivations may be added.

**VISUAL SCORING OF SLEEP**

The AASM rules for sleep scoring are the first significant change to the rules first defined by Rechtschaffen and Kales in 1968. The fact that these rules have retained validity over 40 years is testament to the representativeness of the rules and suggests that changes should indeed be modest. The 2007 update suggests the use of additional information from other EEG derivations: alpha activity from an occipital lead and improved detection of K-complexes and delta activity from a frontal lead. In addition, the AASM rules simplify the staging to collapse slow wave sleep into a single stage (N3) and to eliminate the inconsistently scored Movement Time (MT). Clarification of stage transitions, particularly relating to REM sleep, has been provided to assist scoring with the intent of improving inter-scorer reliability.

The AASM manual also includes a number of helpful clarifications to the rules which are often illustrated by examples. These should be considered to form part of the AASM rules and adopted as indicated below.

Where multiple EEG leads are placed, the scorer must prioritise which lead to use to detect EEG features. In general:

- Central leads may be used to detect all necessary features.
- When placed, occipital leads are preferred for the detection of alpha rhythm and arousals.
- When placed, frontal leads are preferred for the detection of delta waves.
- Where features are visible in only one derivation, they should still be used to score sleep.

**Stage W (Wakefulness)**

Scoring Changes
AASM provide clarification of the features of Stage W but no fundamental change. The rules also modify the Rechtschaffen and Kales definition of sleep onset (3 epochs of sleep) to require only a single epoch.

Implications
Nil.

Supporting Evidence
Two studies conducted after the publishing of the AASM manual have compared Rechtschaffen and Kales rules with the AASM rules. There was no significant change in total sleep time or wake time although Moser et al. found a small but significant increase in wake after sleep onset. They attributed this to the change in rule relating to sleep onset and movement time.

Recommendation
The AASM definition of Stage W should be adopted.
Stage N1

Scoring Changes
AASM recommendations are similar to those of Rechtschaffen and Kales but require that N1 be scored when a K-complex associated with arousal occurs or when an arousal or body movement occurs in N2. This has the effect of increasing N1 at the expense of N2. In adults the differences on average may be 3% of total sleep time but may be greater in children or infants. In adults with frequent arousals as a result of a sleep disorder, the changes may be much larger.

Implications
Stages N1 and N2 are seldom differentiated in calculation of sleep time, sleep efficiency, or computation of indices of disease severity. Some definitions of sleep latency distinguish between N1 and N2 but the effects are likely to be minor. The AASM definition of sleep latency is time to the first epoch of any sleep stage which would be unaffected.

Supporting Evidence
Two studies conducted after the publishing of the AASM manual have assessed the changes in N1, N2 and N3 by comparing scoring using Rechtschaffen and Kales rules with the AASM rules. The studies found that N2 was reduced at the expense of N1 and N3 but that there was no significant change in total sleep time or in scoring reliability.

Recommendation
AASM changes to the definition of N1 will increase the amount of N1 relative to N2 but are unlikely to have a significant clinical impact and for consistency should be adopted. Previously derived normative values for sleep stage distribution and sleep fragmentation need to be recalculated using the new rules.

Stage N2

Scoring Changes
AASM recommendations are similar to those of Rechtschaffen and Kales but clarify rules around the occurrence of K-complexes and arousals (see N1). The definition of N3 also clarifies that sleep spindles may occur in N3. This has the effect of decreasing N2 at the expense of N3. The AASM also recommend that sleep stage revert to N1 following an arousal with the likely result that N2 will become more fragmented. The previous rule requiring sleep stage to revert from N2 if more than 3 minutes elapses without a K complex or sleep spindle has also been abolished. The overall impact is that N2 will be reduced by up to 5% on average with a consequent increase in N1 and N3. In adults with frequent arousals as a result of a sleep disorder, the changes may be much larger.

Implications
In consolidated sleep N2 is seldom differentiated from N1 or N3 in computation of indices of disease severity. The decrease in N2 is therefore unlikely to have any major clinical impact although it must be recognised that differences are not likely to be uniform across all subjects. If the new rules are to be adopted, the systematic decrease in the amount of N2 requires that previously derived normative values for sleep stage distribution be recalculated using the new rules. The adoption of the new rule will also lead to more sleep stage changes in subjects where arousals are frequent.

Supporting Evidence
Two studies conducted after the publishing of the AASM manual have assessed the changes in N1, N2 and N3 by comparing scoring using Rechtschaffen and Kales rules with the AASM rules. The studies found that N2 was reduced at the expense of N1 and N3 but that there was no significant change in total sleep time or in scoring reliability.
**Recommendation**

AASM changes to the definition of N2 will impact on the relative proportions of N1, N2 and N3 but are unlikely to have a significant clinical impact and for consistency should be adopted. Previously derived normative values for sleep stage distribution and sleep fragmentation need to be recalculated using the new rules.

**Stage N3**

**Scoring Changes**

AASM recommendations are similar to those of Rechtschaffen and Kales but clarify rules around the occurrence of K-complexes and arousals (see above). The definition of N3 also clarifies that sleep spindles may occur in N3. This has the effect of decreasing N2 at the expense of N3. AASM recommend that the Rechtschaffen and Kales stage 4 be combined with stage 3 into the new N3.

**Implications**

In consolidated sleep N3 is seldom differentiated from N1 or N2 in computation of indices of disease severity and hence increase of N3 at the expense of N2 is unlikely to have significant clinical implications. The Rechtschaffen and Kales distinction between stage 3 and stage 4 was based on the percentage of delta activity in an epoch. There is a substantial body of evidence supporting the fact that breathing is more stable and arousability less in Rechtschaffen and Kales stages 3 and 4, and studies have tended to aggregate these sleep stages. The arbitrary cut off of 20% delta activity to define stage 3 and 50% to define stage 4 has no known physiological correlates. The collapsing of these stages into the new N3 is unlikely to hide significant differences.

**Supporting Evidence**

Two studies conducted after the publishing of the AASM manual have assessed the changes in N1, N2 and N3 by comparing scoring using Rechtschaffen and Kales rules with the AASM rules. The studies found that N3 was increased at the expense of N2 but that there was no significant change in total sleep time or in scoring reliability.

**Recommendation**

AASM changes to the definition of N3 and the consolidation of stages 3 and 4 are appropriate. The changes are unlikely to have a significant impact and should be adopted.

**Stage R**

**Scoring Changes**

AASM recommendations are similar to those of Rechtschaffen and Kales but clarify rules around the transition from N2 to R and from R to N2. The combined effect of these changes is likely to be modest but could be variable from person to person. Moser et al. observed that differences in the amount of Rechtschaffen and Kales scored REM and AASM scored R were not significant but were dependent on age, with reductions only in younger subjects. In children and adolescents reductions of around 8% in the amount of R were observed. The reader is referred to the AASM guidelines for a comprehensive discussion of the changes in rules related to scoring stage R.

**Implications**

Significant shifts from N2 to R may result in a redistribution of events between N2 and R and hence may impact on the partitioned arousal or respiratory indices.

**Supporting Evidence**

The AASM recognised that the rules relating to onset and offset of REM sleep were poorly defined in the Rechtschaffen and Kales manual “…the group concentrated
predominantly on refining and simplifying REM sleep scoring rules, especially with regard to the start and end of periods of REM sleep, an area of considerable complexity in the Rechtschaffen and Kales manual."

It might have been expected that as a result of AASM changes the transition to stage R from Stage N2 could occur earlier with a resultant reduction in latency to stage R but this has not been born out in the studies to date. Instead the changes recommended by AASM have resulted in small reductions to the amount of stage R which occur predominantly in younger subjects. This is likely the result of more rigorous offset rules, including the arousal rule defining the end of the sleep stage.

Recommendation
AASM changes to the scoring of R may result in small reductions in stage R, particularly in younger subjects, but for consistency should be adopted.

Major Body Movements

Scoring Changes
AASM do not recommend scoring of Movement Time as a discrete sleep stage. Rules are provided to reassign Movement Time to Wake or a subsequent sleep stage.

Implications
This change eliminates Movement Time and is likely to increase Wake with a small increase in other sleep stages. Changes to Wake and Sleep distribution are likely to be minor.

Supporting Evidence
Two studies conducted after the publishing of the AASM manual have compared Rechtschaffen and Kales rules with the AASM rules. There was no clinically significant change in total sleep time or wake time as a result of the adoption of the new rule.

Recommendation
The AASM definition of Major Body Movement and the assignment of these epochs to Wake or Sleep is unlikely to have a significant impact and for consistency should be adopted.

Continuous Scoring of Sleep and Cyclic Alternating Pattern

The background document on visual scoring of sleep briefly discussed limitations associated with scoring sleep in discontinuous epochs but made no recommendation in the new guidelines. Since the development of the Rechtschaffen and Kales manual, a number of authors have suggested modifications to sleep staging which may more accurately reflect the continuous nature of the sleep wake cycle. The use of defined time periods of 20 or 30 second epochs is arbitrary but although newer computational methods may make techniques such as visual adaptive scoring (VAS) possible there is no evidence that physiological correlates are better than using Rechtschaffen and Kales. Treating sleep as a continuum allows the identification of other cycles within sleep which may have physiologic significance. One of these is the cyclic alternating pattern (CAP), which has been reported to be a normal variant of NREM sleep but has also been associated with some pathologic conditions such as fibromyalgia, depression, parasomnias and fatigue and sleepiness associated with upper airway resistance syndrome. Rules have been proposed to score CAP but the clinical significance of CAP remains controversial and without convenient ways to automate the measurement, routine reporting of CAP is not warranted.
Inter-Scorer Reliability In Sleep Scoring

Disagreement between scorers adds to the uncertainty of measurement which is a critical component of sensitivity and specificity of a test such as PSG. This disagreement may be because of lack of skill or experience but equally it can be because of imprecise scoring rules or imprecisely applied scoring rules. The new AASM guidelines have attempted to address both of these issues by creating more precise rules and requiring that sleep disorders centres adopt the new rules. The current situation in Australia and New Zealand is untenable with different levels of adoption of the guidelines.

The AASM taskforce cited evidence from seven studies evaluating inter-scorer reliability, including two of evidence level 1 and one of level 2. The level of agreement varied from 68% to 82% with poorest agreement unsurprisingly in N1 and between the old Rechtschaffen and Kales stages 3 and 4. The AASM have specifically addressed these issues by providing significant clarification around N1 and eliminating the major source of disagreement between stage 3 and stage 4 by combining them into N3.

A study of inter-scorer reliability by Danker-Hopfe et al. using the new AASM rules found small increases in reliability of all stages except N2. They attributed this to the greater fragmentation of N2 resulting from arousals. A study by Ruehland et al. looking at the use of three EEG derivations versus one reported similar results but changes in reliability were not statistically significant. The changes to inter-rater reliability were small, a little over 1%, and are unlikely to provide significant reductions in inter-scorer differences.

Whilst these studies do not support the contention that the new AASM rules will result in improved reliability, it must be remembered that both studies were performed in carefully controlled environments using well defined rule sets and that real-life performance may be quite different. Data from Australasian sleep centres supports the view that clarification of rules can assist in improving at least some aspects of scoring reliability. A study by Rochford et al. in fifteen laboratories found overall values of agreement for all sleep stages of 82%. With the implementation of a training program which included clarification of rules the overall level of agreement increased to 85%. Adoption of a well defined rule set with ongoing inter-laboratory scoring concordance to ensure that interpretation remains consistent across laboratories is likely to result in improved inter-scorer reliability.

AROUSAL SCORING

The AASM rules for arousal scoring represent a small change to the ASDA rules of 1992. The addition of frontal leads and occipital leads in the recommended polysomnographic montage is designed to improve the detection of arousals.

Technical Considerations
The AASM require the use of frontal and occipital EEG leads in addition to central leads which may both increase the number of arousals detected. (See discussion of EEG above).

Scoring Changes
In the 2007 manual AASM indicate that “Arousal scoring should incorporate information from both the occipital and central derivations” interestingly, by implication, not frontal derivations. In a subsequent document they clarify this by stating “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.” It is concluded therefore that information from any of the three EEG derivations may be used to score an arousal.
In REM sleep arousals may only be scored if accompanied by an increase for 1 second or more in chin EMG activity.

There are no other changes to the currently accepted ASDA arousal scoring rules.

The classification of arousal events as respiratory related, limb movement related or spontaneous is important in the diagnosis of respiratory or movement disorders during sleep. The AASM rules provide guidance on the classification of an arousal associated with a limb movement but not the temporal association with a respiratory event.

It is clear from a number of studies that an arousal associated with a limb movement may occur either before or after the event\textsuperscript{49,50} and the AASM rules provide a 0.5 second window in which the events are considered associated. In relation to association with respiratory events, the Sleep Heart Health Study provided a detailed scoring manual\textsuperscript{51} which suggested that an arousal occurring less than 5 seconds after the termination of a respiratory event should be classified as respiratory related. Whilst this may be appropriate for obstructive respiratory events, it is likely that for central respiratory events or Cheyne-Stokes respiration, the arousal may occur during the hyperventilatory phase of breathing.

The following criteria should be applied to classify arousal types:

- **Respiratory arousal**: Scored when the arousal occurs less than 5 seconds after the termination of the respiratory event.
- **Limb movement arousal**: Scored when there is overlap of the events or when there is $<0.5s$ between the end of one event and the onset of the other event irrespective of which event (arousal or limb movement) occurs first.
- **Spontaneous arousal**: Not meeting one of the above association rules.

Respiratory arousals associated with hyperventilatory patterns of breathing are likely to occur in association with breaths of increased amplitude. If an arousal meets both respiratory and limb movement association rules, a respiratory arousal should be scored.

**Implications**

Adoption of frontal and occipital leads may increase the number of arousals scored\textsuperscript{23,24} This will have implications for scoring of sleep and respiratory events due to rules which incorporate the presence of arousals. The precedence given to respiratory events over limb movement events is assigning arousals may underestimate the importance of limb movements in some patients with a movement disorder. It is important that the scorer distinguishes a primary respiratory event from a respiratory disturbance that is secondary to movement or arousal.

**Supporting Evidence**

Despite an acceptance from the earliest days that occipital and/or frontal leads should increase the sensitivity of detection of arousals, there is no convincing evidence that the addition of these leads makes a clinically important difference. There are studies in which a difference is found\textsuperscript{23,24} and studies which refute this.\textsuperscript{22,25} The inconsistent information from these studies may reflect the uncertainty of measurement associated with the relatively poor inter-scorer concordance in scoring arousals or may be a consequence of the relatively small study sizes. However, the failure to consistently find a measurable difference suggests that any difference is likely to be small and of questionable clinical significance.

**Recommendation**

The use of frontal and occipital leads in addition to central leads requires that arousal events which are apparent in any one of the channels be scored. This is likely to have a small impact on the magnitude of the arousal index and normative values should be re-evaluated. The minor changes to arousal scoring rules should be adopted for consistency. Where arousal events are categorised into respiratory, limb movement or spontaneous the associations defined above should be used.
CARDIAC RULES

The AASM cardiac rules attempt to provide consistency in the measurement and reporting of cardiac events during sleep.

Technical considerations
AASM recommend the use of a single modified Type II lead with electrodes placed on the torso rather than arms or legs. With normal cardiac physiology, the use of the Type II lead provides a signal with well defined QRS complexes and is preferable to other derivations for consistent determination of heart rate and ECG abnormalities. The use of additional leads is optional and based upon clinical need.

Scoring Changes
AASM rules provide increased clarity about the measurement and reporting of cardiac events and findings.

Implications
AASM rules provide guidance in the absence of previous rules relating to cardiac events.

Supporting Evidence
Nil.

Recommendation
The AASM cardiac rules are appropriate and should be adopted to standardise reporting of cardiac events.

PERIODIC LIMB MOVEMENTS DURING SLEEP

The AASM rules for scoring limb movements represent a small change to the ASDA rules of 1993. Clarifications are provided around the timing of events which coexist with other events.

Technical Considerations
The AASM rules require the use of EMG electrodes placed on the anterior tibialis muscle. Piezo sensors to detect muscle movement are commonly used in Australia and have been used in a number of sentinel studies, such as the Sleep Heart Health Study. Evidence supporting their use and calibrating them against anterior tibialis EMG should be sought.

Signals from piezo sensors cannot be compared directly with EMG signals. AASM rules require an 8µV increase in background activity of leg EMG lasting between 0.5s and 10s. If piezo sensors are used, a leg movement is usually defined as a doubling of background activity lasting between 0.5s and 10s.

Scoring Changes
AASM rules reiterate the ASDA guidelines for the scoring of periodic limb movements and provide additional clarification of timing of events in relation to other events. The AASM rules require that co-existing respiratory events take precedence over limb movement events if they occur between 0.5s before or 0.5s after a limb movement event.

Implications
AASM rules provide clarification in dealing with difficult issues such as concurrent respiratory events and limb movements. In situations where both types of events occur this may exaggerate respiratory disturbances at the expense of limb movements and associated arousals. This raises concerns of inappropriate diagnosis in situations where limb movements and associated arousals result in sleep disruption and ventilatory instability. The AASM rules will score these events as a respiratory disturbance but the fundamental abnormality may be a limb movement. Previous studies have found that
both conditions are prevalent in the population presenting to sleep disorders centres for investigation of obstructive sleep apnoea.\textsuperscript{54,55} Oversimplification by ignoring coexisting limb movements may result in patients being under-diagnosed and under-treated for this condition.

Supporting Evidence
Nil.

Recommendation
The AASM rules provide clarification and simplification in situations which are difficult to score but in doing so may over simplify with the result that respiratory disorders may be inappropriately diagnosed. A study of the implication of the adoption of the AASM rules in this difficult situation would be helpful but in the absence of independent evidence of the underlying pathophysiology may not provide convincing evidence which would support their adoption. Nevertheless, the AASM rules are likely to provide greater clarity and should be cautiously adopted. Scorers should make note of these issues where events coexist and should bring this to the attention of the reporting physician. Physicians reporting polysomnography should be aware of the uncertainties that exist in scoring and diagnosis of these difficult studies. Evidence supporting the use of piezo sensors for the detection of limb movements should be obtained as these are commonly used in Australian laboratories.

ALTERNATING LEG MOVEMENT ACTIVATION, HYPNAGOGIC FOOT TREMOR, EXCESSIVE FRAGMENTARY MYOCLONUIS, BRUXISM, REM SLEEP BEHAVIOUR DISORDER, RHYTHMIC MOVEMENT DISORDER.

The AASM rules attempt to provide consistency in the measurement and reporting of these less common movement disorders. The guidelines do not discuss the use of EMG sensors other than chin or leg sensors. A number of laboratories use additional EMG placements where movement disorders are suspected. The same scoring rules should be applied to these sensors as to leg EMG.

Scoring Changes
AASM rules provide definitions for these conditions which have not previously been available.

Implications
The absence of previous rules for defining these sleep disturbances does not allow comparison. Clarification will provide a basis for more systematic reporting of uncommon sleep disorders.

Supporting Evidence
Nil.

Recommendation
The AASM rules provide definition of events which have not previously been defined. These definitions should be adopted. Where additional EMG sensors are placed movements should be defined using the rules described for leg EMG.

RESPIRATORY EVENT SCORING

The AASM rules for scoring respiratory events incorporate major changes to respiratory scoring rules. The rule clarifications were needed to manage divergent criteria being used for research and clinical practice. The “Chicago” criteria\textsuperscript{11} have been consistently used in research however in the United States eligibility for Medicare and Medicaid Services used a different hypopnoea definition.\textsuperscript{12} In 2005, the AASM through the Practice Parameters
Committee reported that, “Several clinical definitions of hypopnea are in clinical use and there is no clear consensus”. Whilst it might be expected that the intent of the new AASM guidelines was to resolve this tension, they have developed a recommended and an alternative definition which differ substantially and will result in continuing confusion. The clarification of this situation for Australian and New Zealand laboratories is one of the main reasons for the preparation of this consensus document.

**Technical Considerations**

**Sensor Changes**

AASM rules define the sensors to be used for detection of respiratory events. These are:

- Oronasal thermal sensor for the detection of apnoea;
- Nasal pressure sensor for the detection of hypopnoea;
- Oesophageal manometry or inductance plethysmography for the detection of respiratory effort;
- Pulse oximetry with rapid instrument response time (≤ 3 sec) for the measurement of blood oxygen levels.

**Implications**

The AASM rules provide clarity to laboratories in the selection of measurement devices for respiratory events. In Australia, with the widespread acceptance of the Chicago criteria, an oronasal thermal sensor was abandoned by many laboratories. The other recommendations are in keeping with the ASA/TSANZ criteria for Sleep Studies in Adults. Due to its greater sensitivity to airflow, the use of the oronasal thermal sensor is assumed to result in the scoring of less events with complete cessation of airflow (apnoea) with a consequent increase in hypopnoeic events but the changes would depend on the hypopnoea definition (see below).

**Supporting Evidence**

A retrospective study conducted by an Australian laboratory found that use of an oronasal thermal sensor did in fact decrease the number of apnoeic events but not every such rescored apnoeic event was then classified as a hypopnoea no matter which hypopnoea definition was used. Although the differences were modest, the assumption that there would be no change in the summed apnoea-hypopnoea index was not supported. The study found that use of the oronasal thermal sensor is likely to result in a moderate reduction of the apnoea-hypopnoea index if the recommended hypopnoea definition is used but a small difference if the alternative hypopnoea definition is used.

The use of respiratory effort sensors other than respiratory inductance plethysmography was not recommended under ASA/TSANZ guidelines. The AASM guidelines reaffirm the unsuitability of other devices such as piezo strain gauges.

The AASM guidelines also reaffirm that oximeter response times and averaging times are important, recognising earlier studies that showed that the number of oxygen desaturation events could be considerably underestimated with oximeter averaging times of greater than 3 seconds.

**Recommendation**

The AASM recommended use of an oronasal thermal sensor will reduce measured apnoea-hypopnoea index and requires a re-evaluation of normal values and cut-points for the diagnosis of sleep disordered breathing. If an abbreviated montage is employed and only a nasal pressure sensor is used, the use of the AASM alternative hypopnoea definition will result in smaller differences which may not be important in routine clinical practice. Nevertheless, the desirability of retaining parity with the AASM favours the use of both an oronasal thermal sensor and a nasal pressure sensor where practical. Other AASM sensor recommendations are in line with the earlier guidelines of ASA/TSANZ.
Event Duration Rules

Scoring Changes
The AASM rules have attempted to provide increased clarity about the measurement of event duration by defining the start of an event as the “nadir preceding the first breath that is clearly reduced”. The termination of the event is defined as the beginning of the “first breath that approximates the baseline breathing amplitude”. This approach is taken from the Sleep Heart Health Study\(^5\) and explained by Redline et al.\(^5\) in the discussion accompanying the AASM manual:

“For these situations, and from a pragmatic perspective, the Sleep Heart Health Study implemented a number of scoring rules, including: 1) events are started at the nadir of the first breath that is clearly reduced compared to baseline breathing; 2) events are terminated with the first “breaking breath” that approximates baseline breathing amplitude; 3) when baseline breathing amplitude cannot be easily determined (and when underlying breathing variability is large), events are terminated when there is a clear and sustained increased in breathing amplitude, or when a desaturation occurs followed by an increase in saturation of at least 2% is observed. This scoring method was proven to show high inter- and intrascorer reliability, and as discussed elsewhere, produced AHIs that correlate with disease indices.”

However, in this definition it is not clear which signal should be used to define “nadir”. The AASM Manual provides Figures 1 and 2 (redrawn below) with “horizontal brackets” to explain this definition. The horizontal brackets in Figure 1 (apnoea) refer to the thermal sensor and in Figure 2 (hypopnoea) refer to the nasal pressure sensor. In the figures below vertical lines have been drawn at the start and end of the horizontal brackets and the bracket duplicated against the alternate signal. From these diagrams it becomes apparent that the point referenced is the nadir or lowest point of the thermal sensor signal or respiratory inductance sum signal.

![Figure 1 and Figure 2 redrawn from the AASM Manual. Note that by definition nasal pressure and thermal sensor are displayed with negative deflections upwards reflecting inspiratory airflow.](image)

To appreciate the temporal association of these signals it is important to understand the nature of each sensor. A nasal pressure sensor measures flow whereas an oronasal thermal sensor measures temperature. Flow is maximal early in expiration and zero at end expiration whereas temperature is maximal towards the end of expiration. Respiratory inductance plethysmography measures thoracic volume and is minimal at end expiration. The nadir described by AASM occurs where flow is zero, temperature is greatest and respiratory volume is smallest: that is at end expiration. This seems an appropriate time point from which to measure the commencement of a respiratory event. The end of the event is defined by the point at
which flow recommences or returns to normal, that is the end expiratory nadir preceding the first normal breath following the event.

Therefore to clarify the AASM definitions of event duration, this discussion recommends that event duration be measured from the start of inspiration of the first breath that is clearly reduced to the start of inspiration of the first breath following the event that approaches baseline amplitude – the “breakthrough breath” to use AASM terminology. This points are shown as vertical lines in Figures above and below.

- The start of the event corresponds to (i) the expiratory nadir of the thermal sensor or plethysmographic sum signal preceding the first significantly reduced inspiration, or (ii) the point of zero flow on the nasal pressure signal preceding the first significantly reduced inspiration.

- The end of the event corresponds to (i) the expiratory nadir of the thermal sensor or plethysmographic sum signal preceding the first normal inspiration following the event or (ii) the point of zero flow on the nasal pressure signal preceding the first normal inspiration.

The AASM rules, in a quest for simplicity, also appear to have created a problem in the apnoea and hypopnoea duration definition. To define an event they indicated that the flow amplitude reduction criterion be present for 90% of the event duration. A subsequent clarification in their “Frequently Asked Questions” publication addressed this point:

“Scoring of hypopneas and apneas requires a minimum duration of 10 seconds. If the amplitude criteria are met during any contiguous 9 seconds of an event that lasts 10 seconds or longer then the event should be scored even if the duration of the amplitude reduction does not constitute 90% of the total event duration.”

The implication of this is that an event which demonstrates reduction of airflow for 9 seconds (90% of the minimum event duration) should be classified accordingly with the event duration defined by the previously described duration rules. In Figure 3 (below) the latter half of the hypopnoeic event meets the amplitude criterion but the nadir preceding the first clearly reduced breath defines the overall length. Figure 4 illustrates the application of the same rule to an apnoea.

![Figure 3 - Nasal pressure hypopnea](image1)

![Figure 4 - Oronasal thermal apnoea](image2)

**Implications**
The AASM rules relating to event duration require clarification particularly in relation the rule requiring 90% of the event to meet amplitude criteria. With the clarifications discussed above, the changes to previous duration definitions are small and unlikely to result in a significant change to the number of events scored. Careful application of these rules may be important in improving inter-scorer concordance which relies on temporal associations.
Supporting Evidence
Nil.

Recommendation
The AASM event duration rules as described in subsequent documentation are generally appropriate but the following clarifications should be applied:

1. Event duration is measured from the start of inspiration of the first breath that is clearly reduced to the start of inspiration of the first breath following the event that approaches baseline amplitude.

2. The start of the event corresponds to (i) the expiratory nadir of the thermal sensor or plethysmographic sum signal preceding the first significantly reduced inspiration, or (ii) the point of zero flow on the nasal pressure signal preceding the first significantly reduced inspiration.

3. The end of the event corresponds to (i) the expiratory nadir of the thermal sensor or plethysmographic sum signal preceding the first normal inspiration following the event or (ii) the point of zero flow on the nasal pressure signal preceding the first normal inspiration.

4. An apnoea or hypopnoea should be scored if the flow amplitude criteria are met during 90% of any contiguous 10 second period during the event. The event duration is the length of the entire episode as defined above.

Oxygen Desaturation Events

Scoring Changes
AASM indicate that oxygen desaturation should be measured from “pre-event baseline”.

Implications
In most cases the oxygen desaturation is calculated by computer software which will apply its own algorithm to the particular situation. Depending on the construction of the algorithm this could result in a decrease or increase in the true oxygen desaturation index:

- Where the desaturation is calculated from an average baseline this may underestimate the number of desaturation events if the baseline is a running average of a previous time period including previous desaturation events.
- Where the desaturation is calculated from the highest saturation achieved before an event to the lowest saturation achieved during an event, this may overestimate the number of desaturation events because of hyperventilation which often precedes a respiratory event, either as the result of recovery breaths or more markedly in the case of Cheyne-Stokes respiration.

AASM have recognised this issue and in a subsequent publication attempted to address the problem of a “baseline”. It is assumed that the following statement applies to both flow amplitude and oxygen saturation baseline.

“If there is no clear baseline breathing to measure, due to a high frequency of abnormal respiratory events, then the recovery breaths between the frequent apneas or hypopneas would be acceptable to use for an approximate baseline against which to measure the percent of drop for the next reduction in airflow.”

Supporting Evidence
Nil.
**Recommendation**

The definition of an oxygen desaturation event is critical to both the definition of hypopnoea and in situations where the oxygen desaturation index is used as an independent measure of respiratory disturbance. The AASM definition of desaturation from pre-event baseline should be adopted but when using computer assisted scoring, laboratories need to reassure themselves that the algorithms applied in the software used are compliant with this definition.

**Apnoea Definition**

**Scoring Changes**

AASM rules allow for an apnoea to be scored where airflow as measured by the oro-nasal thermal sensor is reduced by 90% for 90% of the duration of the event. The rules also clarify the distinction between obstructive, central and mixed apnoea with obstructive apnoea requiring inspiratory effort throughout the period of absent airflow, a central apnoea having no inspiratory effort and a mixed apnoea beginning with no effort and concluding with inspiratory effort.

**Implications**

AASM rules clarify the scoring of apnoea. The allowable airflow of 10% or less of baseline could be expected to increase the apnoea index and, depending upon the choice of hypopnoea definition, may decrease the hypopnoea index. It is however possible that events which were not classified as apnoea using a complete cessation of airflow criterion may not qualify as hypopnoea. This could result in a decrease in apnoea-hypopnoea index.

**Supporting Evidence**

The previous lack of clarity relating to the definition of an apnoea is likely to have led to a variety of similar but not identical practices in Australian laboratories. A review of measurement variability in laboratories in Victoria highlighted considerable differences in apnoea definition\(^6\) and an inter-laboratory scoring concordance program has identified major discrepancies in the way various laboratories and scorers report central, mixed or obstructive apnoea.\(^5\) This distinction can be particularly important in predicting which patients are likely to respond to treatment of upper airway obstruction and also in correct classification of subjects entering trials of treatment efficacy.

**Recommendation**

The AASM rule defining absence of airflow provides clarity in an area that has previously been variably applied. Changes to apnoea-hypopnoea index are likely to be modest and the AASM rule should be adopted.

The AASM rules on apnoea classification are straightforward to apply but will need to be validated by confirming that treatment outcomes match expected outcomes in the increasingly important groups of patients with cardiovascular comorbidities who often manifest various types of apnoeic events. In the absence of other accepted definitions of central, mixed and obstructive apnoea, the AASM guidelines should be adopted.

**Hypopnoea Definition**

**Scoring Changes**

AASM provide two definitions of hypopnoea which are fundamentally different and different to the ASA/TSANZ previously recommended Chicago criteria.\(^11\) The recommended definition requires at least a 30% reduction in airflow accompanied by a fall in oxygen saturation of 4% or more. The alternative definition requires a 50% reduction in airflow accompanied by an arousal or a fall in oxygen saturation of 3% or
more. It seems likely that, irrespective of any clinical imperatives, an important factor in the inclusion of the recommended hypopnoea definition was regulatory issues in the United States where the eligibility for reimbursement of the cost of CPAP treatment has been based on the number of respiratory events accompanied by 4% oxygen desaturation.61

The AASM manual, in a footnote, discusses the categorisation of hypopnoeic events into central, obstructive and mixed events indicating that this should not be attempted without an objective measure of respiratory effort such as oesophageal pressure, calibrated respiratory inductance plethysmography or diaphragmatic EMG.

Implications
AASM rules will reduce the number of hypopnoeas scored and hence reduce the apnoea hypopnoea index. The AASM recommended definition does not recognise hypopnoeas without a 4% oxygen desaturation hence missing a considerable proportion of those previously scored under Chicago criteria. While closer to the Chicago criteria than the recommended definition, the alternative definition eliminates hypopnoeas which achieve a 50% reduction in airflow but do not have an associated arousal or desaturation of 3% (so called Chicago Type A). New definitions of normal values will be required if the AASM rules are adopted.

Categorisation of hypopnoeic events is not common practice within Australasian adult sleep laboratories and although it may be relevant in detailed research studies, its use in routine clinical diagnostic laboratories would be difficult to implement and likely to add to confusion.

Supporting Evidence
It is well established that changes in the definition of hypopnoea and the inclusion of supporting information can change the reported apnoea-hypopnoea index significantly.62 A retrospective study by Ruehland et al.63 conducted in two Australian laboratories found that use of the recommended hypopnoea definition without a change in the severity rules resulted in a major change in the number of patients classified as having sleep disordered breathing. To achieve similar classification to Chicago criteria, a cut-off of 30 events/hr would have needed to be reduced to 10 events/hr. A study from Guilleminault et al.64 assessed whether the recommended and alternative definitions accurately identified symptomatic obstructive sleep apnoea in lean adults whose respiratory events in sleep often do not cause oxyhaemoglobin desaturations. Similarly to Ruehland et al., they found the recommended rule would have resulted in 40% of the symptomatic individuals having an apnoea-hypopnoea index less than 5 and hence falsely classified as “normal”. They recommended the alternative definition for hypopnoea when scoring sleep studies in lean patients.

It has long been recognised that respiratory events accompanied by desaturation, with or without an accompanying arousal, are associated with clinical outcomes in patients with obstructive sleep apnoea. Significant correlations were found with hypertension, cardiovascular disease, neurocognitive test scores, sleepiness, and motor vehicle accidents.68 Experimental models of intermittent hypoxia have also established links with hypertension.69 Using data from the Sleep Heart Health Study population, Punjabi et al.70 and Redline et al.71 attempted to tease out the contribution of the oxygen desaturation from the arousal associated with a respiratory event. They found that only the number of hypopnoeic events accompanied by oxygen desaturations of 3% or more predicted cardiovascular outcomes. Furthermore, a study of all cause mortality found it to be associated with intermittent hypoxaemia but not sleep fragmentation.72

Adding further support to the importance of oxygen desaturation events in cardiovascular outcomes, are findings that inflammatory markers are more strongly associated with oxygen desaturation than with the apnoea-hypopnoea index.73,74,75
Notwithstanding the importance of events accompanied by oxygen desaturation, the reliance of the recommended hypopnoea definition on an absolute oxygen desaturation criterion ignores two fundamental issues associated with the use of oxygen saturation as a marker of respiratory disturbance.

- The first issue is that the oxygen dissociation curve which defines the relationship between oxygen tension and oxygen saturation is alinear meaning that a patient with low baseline saturation is going to desaturate more in response to a given respiratory disturbance than a patient who has a high baseline saturation. Conversely a patient with high baseline saturation and greater oxygen reserve will desaturate less. As a consequence patients with underlying respiratory disease, for example, are likely to have a greater number of hypopnoeas than patients without comorbidities.

- The second issue is the difficulty in selecting a “pre-event baseline” oxygen saturation from which to judge the degree of oxygen desaturation (see above). This may be of particular relevance where the number of respiratory events is so high as to preclude an accurate estimate of baseline oxygen saturation or where periods of hyperventilation are interspersed with oxygen desaturation events.

The AASM recommended hypopnoea rule places great reliance on the assumed objectivity of a 4% desaturation to define a respiratory event. Whilst this criterion may improve inter-scorer reliability, the variation in computational algorithms may confound the measurement. Furthermore, the physiological and clinical consequences of oxygen desaturation events which occur as part of Cheyne-Stokes respiration may be quite different to those of events occurring in a patient with obstructive sleep apnoea.

The AASM alternative definition has some of the same issues in reliance on an absolute change in oxygen saturation to define an hypopnoeic event, however, the presence of an arousal allows otherwise unreported events to be scored. The study by Ruehland et al.\textsuperscript{63} found that the AASM alternative definition also resulted in a significant reduction in apnoea hypopnoea index but the degree of reduction compared to Chicago criteria was significantly less than with the recommended definition: a cut-off of approximately 18 events/hr resulted in the same number of patients being diagnosed with sleep disordered breathing as a Chicago criteria cut-off of 30 events/hr. The response in individuals was not uniform. In some individuals the adoption of the AASM definition resulted in a very large change in apnoea-hypopnoea index, in others the change was small. The largest changes occurred in patients who had a larger proportion of hypopnoeas and whose apnoea-hypopnoea index was in the mid-range. In a subset of patients they found that the presence of an arousal in the absence of desaturation accounted for 50% of the hypopnoeas that were scored using the alternative definition as opposed to the recommended definition. In an earlier study, Cracowski et al.\textsuperscript{76} reported that 60-70% of events scored to criteria approximating the “Chicago” criteria were scored because of an arousal alone. It is apparent that there are a number of clear respiratory events which manifest as an arousal without an accompanying desaturation.

There are few studies which have attempted to examine the correlation of respiratory indices with outcomes other than cardiovascular consequences. The study of Guilleminault\textsuperscript{64} in lean sleep apnoeic subjects provides some support to the view that improvements in self-reported sleepiness correlated better with changes in the indices of respiratory events which included an arousal in the definition. They recommended that the AASM alternative definition be adopted.

Whilst cardiovascular consequences may correlate more with oxygen desaturation than respiratory events overall, there is clear evidence that arousal from sleep is associated with changes in cardiac function and that disrupted sleep has long term metabolic consequences. One of the cardinal signs of arousal from sleep is in fact the tachycardia associated with an arousal that terminates the bradycardia.
associated with a respiratory event. A recent study by Smith et al. found that arousals produce marked QT interval shortening and PR interval elongation. There is also convincing evidence to show that sleep disruption and the arousal index, in particular, is predictive of metabolic consequences of sleep apnoea.

A tacit acknowledgement that the alternative hypopnoea definition might more closely reflect clinical outcomes is the recommendation by the AASM in relation to prospective epidemiological studies. In its “Frequently Asked Questions” explanatory document available on the AASM website, they state:

“We strongly recommend that investigators use the alternative rule for hypopneas (page 46, 4.B.) in all prospective epidemiological and outcome studies. For clinical purposes, sleep specialists may select either the recommended (pg 46, 4.A.) or alternative (page 46, 4.B.) rule. Certainly, for comparison purposes in clinical research or practice, both methods may be reported.”

Recommendation

It is concluded that the balance of available evidence and consensus of expert opinion clearly favours the adoption of the AASM alternative definition. The AASM recommended definition is overly conservative and may fail to recognise important physiological events. Neither AASM definition results in the same diagnostic criteria as the previously employed Chicago criteria however the alternative definition is closer. If Australian researchers are to perform studies which are acceptable in North American journals it is essential that research studies be scored to comply with an AASM definition. For consistency therefore it is recommended that clinical studies be scored using the same criteria.

The reporting of apnoea-hypopnoea indices from both AASMrec and AASMalt definitions is not desirable as this is likely to lead to continuing confusion in the literature and amongst non-sleep physicians who may view the results of polysomnography.

Categorisation of hypopnoea into obstructive, central or mixed event types is not practical for routine diagnostic purposes as it requires additional confirmatory signals. It is not recommended that this be attempted except where a specific research question is being addressed.

These changes will require the derivation of a new set of normative values and a redefinition of severity criteria for clinical management of sleep disordered breathing.

Interscorer Reliability of Respiratory Scoring

The search for improved interscorer reliability for scoring respiratory events greatly influenced respiratory scoring definitions. The AASM review paper by Redline et al. devotes a significant amount of discussion to this important factor which, if ignored, could invalidate many of the clinical associations of obstructive sleep apnoea. It seems likely that requiring a respiratory event to be accompanied by a relatively objective measurement such as a degree of oxygen desaturation will lead to improved interscorer reliability. Whitney et al. found that hypopnoeic events associated with 2–5% desaturations were more reliably scored than those requiring neither confirmatory criterion. Adoption of the AASM recommended hypopnoea definition would address these issues but fails to recognise the importance of events falling below this 4% desaturation criterion. The AASM alternative hypopnoea definition incorporates the need for a significant (50%) fall in ventilation with a 3% desaturation or an arousal. While this inevitably will lead to greater interscorer variability, due at least in part to variability in the scoring of arousals, it is likely to be better than existing Chicago criteria which for type A hypopnoeas rely solely on a comparison of ventilation during an event with the baseline ventilation preceding an event.
For measurements of interscorer reliability which rely on events being scored at matching times it is also important that the respiratory event duration rules be adopted.

Interscorer reliability is an important consideration in the reporting of polysomnography. The adoption of the AASM alternative criteria will go some way to minimising this but ongoing inter-laboratory comparisons are required to improve and sustain the improvements in interscorer reliability of respiratory events.

**RESPIRATORY EFFORT RELATED AROUSALS, HYPOVENTILATION, CHEYNE-STOKES BREATHING**

AASM rules provide definitions for these conditions which previously have not been universally accepted.

**Scoring Changes**

The definition of Cheyne-Stokes respiration requires three consecutive cycles of crescendo and decrescendo changes in breathing signal amplitude accompanied by five central apnoeic or hypopnoeic events per hour or a period of 10 minutes of the cyclic breathing pattern. The guidelines are not specific about the sensors used for detection but as effort-related events, by implication, the changes in breathing pattern should be seen in nasal pressure and chest and abdominal respiratory inductance plethysmography.

Oesophageal manometry is the preferred method for the definition of respiratory effort related arousals (RERAs) and as such would require instrumentation that is not standard in polysomnography in Australia and New Zealand. However, the rules now allow nasal pressure and respiratory inductance plethysmography to be substituted for oesophageal manometry in the detection of RERA events. This routine non-invasive methodology, which is readily available in all laboratories, makes scoring of RERAs practical. Further data are required to address the clinical utility and outcomes of scoring RERAs as unique respiratory events. In general, they simply represent an hypopnoea which leads to a cortical arousal, but does not reach the arbitrary alternative hypopnoea definition which includes a 50% drop in the nasal pressure signal.

The definition of hypoventilation requires the use of end-tidal or transcutaneous carbon dioxide monitoring which are not routinely used in polysomnography in adults. Nevertheless, in situations where hypoventilation is suspected, transcutaneous carbon dioxide monitoring is indicated.

**Implications**

The absence of previous rules for defining these respiratory sleep disturbances does not allow comparison. Clarification will provide a basis for more systematic reporting of the increasingly important area of sleep disorders associated with co-morbid conditions.

**Supporting Evidence**

Cheyne-Stokes respiration is a common feature of breathing in patients with heart failure, other cardiovascular conditions and cerebrovascular disease. It may occur both awake and asleep and has been associated with poor prognosis in heart failure patients.

RERAs have been suggested to comprise less than 5% of the events in moderate to severe obstructive sleep apnoea. However, this is based on scoring hypopnoeas using the Chicago definitions, where RERAs were relatively infrequent. A recalculaton of the data from this publication using the alternative hypopnoea definition reduced the number of hypopnoeas from 80% of total events to 43% of total events, and conversely increased the number of RERAs using the new AASM definition from 5% to 30% of total events in the group tested. Given that the RERA measurement technology is readily available, that there is now a clear definition, and that the RERA event frequency may be substantial in some patients, it is appropriate to consider RERAs when assessing the
overall severity of sleep disordered breathing. RERAs should be scored and reported separately to the AHI, but could be summed with apnoeas and hypopnoeas to produce an overall Respiratory Disturbance Index (RDI).

Sleep hypoventilation in the absence of underlying comorbidity is rare. In populations of interest where hypoventilation and elevated carbon dioxide levels are suspected, the measurement using transcutaneous carbon dioxide is appropriate, although it can be technically difficult to obtain reliable signals in adults. Other indirect methods of measuring hypoventilation such as end-tidal carbon dioxide have not been shown to be useful.

Recommendation
The AASM rules provide definition of events which have not previously been defined. The reporting of Cheyne-Stokes respiration is important as it may signal underlying cardiovascular or cerebrovascular disease and it may not respond to traditional treatment modalities for OSA.

The definitions of hypoventilation accord with the commonly accepted practice in Australian and New Zealand laboratories and should be adopted. Transcutaneous carbon dioxide measurements should be reported in patients suspected of sleep hypoventilation.

The definition of RERAs is now clearer, and the event frequency is likely to be much greater given the adoption of the AASM alternative hypopnoea definition. It is concluded that the balance of available evidence and consensus of expert opinion favours the adoption of the AASM definition, with the use of nasal pressure as the preferred method of airflow measurement. For reporting purposes, AHI should be derived from the sum of apnoeas and hypopnoeas and RDI from the sum of apnoeas, hypopnoeas and RERAs. Adoption of these recommendations will require the derivation of a new set of normal values and a redefinition of severity criteria for clinical management of sleep disordered breathing.

PARAMETERS TO BE REPORTED FOR POLYSOMNOGRAPHY

The AASM guidelines and before that the TSANZ/ASA guidelines make recommendations about the content of the polysomnography report. These are comprehensive and should be adopted.

ADDITIONAL RECOMMENDATIONS

Respiratory Events During PAP Titration

The AASM guidelines make no recommendation regarding the measurement or scoring of respiratory events during PAP titration. Kushida et al., in the guidelines for manual PAP titration, have addressed a few of the issues.

Airflow from mask pressure

Airflow may be qualitatively reflected by pressure changes in the CPAP mask. Kushida recommends that this pressure signal from the mask be referenced to pressure measured at the PAP pump to give a differential pressure which better reflects the fluctuations due to respiration. Issues with the use of this signal are discussed above.

Using mask pressure as the airflow signal is somewhat analogous to nasal pressure in a non-PAP setting and allows the scoring of hypopnoea using the AASM rules. Kushida does not recommend the placement of a thermal sensor within the PAP mask. The absence of this oronasal thermal sensor precludes the use of the AASM apnoea definitions meaning that apnoea must be approximated from the pressure signal. In non-PAP studies, Thornton et al. have shown that, when the AASM
alternative hypopnoea definition is used, the nasal pressure signal is a close estimate of AHI using an oronasal thermal sensor. It could therefore be expected that apnoea-hypopnoea indices measured from mask pressure would be a reasonable representation of the number of respiratory events. Apnoea and hypopnoea events scored from mask pressure should be summed and reported as AHI in PAP studies.

**Airflow from PAP device**

Many PAP machines have output signals which can be interfaced to a polysomnograph to provide pressure, flow and leak signals. Caution should be exercised in using these signals to score events unless they have been validated against independent measures of flow or pressure.

**Respiratory Effort Related Arousals (RERAs) from the flow profile**

Kushida et al. note that subtle events such as RERAs may be important in detecting partial airway occlusion and hence requiring an increased pressure to control events. They suggest the combination of flattened flow profile and increasing effort from chest and abdominal efforts which lead to arousal being scored as a RERA. This recommendation should be adopted and RERAs reported in RDI as for non-PAP studies.

**Snoring**

Noise from a microphone or sound level meter is often unreliable in the detection of snoring during PAP titration as the bias flow from the PAP mask may produce a noise which is synchronised with breathing. Kushida recommends that a saw-tooth or snoring pattern superimposed on a flow signal be used as a marker of snoring. This requires relatively rapid response and hence may not be available from the flow signal produced by the PAP device. A piezo sensor to detect movement of the upper airway caused by snoring is an alternative. Caution should be exercised when reporting snoring during PAP studies.

**Scoring Events In Wake**

The AASM manual does not clarify the scoring rules for events occurring during epochs which are marked as wake. A wake epoch can contain up to 15 seconds of sleep and hence both arousal and respiratory events may occur in these epochs. In an attempt to clarify the rules in its response to frequently asked questions, the AASM has likely further confounded the discussion by suggesting contradictory methods by which arousals and respiratory events should be managed.

- “... 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 that situation.”

- “... 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.”

The internal contradiction resulting from counting all events and dividing only by sleep time to calculate an event index is unsupportable. For this reason it is recommended that only events assigned to sleep epochs are counted in the calculation of the index. This applies to arousals, respiratory events and limb movements. It is recognised that this will underestimate respiratory or arousal disturbances in some studies. Where this occurs the scorer should draw the attention of the reporter to this issue.

Ambiguity remains about how to assign events to epochs and how to count events which may span epochs of Wake. The arbitrary division of a continuous recording of sleep into 30 second epochs precludes a precise method of calculation. AASM recommend that if
any portion of an event occurs in a sleep epoch the event should be counted in the AHI.\textsuperscript{26} The application of this rule will tend to increase AHI because events that span epochs of wake may be counted. It is also recognised that this rule may be difficult to apply if it is not supported by the PSG software. An alternative acceptable rule is that events are arbitrarily assigned to the epoch in which they originate. With the application of this rule, events that commence in sleep but terminate in a wake epoch will be counted in the AHI whereas events that commence in a wake epoch will not be counted. This will result in some events being over-counted and some being under-counted but differences from the AASM recommended rule will be small.

**DISCUSSION**

There remain significant issues in the measurement, scoring and reporting of data from polysomnography. The guidelines prepared by AASM in 2007 represent a significant step forward in the standardisation of the rules but fail, perhaps understandably, in a number of areas. This document has attempted to address some of these issues.

Various authors have raised issues concerning the inherent problems with sleep analysis and the division of sleep into 30 second slices. This arbitrary division however is so widely accepted that although these views may inform sleep analysis into the future, they add nothing to the current discussions.\textsuperscript{14,85}

An important issue that needs to be addressed is the reporting and analysis of data from PSG. The AASM manual defines parameters which should be reported from polysomnography but notably makes no attempt to categorise results as normal or abnormal or to define severity criteria. Given the impact of the new AASM rules in some critical areas such as the apnoea-hypopnoea index, this is necessary. The adoption of the AASM alternative definition of hypopnoea and routine scoring of RERAs, for example, will change the criteria that should be used to define these values used for the definition of a clinically important sleep disorder.\textsuperscript{63} Issues that are poorly understood and can impact on the reporting of PSG include the variation of basic polysomnography indices such as AHI with age and even more basic considerations such as the confidence that can be attributed to a reported value, AHI for example.\textsuperscript{87} Comprehensive normative values using the new AASM rules for both genders and over a range of ages are urgently required.

Also under-appreciated by clinicians interpreting reports of polysomnography is the uncertainty in the measured indices resulting from inter-scorer variability in the scoring of the PSG.\textsuperscript{40,46} Failure to recognise or address these issues limits the reliability of PSG and is likely to have contributed substantially to many of the failures of PSG to demonstrate strong associations with clinical outcomes.

“Scoring variability associated with sleep studies can have a profoundly negative impact on reliability, as it introduces unwanted variability into common sleep variables of interest (eg, sleep staging, total sleep time, number of apneas and hypopneas). In research, this can result in underpowered studies (ie, studies that cannot detect an important effect if one indeed exists). In clinical practice, such error has the potential to result in false negatives or false positives.”\textsuperscript{40}

Sleep laboratories should move to reporting upper or lower limits of normal for derived indices and provide the reporting sleep physician with estimates of uncertainty of measurement.

**FUTURE DIRECTIONS**

**Automated sleep scoring**

There is a rapidly increasing body of literature supporting various schemes for the automated scoring of sleep and associated events.\textsuperscript{6} There are a number of conflicting views about the reliance on automated scoring\textsuperscript{88,89} but there is no doubt that as
technology and computerised algorithms improve automated scoring will continue to improve. At this time AASM conclude, and this review agrees, that fully automated scoring is not a substitute for manual scoring of a polysomnogram by a well trained scorer who is conversant with the subtleties of sleep recordings that may be crucially important to clinical decision making.

**Diagnosis without PSG**

Whilst a comprehensive review of abbreviated channel polysomnography or non-polysomnographic methods of sleep diagnosis is beyond the scope of this review, a brief comment on the future of this technology is warranted as there is no doubt that significant advances have taken place in this area in the last five years. In its review of polysomnography in adults in 2005, the ASA/TSANZ recommended that in relation to studies done for the diagnosis of sleep apnoea:

“…that if portable, limited channel sleep studies are to be used this should only be under the supervision of an accredited sleep physician who is familiar with the strengths and weaknesses of these types of studies and who is knowledgeable about the specific device to be used.”

and that the role of limited channel studies should be to “rule-in” obstructive sleep apnoea rather than to rule it out. Subsequent studies have provided evidence that under carefully controlled conditions alternative algorithms for the diagnosis and management of respiratory sleep disorders may achieve clinical outcomes comparable with conventional diagnostic methods. If such diagnostic schemes are to be used it is appropriate that normative values using devices of this type be established.

**CONCLUDING STATEMENT**

The AASM manual represents a major advance in the standardisation of polysomnography. Given the resource implications, the comprehensive reviews that underscore the recommendations are unlikely to be able to be repeated with such thoroughness in the foreseeable future. In general the recommendations of AASM are sound and if Australian and New Zealand laboratories are to contribute research which is directly comparable with that originating from North America, they must adopt the recommendations in large part. Notwithstanding this there are a few issues on which the AASM guidelines have failed to provide the guidance required, most notably in the scoring of respiratory events. It is for this reason and to interpret the recommendations from the perspective of a clinical sleep laboratory in Australia or New Zealand that this review has been written.
## REVISION HISTORY

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