Simplifying the Complexity of Polysomnography - Understanding the Objective Measurement of a Sleep Disorder

Dr Darren O’Brien
Scope

- Subjective Measures of Sleepiness
- Physiologic/Biologic Measures of Sleepiness
- Polysomnography (PSG)
  - Sleep Unit based and Portable (Home)
  - Diagnostic PSG
  - Continuous Positive Airway Pressure (CPAP) titration PSG
  - Multiple Sleep Latency Test PSG
Sleepiness and Fatigue

Although these terms are used interchangeably there are differences. Sleepiness refers to the urge to fall asleep. It is the result of a biological need to sleep that can be irresistible. Fatigue refers to the reluctance to continue a task as a result of physical or mental exertion or a prolonged period of performing the same task.
The Problem

Safety alert after sleeping driver causes heavy mine vehicle collision

By Editor on 28 August 2009 1 comments 217 views

THE Queensland Department Of Mines And Energy has issued a safety alert on vehicle collisions on mine sites.

According to the alert, the incident occurred at a surface mine on the first nightshift, at 4.30am.

An operator of a loaded rear dump truck fell asleep at the wheel on entering a left hand bend, crossed the lanes and collided with an approaching empty rear dump truck.

The operator of the empty truck saw what was happening, tried to avoid the collision, and also attempted communication on the 2-way radio without success. There were no injuries.

The incident is being investigated, but fatigue has been identified as a factor. The Department of Mines and Energy said there were no injuries because both trucks were left-hand drive, both were heavy class vehicles, and the empty truck did not roll.

In April 2008, the Department of Mines and Energy issued safety Alert 194, drawing attention to a probable head on collision between two rear dump trucks, when a loaded truck lost control but was stopped by a substantial centre berm dividing the haul road.

Light and heavy vehicles are subject to a variety of hazards, including wet roads, micro sleeps, brake faults, speed, inexperience and various distractions to the driver.
Sleepy Driving

4. PLEASE COMPLETE THE FOLLOWING QUESTIONS ABOUT YOUR SLEEP

Describe your sleep problem:

I am sleeping too much. I get 9-10 hrs at night, then afternoon nap. I am tired all the time.

Describe your sleep problem:

Fall asleep at traffic light.

Describe your sleep problem:

Waking up unrefreshed from what I think is a good night sleep and sleepy at work.

Describe your sleep problem:

Always tired, no matter how much sleep I get. I’ll lie down to read a book or watch TV. During the day will often fall asleep.

Describe your sleep problem:

Tired when wake up. Sleepy anytime.

Have you fallen asleep while operating a motor vehicle or heavy machinery? Y ☑ N ☐

Have you fallen asleep while operating a motor vehicle or heavy machinery? Y ☑ N ☐ once

FALLING ASLEEP WHILST DRIVING

Clinical History

Fall asleep when stopped at traffic lights

2-3 episodes in the last 3 months

Investigation Required:
Site Fatigue Management Training

- Fatigue and Alertness
- Personal Costs of Shift work
- Fatigue at Work and on the Road
- What causes Fatigue?
- Roster Assessment
- Understanding Sleep
- Getting to Sleep
- Improving Your Sleep
- Stop Worrying and go to Sleep!
- Sleep and Ageing
- Women, Sleep and Shift work
- Circadian Rhythms, Sleep and Alertness
- Getting to Sleep after Night Shift
- Staying Asleep After Night Shift
- Napping
- Alcohol, Drugs and Fatigue
- Staying Alert on Night Shift
- Managing Shift Change
- Healthy Eating for Shift workers
- Are you fit for work?
- Fatigue Assessment, management plan and fatigue profile
Fatigue Calculators and Questionnaires

**Epworth Sleepiness Scale**

Name: ____________________________ Date: ____________

Instructions: How likely are you to do fall asleep in the following situations, in contrast to being wide awake and alert? Score each item from 0 (would never do) to 4 (would almost certainly do). Add the scores from all items to get a total score. A score of 10 or higher indicates a risk of sleepiness.

<table>
<thead>
<tr>
<th>Situation</th>
<th>Chance of Dozing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sitting and reading</td>
<td></td>
</tr>
<tr>
<td>Sitting in a public place, e.g., a theatre or a meeting</td>
<td></td>
</tr>
<tr>
<td>As a passenger in a car for an hour without break</td>
<td></td>
</tr>
<tr>
<td>Driving or operating machinery</td>
<td></td>
</tr>
<tr>
<td>Sitting and talking</td>
<td></td>
</tr>
<tr>
<td>Sitting quietly after lunch/dinner</td>
<td></td>
</tr>
</tbody>
</table>

In circled “yes” if slept or dozed off while driving during the last week.

If your total score is 10 or higher, consider discussing these results with your sleep physician or internal medicine. Following your evaluation they may recommend a sleep study for an accurate diagnosis. If appropriate, effective treatment of an underlying mental disorder, increasing regular exercise for a week or longer can help to identify any sleep pattern.

**Berlin Questionnaire**

Category 2

<table>
<thead>
<tr>
<th>Category 2</th>
<th>Score</th>
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</thead>
<tbody>
<tr>
<td>Confidently</td>
<td>1-4</td>
</tr>
<tr>
<td>Unlikely</td>
<td>5-12</td>
</tr>
<tr>
<td>Definitely</td>
<td>13-20</td>
</tr>
</tbody>
</table>

Category 3

<table>
<thead>
<tr>
<th>Category 3</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very likely</td>
<td>1-4</td>
</tr>
<tr>
<td>Unlikely</td>
<td>5-12</td>
</tr>
<tr>
<td>Definitely</td>
<td>13-20</td>
</tr>
</tbody>
</table>

Sleep Hygiene Index

Name: ____________________________

Instructions: Please rate each of the following statements using the scale below:

<table>
<thead>
<tr>
<th>N (Never)</th>
<th>O (Occasionally)</th>
<th>R (Regularly)</th>
<th>F (Frequently)</th>
<th>M (Most of the time)</th>
<th>U (Always)</th>
</tr>
</thead>
</table>

1. I take naps during the day.
2. I take an average of 6-7 hours of sleep per night.
3. I experience difficulty falling asleep.
4. I go to bed and get up at the same time every day.
5. I have regular sleep habits during the week.
6. I have regular sleep habits on the weekends.
7. I avoid eating late-night snacks.
8. I avoid caffeine and alcohol before bedtime.
9. I exercise regularly.
10. I have a comfortable bed and sheets.

Scoring: Higher scores are indicative of more favorable sleep hygiene status.
Subjective Measures of Sleepiness

• Improve level of knowledge and awareness
• May prompt individual action
• Subjective tools. Rely on personal honesty/integrity of the individual to use them or act on them
• Fatigue calculators may provide false sense of security
Physiologic Measures – Signs of Sleepiness

Optalert Glasses (1992-)

Optalert's patented technology continuously measures drowsiness by using invisible pulses of light to detect eye and eyelid movement. Tiny light emitters and receivers are built into the frames of Optalert glasses worn by the driver. The glasses are connected to the Optalert Vehicle System, installed within the vehicle, which processes all the information being transmitted from the glasses. Whenever Optalert detects the onset of drowsiness – usually before the driver becomes aware of it – a loud beeping noise and a voice message warns the driver immediately. Warnings can include:
Level 1 – Cautionary warning
Level 2 – Critical warning
Inattention
System warnings
Glasses not working
Physiologic Measures – Signs of Sleepiness

Smart Cap (2009)

Smart baseball cap monitors mining fatigue

NEW TECHNOLOGY aimed at combating fatigue-related heavy vehicle driving incidents will be piloted at Queensland mines.

SmartCap technology, brain-monitoring technology that aims to address the dangers of driver fatigue when operating heavy vehicles, has been developed over the last 12 months at the CRCMining mining research centre.

The centre was established by the Federal Government’s Cooperative Research Centre’s program to deliver safety and productivity enhancing technologies to the mining industry.

Fatigue information is collected by microelectronics concealed within a baseball cap.

The technology uses a number of sensors to measure brain-wave information through hair. It then applies an independently validated formula to identify when the wearer is experiencing symptoms of fatigue.

“When a fatigue danger limit is reached, a warning message is sent from the operator’s cap to an in-cab display, notifying operators of the threat, and alerting them to the need to stop, rest and refresh,” Queensland Minister for Mines and Energy, Stephen Robertson, said at the launch of the technology.

Invented by CRCMining engineer Dr Daniel Ronauger, this tool has been developed by CRCMining as part of an Australian Coal Association Research Program (ACARP) funded project.

Anglo American Chief Executive Cynthia Carroll said the technology was an exciting development for the mining industry.

“Anglo is looking forward to having its Australian coal mines host the SmartCaps onsite application and is even more eager to see the results the technology returns,” Carroll said.

“For many years the mining industry has been searching for mechanisms to assist in the detection of operator fatigue, to prevent fatalities and our people from being injured.”

To read more click here

MIAHAFI MILLS

Mining Daily 1 October 2009
Physiologic Measures

- Objective measure of signs of sleepiness if interpreting features correctly
- Provides potential opportunity for evasive action to me taken – potentially mitigating a real time accident
- Will not permit specification or quantification of a sleep disorder beyond identifying a very high propensity for sleep in a given individual
Polysomnography or PSG or Sleep Study

Objective Measure of Sleepiness, Sleep Quality and Sleep Quantity performed in a sleep unit or at home/in a mine site donger with a portable PSG unit. Will provide data suitable for the medical diagnosis of a sleep disorder.

A PSG is the continuous and simultaneous recording of multiple physiologic variables during sleep, that is, electroencephalogram (EEG), electrooculogram (EOG), electromyogram (EMG), electrocardiogram (ECG), respiratory air flow, respiratory movements, leg movements and other electrophysiologic variables.

The name is derived from Greek and Latin roots: ‘poli' (many), 'somnus' (sleep), and 'grapho' (to write).
Evolution of Polysomnography (PSG)

- 1930 Berger sleep vs. waking Electroencephlogram (EEG)
- 1937 Loomis EEG of different sleep states
- 1953 Aserinsky and Kleitman Electro-oculogram (EOG)
- 1957 Dement & Kleitman describe Rapid Eye Movement (REM) sleep
- 1959 Jouvet & Michel Electromyogram (EMG) decrease in REM sleep
- 1968 A manual of standardised terminology, techniques and scoring system for sleep stages of human subjects Allan Rechtschaffen and Anthony Kales
Evolution of Polysomnography (PSG)

- 1981 Colin Sullivan developed Continuous Positive Airway Pressure treatment for Obstructive Sleep Apnoea
- 1992 ASDA (American Sleep Disorders Association) EEG Arousals: Scoring rules and examples
- 1999 Sleep-related breathing disorders in Adults: Recommendations for Syndrome Definition and Measurement Techniques in Clinical Research - Report of an American Academy of Sleep Medicine Task Force (Sleep Vol 22 No. 5)
PSG – A Medical Test

Sleepy individual – Discusses their sleep problem with General Practitioner or Sleep Specialist.

If Dr agrees there is need for a sleep study – he or she completes the referral and faxes or emails it for booking.
Polysomnographic Tests

• Diagnostic PSG - investigative study to determine if there are identifiable problems with the patient’s sleep

• CPAP titration PSG - If a patient is identified as having obstructive sleep apnoea, a PSG is performed in which the nurse or technician adjusts the CPAP pressure level during the study.

• Split Night PSG- Combines a diagnostic study and a CPAP titration study into one night. The patient is diagnosed during the first half of the night; CPAP applied the second half if required by protocol.

• Multiple Sleep Latency Test (MSLT)

• Maintenance of Wakefulness Test (MWT)

Both MSLT and MWTs are daytime tests.
### 88 Sleep Disorders

<table>
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<th>Sleep-onset Association Disorder</th>
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<td>Nocturnal Eating (Drinking) Syndrome</td>
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<tr>
<td>Environmental Sleep Disorder</td>
<td>Food-Allergy Insomnia</td>
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<tr>
<td>Toxic-induced Sleep Disorder</td>
<td>Adjustment Sleep Disorder</td>
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<tr>
<td>Insufficient Sleep Syndrome</td>
<td>Anxiety Disorders</td>
</tr>
<tr>
<td>Sleep-state Misperception</td>
<td>Mood Disorders</td>
</tr>
<tr>
<td>Psychophysologic Insomnia</td>
<td>Alcoholism</td>
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<tr>
<td>Stimulant-dependent Sleep Disorder Psychosis</td>
<td>Hypnotic-dependent Sleep Disorder</td>
</tr>
<tr>
<td>Alcohol-dependent Sleep Disorder Panic Disorder</td>
<td>Idiopathic Insomnia</td>
</tr>
<tr>
<td>Primary Snoring</td>
<td>Sleep-related Asthma</td>
</tr>
<tr>
<td>Central Alveolar Hyperventilation Syndrome</td>
<td>Sleep Choking Syndrome</td>
</tr>
<tr>
<td>Sleep-related Abnormal Swallowing Syndrome</td>
<td>Sleep-related Laryngospasm</td>
</tr>
<tr>
<td>Chronic Obstructive Pulmonary Disease</td>
<td>Congenital Central Hyperventilation Syndrome</td>
</tr>
<tr>
<td>Obstructive Sleep Apnea Syndrome</td>
<td>Sudden Infant Death Syndrome</td>
</tr>
<tr>
<td>Central Sleep Apnea Syndrome</td>
<td>Infant Sleep Apnea</td>
</tr>
<tr>
<td>Narcolepsy</td>
<td>Atypical Insomnia</td>
</tr>
<tr>
<td>Posttraumatic Hypersomnia</td>
<td>Idiopathic Hypersomnia</td>
</tr>
<tr>
<td>REM Sleep Behavior Disorder</td>
<td>Sleep-related Epilepsy</td>
</tr>
<tr>
<td>Recurrent Hypersomnia</td>
<td>Nocturnal Paroxysmal Dystonia</td>
</tr>
<tr>
<td>Fatal Familial Insomnia</td>
<td>Dementia</td>
</tr>
<tr>
<td>Parkinsonism</td>
<td>Cerebral Degenerative Disorders</td>
</tr>
<tr>
<td>Sleep-related Headaches</td>
<td>Electrical Status Epilepticus in Sleep</td>
</tr>
</tbody>
</table>

### Short Sleeper
- Shift-Work Sleep Disorder
- Advanced Sleep-Phase Syndrome
- Irregular Sleep-Wake Pattern
- Long Sleeper

### Delayed Sleep-Phase Syndrome
- Non-24-Hour Sleep-Wake Syndrome
- Time-Zone Change (Jet-Lag) Syndrome

### Nightmares
- Sleep Bruxism
- Sleep Stills
- Fragmentary Myoclonus
- Terrifying Hypnagogic Hallucinations
- Sleep Tailing

### Nocturnal Leg Cramps
- Periodic Limb Movement Disorder: Peptic Ulcer Disease
- Impaired Sleep-related Penile Erections
- Menstrually-associated Sleep Disorder
- Nocturnal Cardiac Ischemia
- Sleep Hyperhidrosis
We most commonly find......

- Obstructive Sleep Apnoea
- Insomnia
- Narcolepsy
- Depression
- Periodic Limb Movements in sleep
- Withdrawal from stimulants
- Insufficient sleep syndrome
- Drug Dependence/Abuse
- Medication side effects
- Post Traumatic Hypersomnia
- Obesity Hypoventilation
- Respiratory Failure
- Patients with Night Terrors, REM Behaviour Disorders and Epilepsy
Physiological measurements undertaken during Polysomnography

**Sleep**
- • EEG (brain signals)
  - • C4 – A1, C3 – A2
  - • O2 – A1, O1 – A2
- • EOG (eye muscle activity)
  - • LOC (left eye) and ROC (right eye)
- • EMG (chin muscle activity)
  - • EMG s (chin = sub-mental)

**Respiration**
- • Airflow (Oral - Thermistor, Nasal pressure - Cannula)
- • Respiratory Effort
  - • Thorax (Ribcage)
  - • Abdomen (Diaphragm)
- • Pulse Oximetry
  - • SaO₂ (Oxygen saturation)
  - • Pulse
- • Body position
- • Transcutaneous CO₂ (when requested)
- • Microphone (snoring)

**Cardiac status**
- • ECG

**Muscle Activity**
- • EMG leg EMG t (anterior tibialis muscle – along shin)
Setting up for the Sleep Study
Head Measurement
10-20 System EEG electrode placement landmarks
Setting up for the Sleep Study
Site preparation and glue-on Electrode Application
Setting up for the Sleep Study
Application of ‘Respi-Bands’, Leg electrodes and Nasal Cannula
Setting up for the Sleep Study
Application of Nasal Cannula
Setting up for the Sleep Study
Connection of Patient to ‘Headbox’
The Diagnostic Sleep Study
Overnight attended monitoring of patient and data signals in the sleep unit
Brief Digression

Sleep Unit PSG?  or  Portable PSG?
Sleep Unit based PSG

- Performed for over 30 years.
- Considered ‘gold standard’. Usually conducted within a hospital sleep unit or sleep clinic.
- Patient is ‘attended’ overnight by a Scientist, Nurse or Medical staff.
- Patient well being and signal quality/data integrity is monitored and maintained.
- PSG hardware capable of 27+ channels for data capture.
- Video monitoring.
- Pressure titration of CPAP or Bilevel machines can be performed by a scientist, nurse or medical staff.
Portable (home based) PSG

• Performed for approximately 12 years in Australia.
• Usually conducted in the patient’s home after evening clinic ‘set-up’. Reduced cost.
• Non-attended.
• Potential for data loss if lead/s dislodged.
• Usually no video monitoring.
• 2007 - portable PSG hardware invented capable of measuring majority of sleep unit based channels.
• Some sleep service providers, chemists and other outlets still using single or double channel monitoring devices – NOT PSG -risk of false positives, false negatives sleep study results.
• Medicare Australia intervention 2008 - 2010
# Portable Monitoring Devices 2010

<table>
<thead>
<tr>
<th>Device</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stadius II</td>
<td>Portable monitoring device for monitoring respiratory parameters.</td>
</tr>
<tr>
<td>Apnoelink</td>
<td>Provides continuous monitoring of respiratory parameters.</td>
</tr>
<tr>
<td>LifeShirt</td>
<td>Device for monitoring respiratory parameters with a comfortable design.</td>
</tr>
<tr>
<td>Apnoelink Evolution System (EES)</td>
<td>Extends monitoring capabilities with enhanced sensors.</td>
</tr>
<tr>
<td>Somite</td>
<td>Device for monitoring respiratory parameters with advanced detection sensors.</td>
</tr>
<tr>
<td>Somite PSG</td>
<td>Portable monitoring device with PSG (Polysomnography) functionality.</td>
</tr>
<tr>
<td>EmiTitle® Gold</td>
<td>High-performance device for comprehensive monitoring of respiratory parameters.</td>
</tr>
<tr>
<td>SleepTrek3</td>
<td>Portable device for monitoring respiratory parameters with advanced features.</td>
</tr>
<tr>
<td>WatchPAT2010</td>
<td>Device for continuous monitoring of respiratory parameters.</td>
</tr>
</tbody>
</table>

### Monitor Specifications

<table>
<thead>
<tr>
<th>Model</th>
<th>Channels</th>
<th>Data Parameters</th>
<th>Accessories</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trax</td>
<td>12</td>
<td>Respiratory</td>
<td></td>
</tr>
<tr>
<td>TrackIt Sleep</td>
<td>4</td>
<td>Respiratory</td>
<td></td>
</tr>
<tr>
<td>TrackIt 8+8</td>
<td>6</td>
<td>Respiratory</td>
<td></td>
</tr>
<tr>
<td>Alice® PDM®</td>
<td>18</td>
<td>Respiratory</td>
<td></td>
</tr>
</tbody>
</table>

### Monitoring Features

- **Portable Monitoring Devices 2010**
- **Channels**: 4-32 Channels
- **Parameters**: Respiratory, Heart Rate, Blood Pressure, Oxygen Saturation, etc.
- **Accessories**: Portable, Rechargeable Batteries, Carrying Case, etc.
10. **MSAC’s advice to the Minister**

After considering the strength of the available evidence in relation to safety, effectiveness and cost-effectiveness, MSAC supports public funding for the use of Level 2 unattended sleep studies for investigation of obstructive sleep apnoea (OSA) for a duration of at least 8 hours, for an adult aged 18 years and over, where:

(a) the patient is referred for the investigation by a medical practitioner who has formed a reasonable clinical view that the patient has a high probability of having OSA

*[(b)](the necessity for the investigation is determined by a qualified sleep medicine practitioner (as defined in the explanatory notes to the MBS) prior to the investigation;)]*[referred study]*

(c) a qualified sleep medicine practitioner has:
   (i) established quality assurance procedures for the data acquisition; and
   (ii) personally analysed the data and written the report;

(d) during a period of sleep, the investigation is a recording of a minimum of seven channels which must include continuous EEG, continuous ECG, airflow, thoraco-abdominal movement, oxygen saturation; and two or more of EOG, chin EMG and body position.

(e) interpretation and report of the investigation (with analysis of sleep stage, arousals, respiratory events and assessment of clinically significant alterations in heart rate) are provided by a qualified sleep medicine practitioner based on reviewing the parameters recorded under (d) above.
Regulation and Best Practice Guidelines
American Academy of Sleep Medicine
Clinical Guidelines for the use of unattended portable monitors 2007

Based on a review of literature and consensus, the Portable Monitoring Task Force of the American Academy of Sleep Medicine (AASM) has developed the following recommendations: unattended portable monitoring (PM) for the diagnosis of obstructive sleep apnea (OSA) should be performed only in conjunction with a comprehensive sleep evaluation. Clinical sleep evaluations using PM must be supervised by a physician with board certification in sleep medicine or an individual who fulfills the eligibility criteria for the sleep medicine certification examination. PM may be used as an alternative to polysomnography (PSG) for the diagnosis of OSA in patients with a high prevalence of obstructive sleep apnea (OSA). PM is not appropriate for the diagnosis of OSA in patients with significant cardiac or medical conditions that may preclude the accuracy of PM. PM is not appropriate for the diagnosis of OSA in patients with a history of obstructive sleep apnea (OSA), patients with a history of obstructive sleep apnea (OSA), or patients with a history of obstructive sleep apnea (OSA) or a history of obstructive sleep apnea (OSA).

As a minimum, PM should include multichannel monitoring and a respiratory effort and a respiratory index conventionally used for in-laboratory studies should be used in PM.

The current standard for clinical practice, established through evidence-based reviews by the American Academy of Sleep Medicine (AASM), is to conduct the diagnosis of obstructive sleep apnea (OSA) with in-laboratory polysomnography (PSG). This method has been shown to be accurate with a low failure rate because the study is conducted in a sleep laboratory. PSG, however, is considered costly and is not feasible for mass screening. PM provides an alternative diagnostic test that is less expensive and is more practical for mass screening. PM can be used as an alternative to PSG for the diagnosis of OSA, but it should not be used as a substitute for PSG. PM should be considered for use in some clinical situations, such as in patients with obstructive sleep apnea (OSA) and in patients with mild to moderate obstructive sleep apnea (OSA).

Disclosure Statement
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1.2.1. PM is not appropriate for the diagnosis of OSA in patients with significant comorbid medical conditions that may degrade the accuracy of PM, including but not limited to, moderate to severe pulmonary disease, neuromuscular disease, or congestive heart failure.

1.2.2. PM is not appropriate for the diagnostic evaluation of OSA in patients suspected of having sleep disorders, including central sleep apnea, periodic limb movement disorder (PLMD), insomnia, parasomnias, circadian rhythm disorders, or narcolepsy.
Objective Testing – Our Service
Portable Sleep Study performed with Somte PSG device


Meets AASM (2007) guidelines as a Level 2 device.

14 – 27 channels including multiple EEG for precise sleep staging by scientist.

Clinically robust data capture – no false positive or negative results.
**Instructions for use**

**Before bed:** Please check the display on your Somnate PSG. If there is a lead that has been dislodged or is faulty it will be displayed or will flash e.g. EEG or O2.

You will need to reattach this lead if it has been dislodged. Refer to the handout for the locations and colours of all the leads.

**23 Jul 2006 22:07**

**Problems at night:** If you require assistance at night there is 24 hour help available.

**Sleep Specialists on-call support on:** 0418 511 200 (Please note: on-call support will return your call so minimum call costs apply).

**In the morning:** You will need to return to Pioneer Valley Hospital between 8-9am for the removal of leads by a technician. Please ensure all equipment and paperwork is returned.

**Warning**
- Do not get the equipment wet (no washing up, shower or bathing children)
- Do not expose to extreme high or low heat
- Turn off all electrical equipment within your bedroom (e.g. mobile phones, electric bed/blankets)
- Do not drop or damage the unit
- Do not change the batteries
- Do not participate in physical activity while wearing the device

**Location and Colour of Leads**

- **Purple**
- **Blue**
- **Green**
- **White**
- **Red**
- **Black**
- **Orange**
- **Yellow**

**Other Leads**

- **Flow**
- **AUX**
- **Oximeter**
- **Limb**
- **ThO**
- **ABD**
- **Thoracic hand EMG/TOF**
- **Abdominal band (PEO time)**

**Free call:** 1800 155 225 or (07) 3870 2144
Web: sleepspecialists.com.au E-Mail: sleep@sleepspecialists.com.au

**GOLD COAST**
Brisbane Townsville Sunshine Coast Mackay Darwin Townsville Maryborough Hervey Bay
PSG Analysis

Study data is scored by a qualified Sleep Scientist and reported by Sleep Physician
Diagnostic Sleep Study Signals
Awake

**Awake - eyes closed**

- **EEG**: Alpha waves – 8-13Hz
- **EOG**: Reflects EEG
- **EMG**: highest level of recording

**Awake - eyes open**

- **EEG**: small amplitude, mixed frequency
- **EOG**: blinks
- **EMG**: highest level of recording
Stage 1 Sleep

EEG: Slower activity than wake, can see each distinct wave.

EOG: Rolling eye movements, sinusoidal waves in opposing directions.

EMG: Slightly reduced from wake.
Stage 2 Sleep

- **K-complex**: Sharp negative wave followed by positive.
- **Spindle**: 12-14Hz, >0.5 seconds duration
Stage 2 Sleep

EEG: Presence of spindles or K-complexes
EOG: No movements but may reflect EEG activity
EMG: Slightly reduced
Stage 3 Sleep

EEG: 20-50% of the epoch has waves 75μV in amplitude, of frequency less than 4 cycles per second.

EOG: No movement. May reflect EEG waves.

EMG: Slightly reduced.
Stage 4 Sleep

EEG: more than 50% of the epoch has waves 75µV in amplitude, of frequency less than 4 cycles per second

EOG: No movement. May reflect EEG waves

EMG: Slightly reduced.
REM Sleep

Sawtooth wave
Low amplitude wave with sawtooth appearance
REM Sleep

- EEG: small amplitude, mixed frequency. May have sawtooth waves. Resembles awake with eyes open.
- EOG: rapid eye movements in opposing directions.
- EMG: reduced to lowest level of recording.
Normal Sleep Architecture

- Normal sleep cycle:

  Stage 1  4%
  Stage 2  38%
  Stage 3  4%
  Stage 4  16%
  REM      16%

(Mathur and Douglas, 1995)
Bruxism

Rhythmic muscle activity, reflected in EEG/EOG channels
REM Behaviour Disorder

Increased EMG, reflected in EEG/EOG
Diagnostic Sleep Study Signals
What happens when an individual has obstructive sleep apnoea?
What happens when an individual has obstructive sleep apnoea?
Snoring
What happens when an individual has obstructive sleep apnoea?
Hypopnoea
What happens when an individual has obstructive sleep apnoea?
What happens when an individual has obstructive sleep apnoea?
Obstructive Sleep Apnoea

Obstructed Airway

2 minutes
Obstructive Sleep Apnoea

Drop in oxygen level to 82% (normal >95%) as a result of the obstructed airway
Obstructive Sleep Apnoea

Arousal from sleep due to obstruction and brain stimulating patient to breathe
What happens when an individual obstructs?

OSA haemodynamic and autonomic effects

Morgan et al, 1996.
Effects of obstructive sleep apnoea

Hypertension
Coronary artery disease
Congestive heart failure
Transient Ischaemic Attacks/
Cerebrovascular Accidents
Atrial Fibrillation
Type 2 Diabetes/ Insulin resistance
Severity of Obstructive Sleep Apnoea

Total number of complete cessations (apnoea) and partial obstructions (hypopnoeas) of breathing occurring per hour of sleep. These pauses in breathing must last for 10 seconds and are associated with a decrease in oxygenation of the blood.

Respiratory Disturbance Index (RDI)  
- <5 /hr Normal
- 5-14 /hr Mild
- 15-30 /hr Moderate
- > 30 /hr Severe

Severe patients can obstruct over 150 times per hour (over 1000 times per night).
The Sleep Report – Obstructive Sleep Apnoea

Architecture

Arousals

SaO₂

Respiratory Events

Heart Rate

Body Position

Time

<table>
<thead>
<tr>
<th>Time</th>
<th>Hrs</th>
<th>Epoch</th>
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</thead>
<tbody>
<tr>
<td>22:08:58</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>6:08:58</td>
<td>8</td>
<td>961</td>
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</table>
CPAP – Continuous Positive Airway Pressure

- Considered Gold Standard treatment for Obstructive Sleep Apnoea.
- Air passes through a mask into the patient’s nose and/or mouth, and into the throat, where the slight pressure acts as a splint to keep the patient’s airway open and prevent obstruction.
CPAP – Continuous Positive Airway Pressure Titration PSG
CPAP pressure titration PSG:
At 2214hrs the patient is obstructing on 4cm.
CPAP pressure titration PSG: At 2238hrs patient continues to obstruct, pressure is increased to 8cm and then 9cm.
CPAP pressure titration PSG:
At 0128hrs on 13cm in SWS, consistent airflow shape and normal oxygen level.
CPAP Works - Airway CT Scan
CPAP pressure titration PSG:
Entire night summary

- Arousals reduced to normal range
- Sleep architecture consolidated
- Optimal oxygenation maintained
Effects of OSA and CPAP

Marin et al, Lancet 2005
Daytime PSG –
Multiple Sleep Latency Test
(MSLT)

- Measures the rapidity of the patient falling asleep
- Conducted the day after a Diagnostic Study
- Subject while lying down is asked to sleep (20 minutes)
- If the patient falls asleep in 20 minutes, he is given another 15 minutes to get into REM stage
- Measures Sleep Latency (time taken to fall asleep) Measure REM Latency
- Important in the diagnosis and confirmation of Narcolepsy
- Repeated 5 times every 2 hours throughout the day
MSLT – Nap 1
MSLT – Nap 3
MSLT – Nap 4
### Multiple Sleep Latency Test

<table>
<thead>
<tr>
<th>Mean Sleep Latency</th>
<th>REM Onsets (in 5 naps)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10-15 min</td>
<td>MILD 0-1 NORMAL</td>
</tr>
<tr>
<td>5-10 min</td>
<td>MODERATE &gt; 2 ABNORMAL</td>
</tr>
<tr>
<td>&lt; 5 min</td>
<td>SEVERE</td>
</tr>
</tbody>
</table>

Diagnosis of Narcolepsy = mean sleep latency < 10 mins with 2 or more REM periods in any of the naps
Conclusion

- Polysomnography (PSG) can be viewed as an important adjunct to existing fatigue management training and subjective and other physiologic measures of sleepiness.
- PSG is an objective measure of sleepiness, sleep quality and sleep quantity in addition to other variables.
- PSG permits the medical diagnosis of an underlying sleep disorder.
Conclusion

• Not all Portable (Home) sleep study devices and sleep services in Australia meet current Medicare guidelines.
• Not all sleep services will provide local access to a Sleep Physician for consultation.
• Not all sleep services will be able to perform all of these tests.
• Not all sleep services will provide ongoing support for patients commencing treatment.

The onus is on each organisation to locate a sleep service that can meet the above criteria and provide optimal testing and treatment pathways.
Respiratory and Sleep Specialists
Sleep Investigation Units

- Moranbah Medical Centre Moranbah
- Moranbah Medical Centre Moranbah (21 years in 2010)
- St Vincent’s Hospital Toowoomba
- Wesley Medical Centre Brisbane
- Wesley Medical Centre Brisbane (21 years in 2010)
- St Stephen’s Hospital Maryborough
- Pindara Private Hospital Benowa
- Darwin Private Hospital
- Pioneer Valley Private Hospital Mackay
- Pioneer Valley Private Hospital Mackay (12 years in 2010)
- Kawana Private Hospital Sunshine Coast
- John Flynn Private Hospital Gold Coast (12 years in 2010)
- St Andrew’s Private Hospital Toowoomba (12 years in 2010)
- RiverCity Private Hospital Brisbane
- Wesley Hospital Brisbane (12 years in 2010)
- Wesley Hospital Brisbane (21 years in 2010)
- Wesley Hospital Brisbane (21 years in 2010)
- Wesley Hospital Brisbane (21 years in 2010)

Respiratory and Sleep Specialists
Sleep Investigation Units
Respiratory and Sleep Specialists
Portable Sleep Services

- John Flynn Hospital Tugun
- Blackwater
- Mackay Pioneer Valley Hospital
- Stanthorpe Health and Daily Living Solutions
- Bundaberg Sunshine Sleep and Hearing
- Moranbah
- Tieri
Sleep Investigation Unit
Bowen Basin Sleep Health Centre
Questions/Discussion?