

# **Pediatric Sleep/Circadian Disorders: Management Tools and Strategies.**

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**CNHN Future of Pediatrics**  
**Bethesda, Maryland**  
**June 13, 2018**



# Outline

- *Brief update on basic mechanisms of sleep and circadian science and mechanisms*
- *Common Sleep Disorders*
- *The brief assessment*
- *Intervention Strategies*

# What is sleep?



*“Sleep is a reversible behavioral state of perceptual disengagement from and unresponsiveness to the environment. It is also true that sleep is a complex amalgam of physiological and behavioral processes”.*

*(Carskadon & Dement)*

# SLEEP DISORDERS

PSYCHOPHYSIOLOGICAL INSOMNIA

SLEEP STATE MISPERCEPTION

IDIOPATHIC INSOMNIA

NARCOLEPSY

RECURRENT HYPERSONNIA

IDIOPATHIC HYPERSONNIA

POSTTRAUMATIC HYPERSONNIA

OBSTRUCTIVE SLEEP APNEA SYNDROME

CENTRAL SLEEP APNEA SYNDROME

CENTRAL ALVEOLAR HYPOVENTILATION SYNDROME

PERIODIC LIMB MOVEMENT DISORDER

RESTLESS LEGS SYNDROME

INADEQUATE SLEEP HYGIENE

ENVIRONMENTAL SLEEP DISORDER

ALTITUDE INSOMNIA

ADJUSTMENT SLEEP DISORDER

INSUFFICIENT SLEEP SYNDROME

LIMIT-SETTING SLEEP DISORDER

SLEEP-ONSET ASSOCIATION DISORDER

FOOD ALLERGY INSOMNIA

NOCTURNAL EATING (DRINKING) SYNDROME

HYPNOTIC-DEPENDENT SLEEP DISORDER

STIMULANT-DEPENDENT SLEEP DISORDER

ALCOHOL-DEPENDENT SLEEP DISORDER

TOXIN-INDUCED SLEEP DISORDER

TIME ZONE CHANGE (JET LAG) SYNDROME

SHIFT WORK SLEEP DISORDER

IRREGULAR SLEEP-WAKE PATTERN

DELAYED SLEEP PHASE SYNDROME

NON-24 HOUR SLEEP-WAKE DISORDER

CONFUSIONAL AROUSALS

SLEEPWALKING

SLEEP TERRORS

RHYTHMIC MOVEMENT DISORDER

SLEEP STARTS

SLEEP TALKING

NOCTURNAL LEG CRAMPS

NIGHTMARES

SLEEP PARALYSIS

IMPAIRED SLEEP-RELATED PENILE ERECTIONS

REM SLEEP-RELATED SINUS ARREST

REM SLEEP BEHAVIOR DISORDER

BRUXISM

ENURESIS

SLEEP-RELATED ABNORMAL SWALLOWING  
SYNDROME

NOCTURNAL PAROXYSMAL DYSTONIA

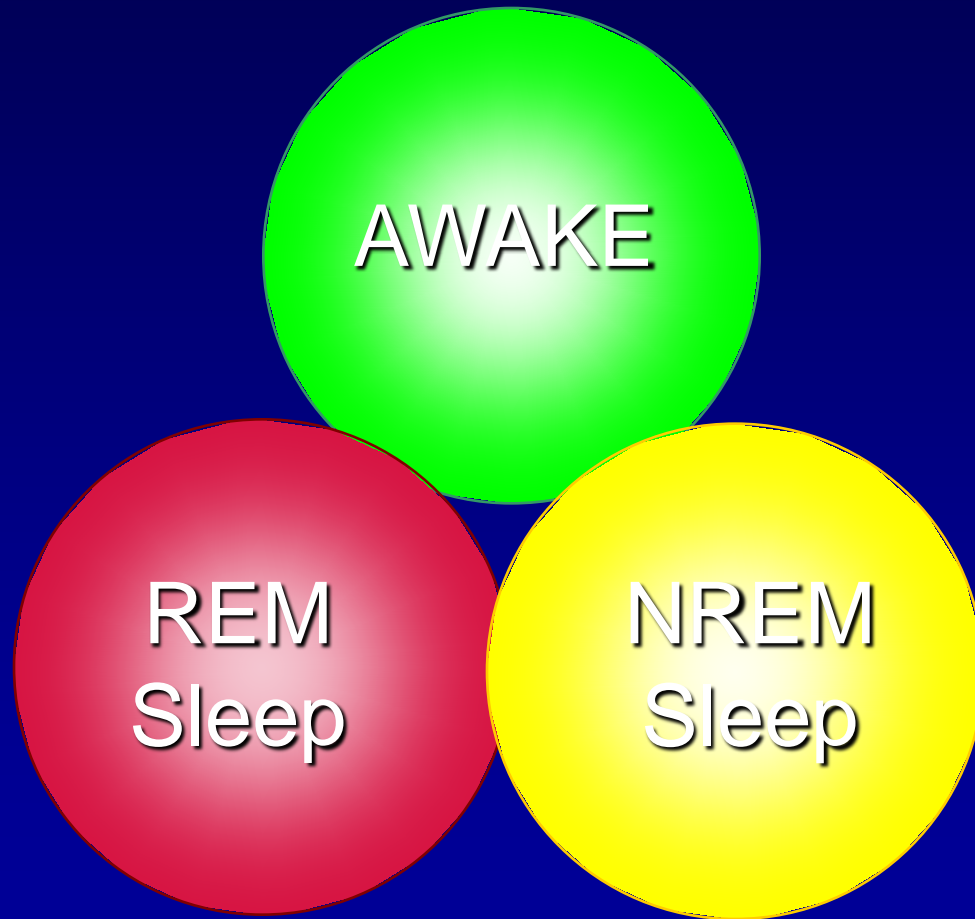
- SUDDEN UNEXPLAINED NOCTURNAL DEATH  
SYNDROME

SUDDEN INFANT DEATH SYNDROME

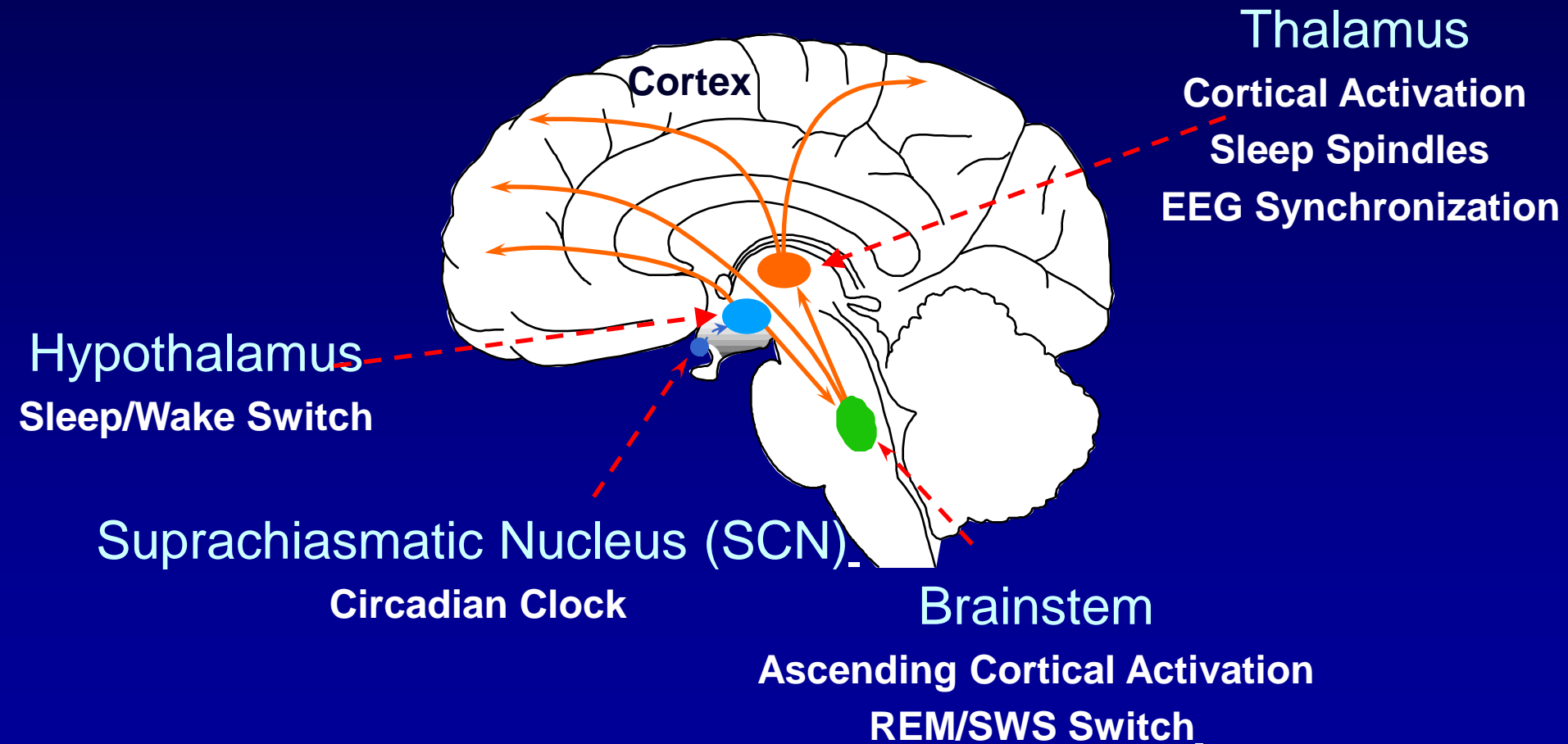
PRIMARY SNORING

INFANT SLEEP APNEA

# States of Being



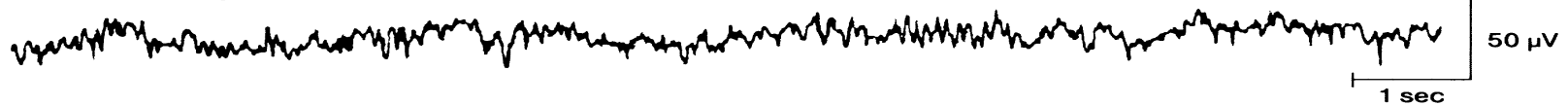
# Neurobiology of Sleep and Wake



SWS = slow-wave sleep

Awake

**Awake:** low voltage – random, fast



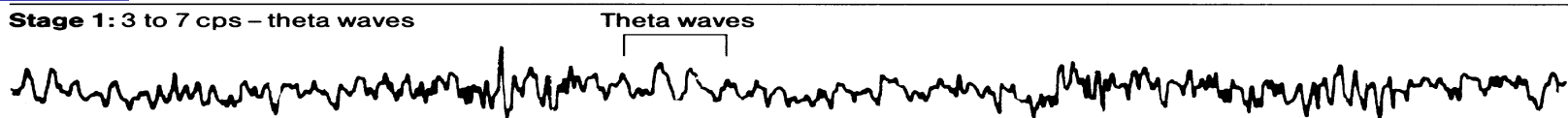
Drowsy

**Drowsy:** 8 to 12 cps – alpha waves



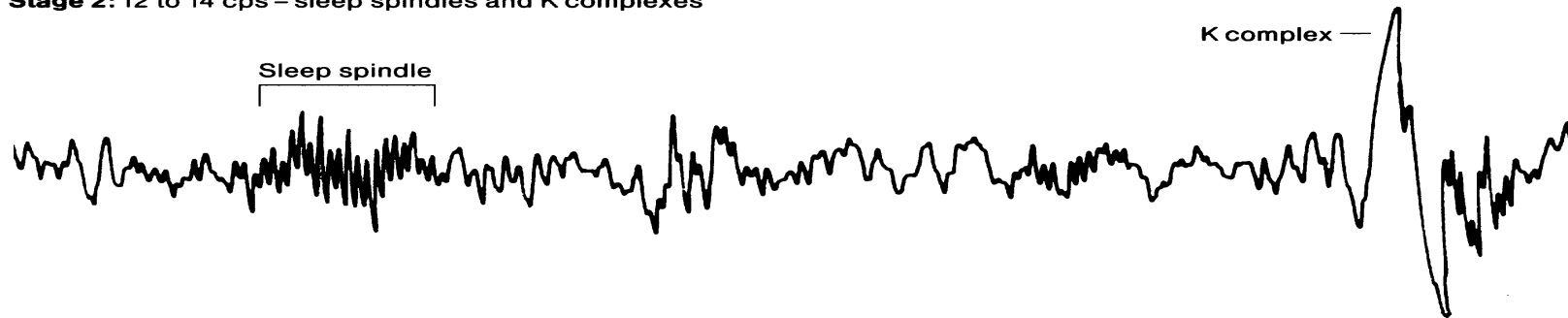
Stage 1

**Stage 1:** 3 to 7 cps – theta waves



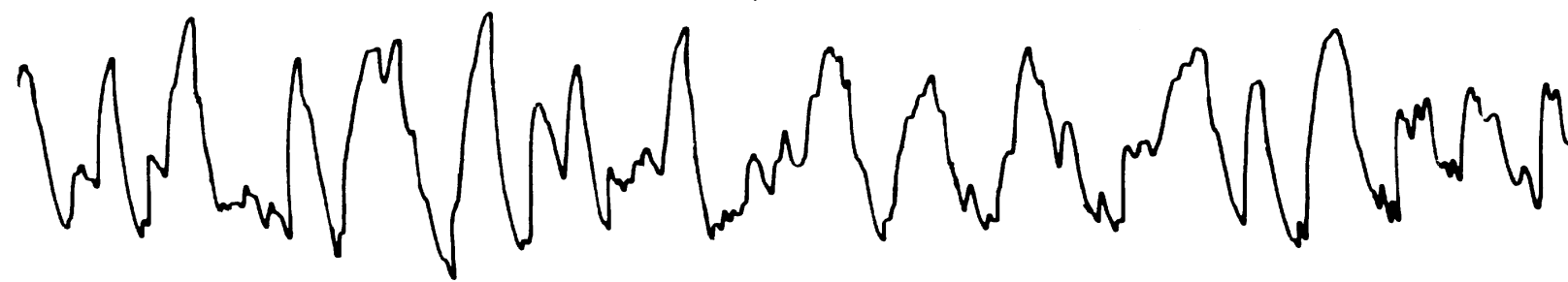
Stage 2

**Stage 2:** 12 to 14 cps – sleep spindles and K complexes



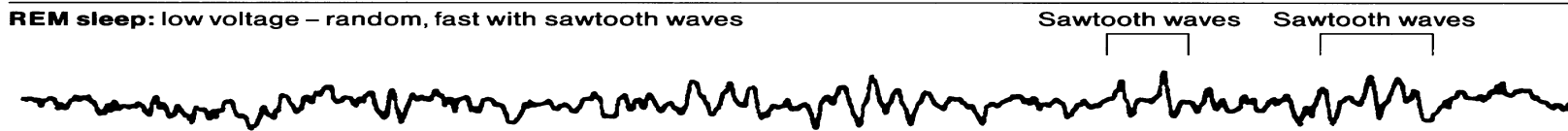
Stage 3

**Delta sleep:** (stages 3 and 4)  $1\frac{1}{2}$  to 2 cps – delta waves  $>75 \mu$ V



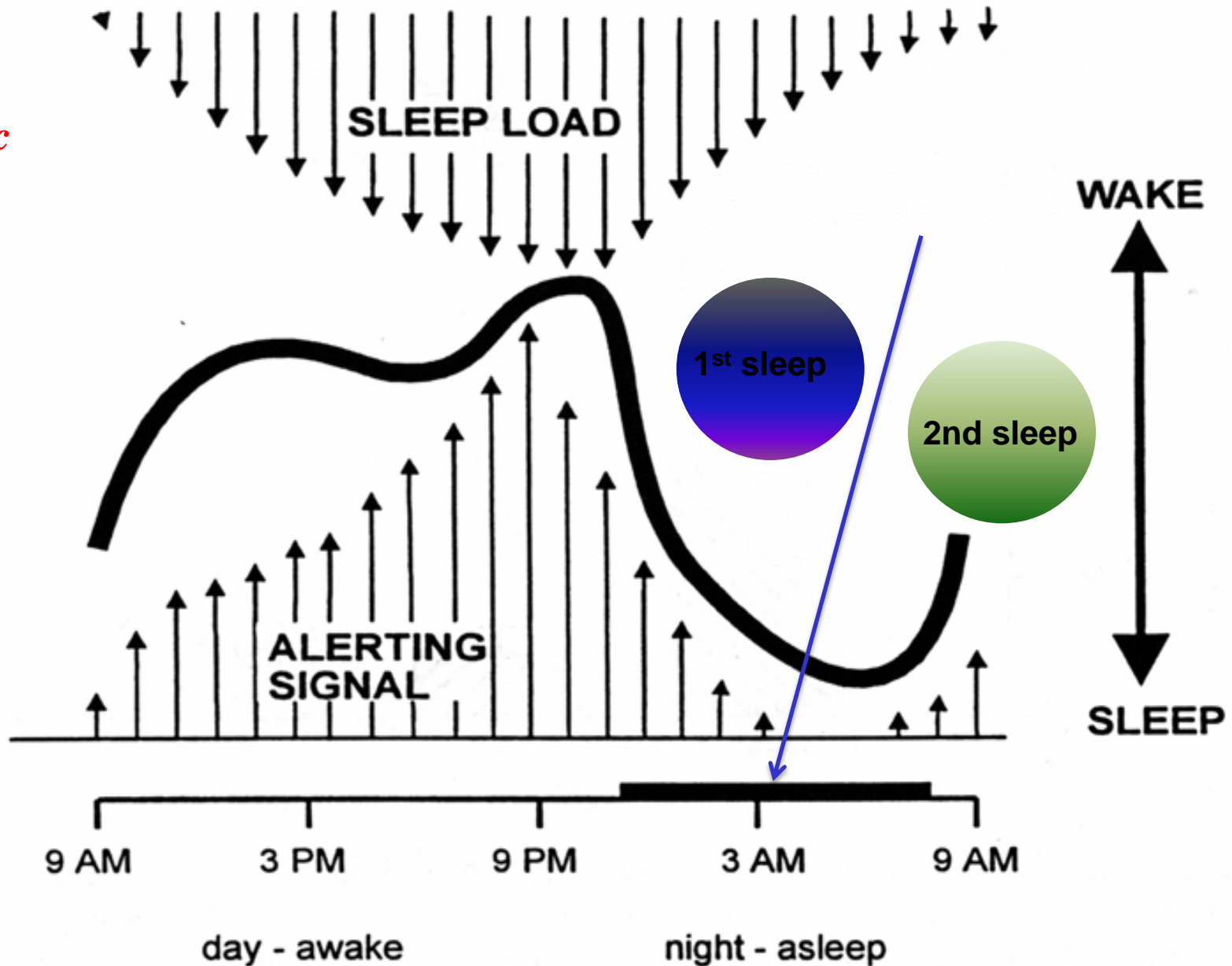
Stage  
REM

**REM sleep:** low voltage – random, fast with sawtooth waves



*Process S*  
*Sleep*  
*Homeostatic*

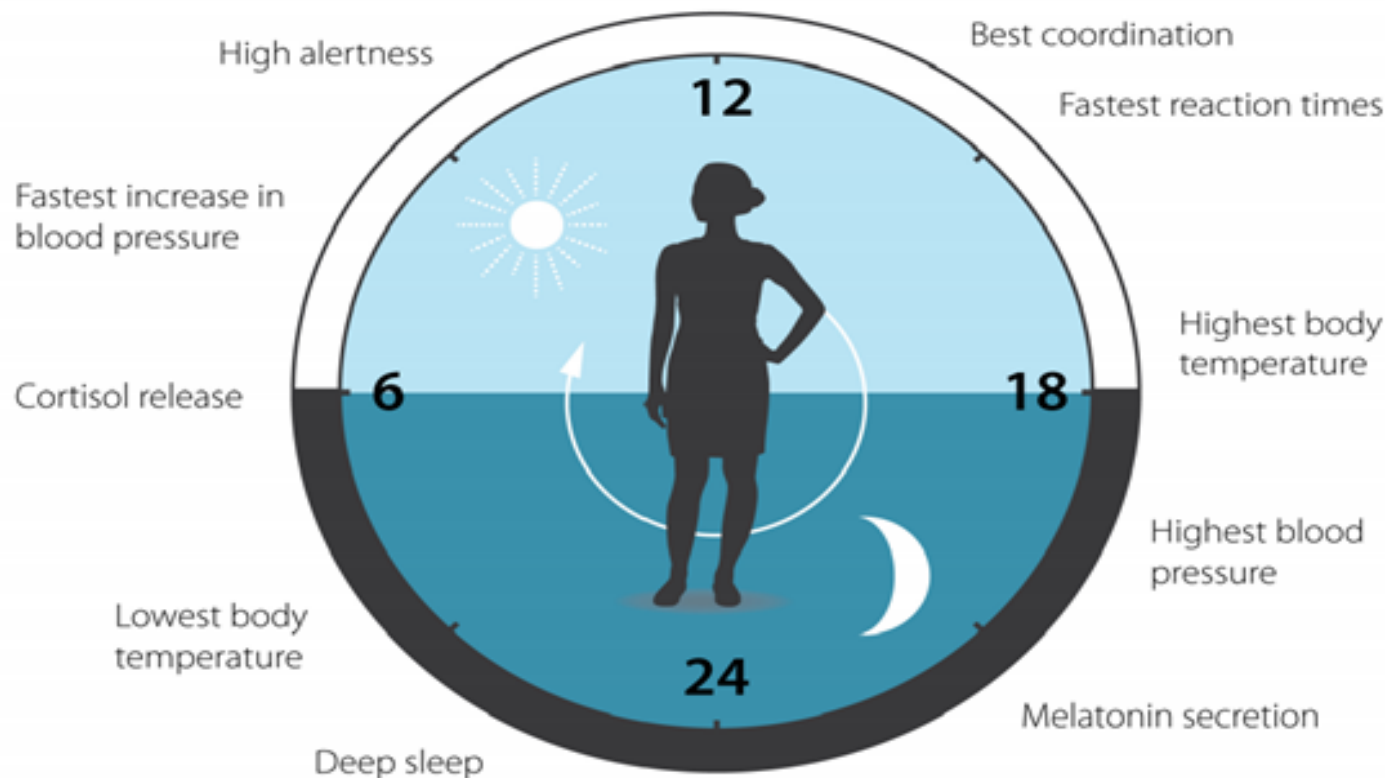
*Process C*  
*Circadian*







## Scientific Background Discoveries of Molecular Mechanisms Controlling the Circadian Rhythm

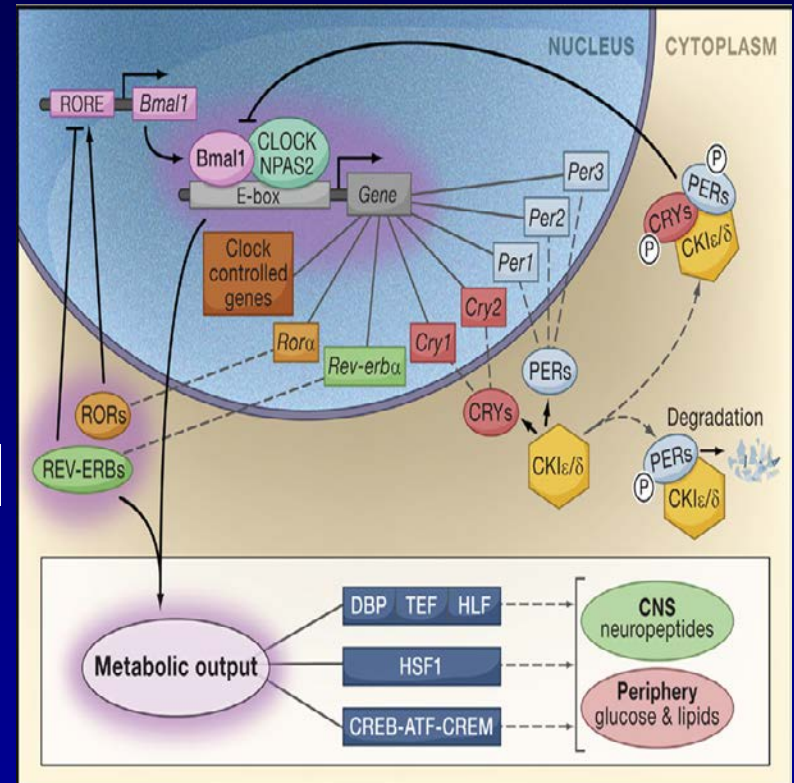


**Figure 3. The circadian clock has an impact on many aspects of our physiology.**

*This clock helps to regulate sleep patterns, feeding behavior, hormone release, blood pressure and body temperature. A large proportion of our genes are regulated by the clock.*

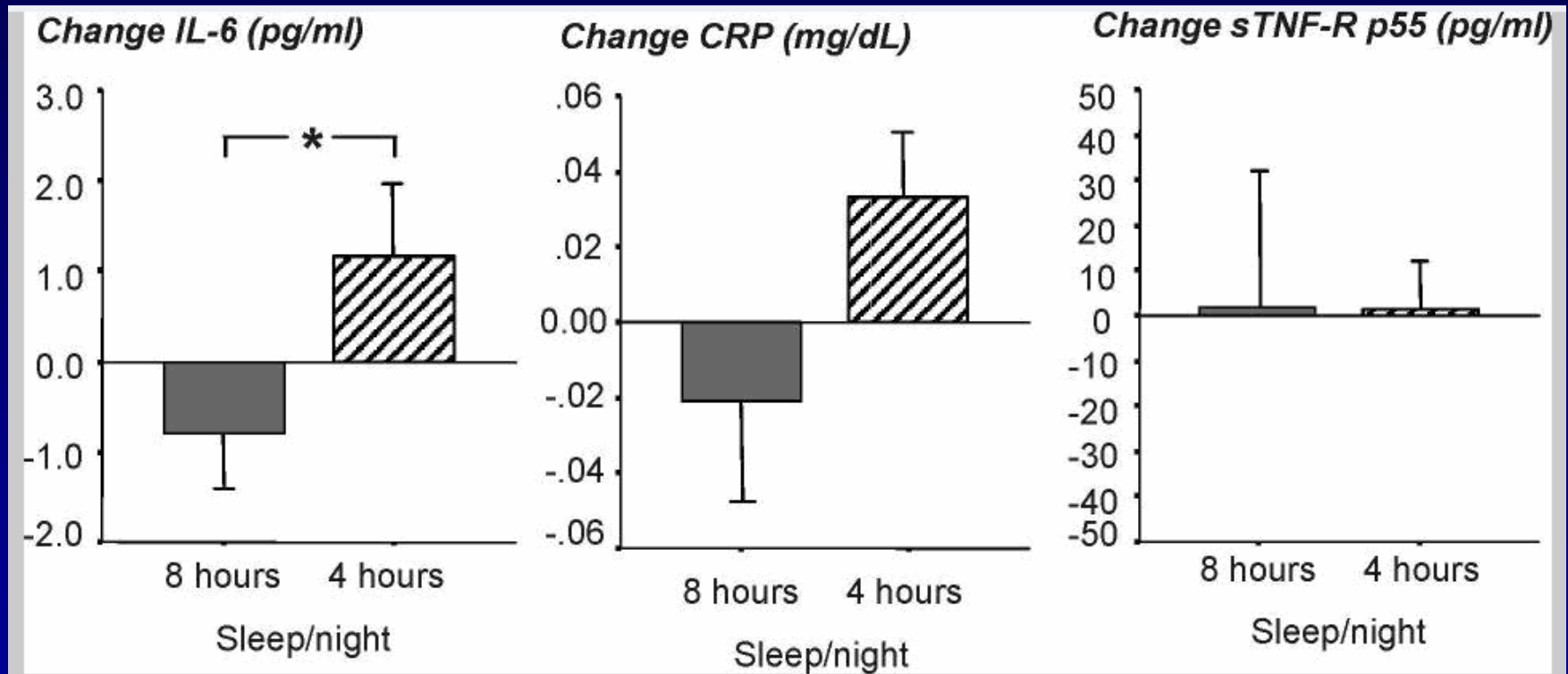
# Molecular Clocks in Cells

- Clocks and the sleep state regulate energy/metabolism, immune function and other essential biological processes through oscillations of enzyme release across day and night



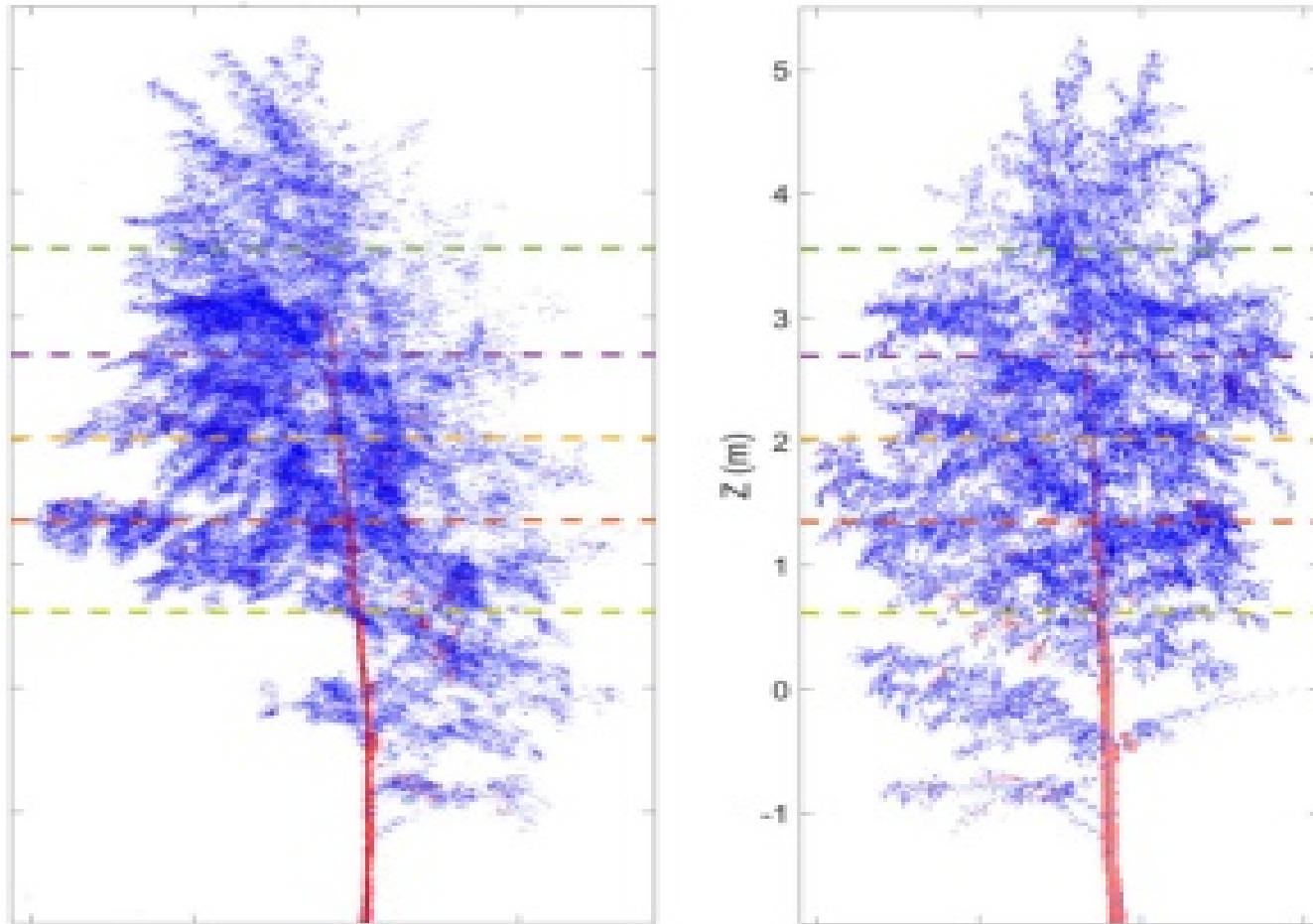
Marcheva, B, Ramsey, KM, Buhr, ED, et al. Disruption of the clock components CLOCK and BMAL1 lead to hypoinsulinaemia and diabetes. *Nature*, July 2010. 466; 627-631

# Sleep Duration Dependent Markers of inflammation



[Haack M](#) [Sanchez E](#) [Mullington JM](#). Elevated inflammatory markers in response to prolonged sleep restriction are associated with increased pain experience in healthy volunteers. *Sleep*. 2007, September1; 30(9): 1145-1152.

# Trees Sleep Too!

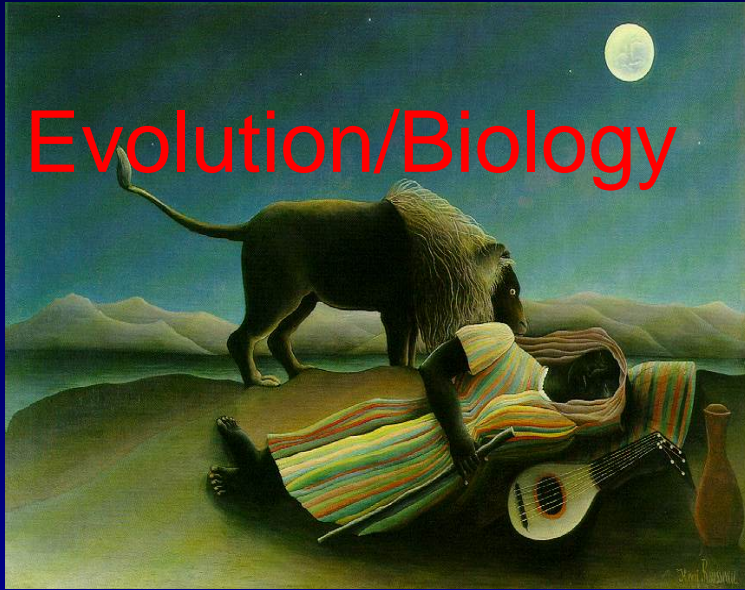


- Eetu Puttonen, Christian Briese, Gottfried Mandlbauer, Martin Wieser, Martin Pfennigbauer, András Zlinszky, Norbert Pfeifer. **Quantification of Overnight Movement of Birch (*Betula pendula*) Branches and Foliage with Short Interval Terrestrial Laser Scanning.** *Frontiers in Plant Science*, 2016; 7 DOI:



# What Mediates Sleep Propensity and Wakefulness

Evolution/Biology



Drugs/alcohol



Lifestyle choices



Light



Social/workplace



Vigilance



# Setting an Example!





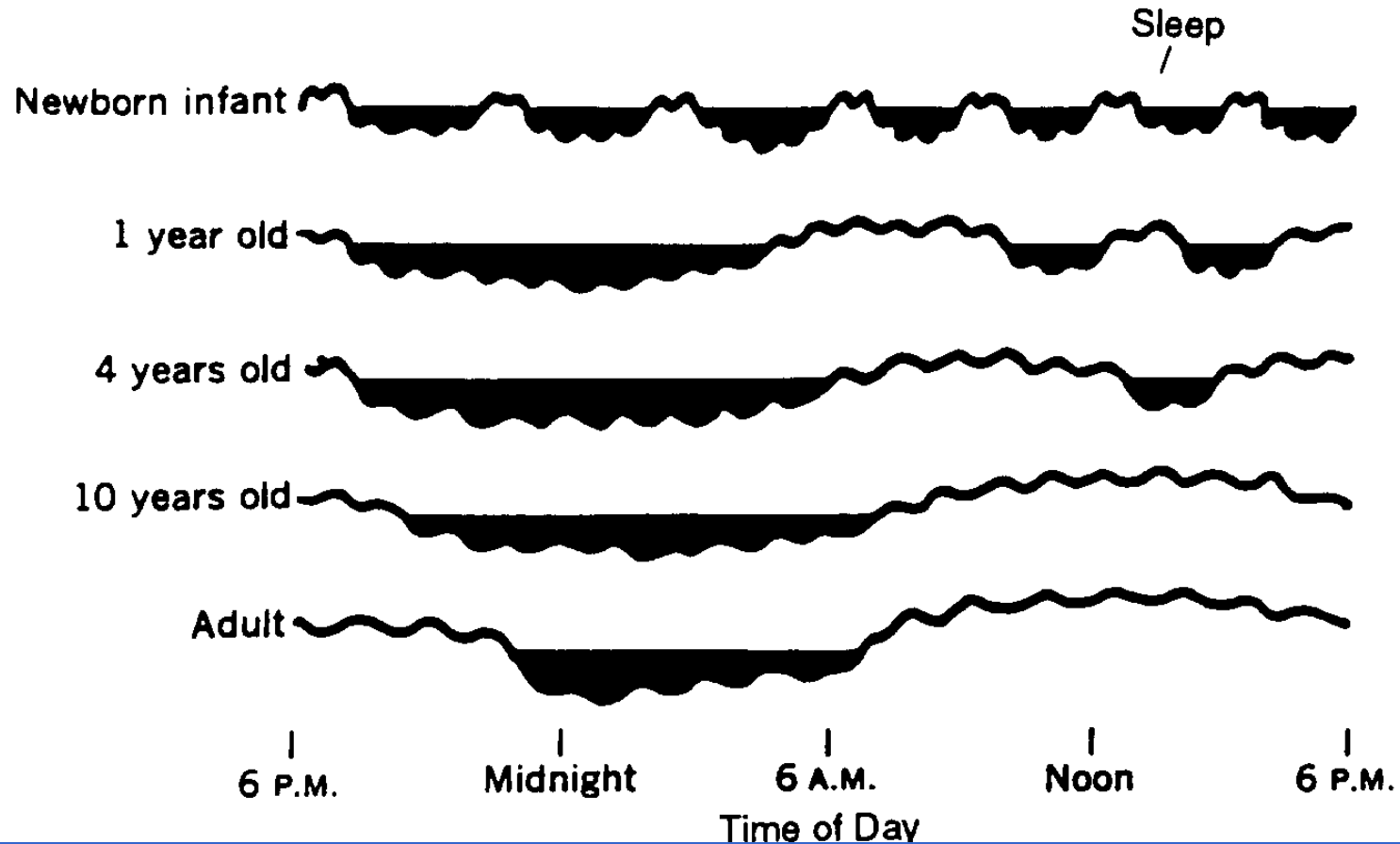
# National Sleep Foundation 2009 Survey

## Self reported poor vs. normal 'sleepers'

- Sleep needs are not being met (43% vs. 23%);
- They sleep less than 6 hours on a typical workday or weekday (30% vs. 15%);
- They use a “sleep aid” (43% at least a few nights a week vs. 26%); and/or
- They have been told by a doctor they have/had a sleep disorder (25% vs. 10%).

# Distribution of Sleep Periods

AS A CHILD DEVELOPS, ITS SLEEP GRADUALLY BECOMES RESTRICTED TO THE NIGHT



**Rosen, Gerald, Sleep Academic Award**



# Estimated Norms: Sleep Timing and Duration

| Age group                            | Duration and Timing                   | Population Study Switzerland<br>{Iglowstein, 2003 |
|--------------------------------------|---------------------------------------|---|
| Infants<br>1-18 months               | 13-18 hours<br>1-4 naps<br>6pm-6am    | 13.9-14.2 hours                                   |
| Toddlers and Pre-school<br>1-5 years | 11-12 hours<br>1 nap<br>6:30pm-7:00am | 11.4-13.5 hours                                   |
| School Age<br>6-10 years             | 10.5-11<br>7:30Pm-8:00am              | 9.9-11 hours                                      |
| Early Teens<br>11-14 years           | 9.5-10.5 hours<br>9:00pm-8:00am       | 8.1-9.6 hours                                     |
| Late Teens<br>15-19                  | 8.5-9.5<br>11:00pm-8:00am             |   |

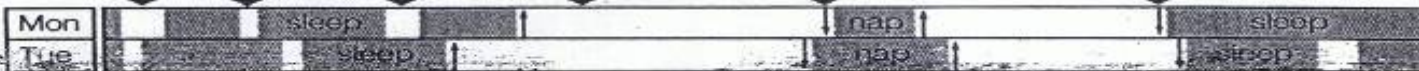
# Sleep Logs

DATE OF SLEEP RECORD: FR

## INSTRUCTIONS:

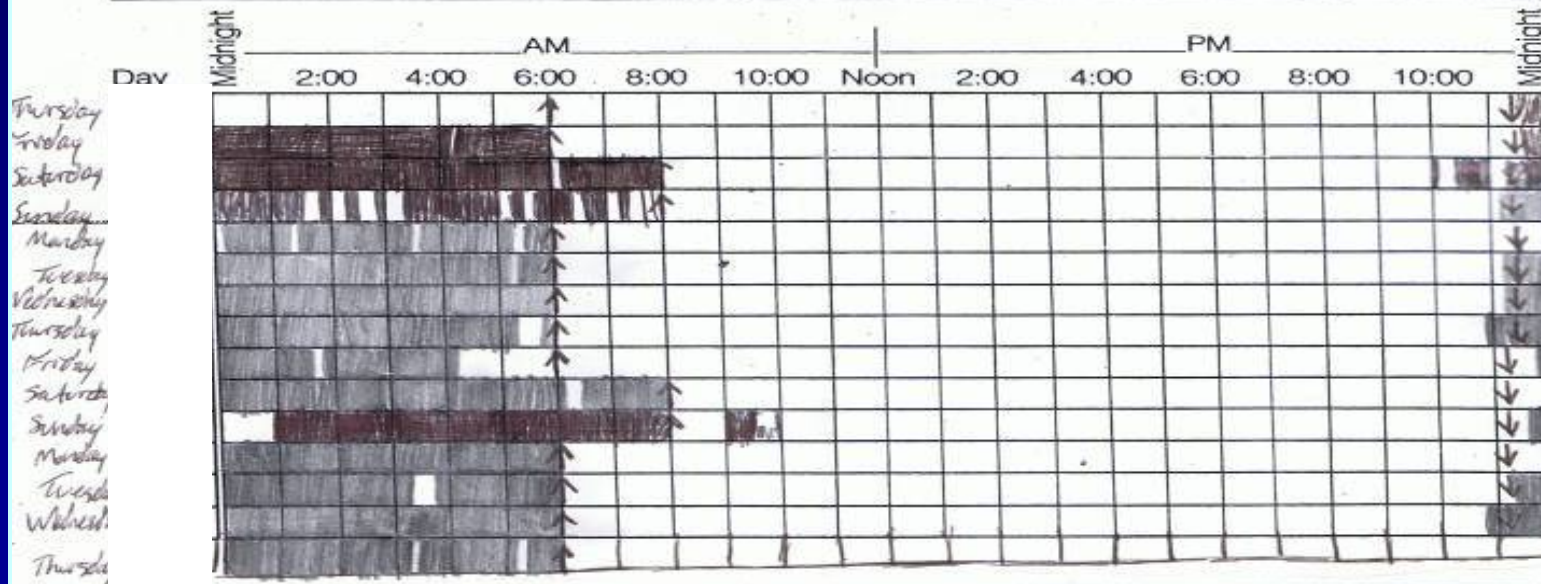
Leave blank the periods your child is awake.

Mark your child's bedtimes with downward-pointing arrows. ↓



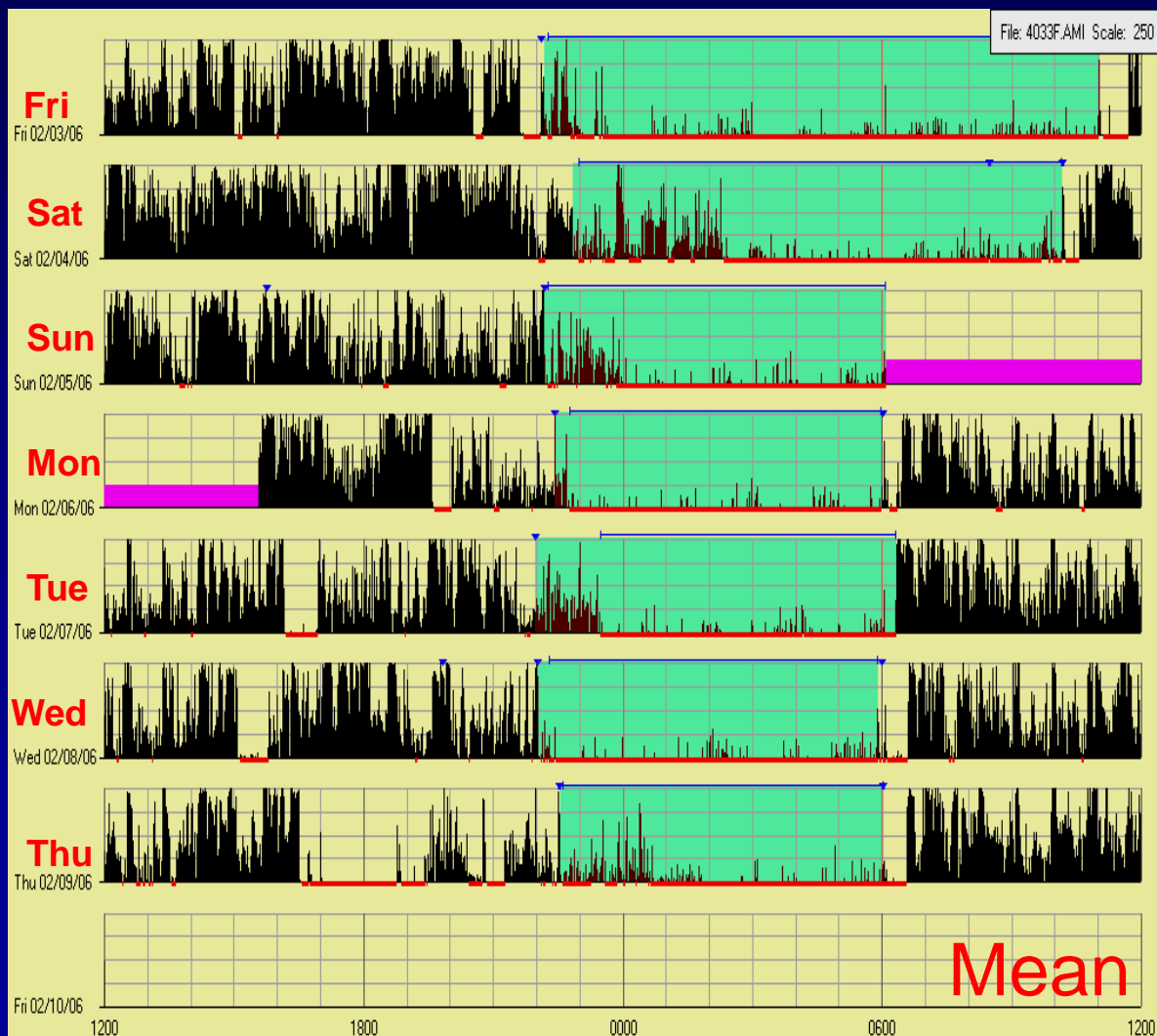
Fill in the times your child is asleep with shaded boxes.

Mark the times your child gets up in the morning and after naps with arrows pointing upwards. ↑



SPECIAL OBSERVATIONS AND NOTES

# Actigraphy



| TIB<br>TST             | SOL(log |
|------------------------|---------|
| 22:12-11:01<br>724     | 45      |
| 22:52-10:09<br>505     | 210     |
| 22:12-6:05<br>387      | 101     |
| 22:27-5:58<br>432      | 20      |
| 22:00-6:19<br>406      | 90      |
| 22:035:53<br>457       | 25      |
| 22:34-6:01<br>380      | 126     |
| 22:207:14<br>470 (120) | 88(67)  |

# Best Validated Test of Sleepiness



# The Sleep Habits Assessment

| <b>B</b> edtime  | <b>E</b> <sub>DS</sub><br><br>(Excessive Daytime<br>Somnolence)  | <b>A</b> wakenings   | <b>R</b> egularity  | <b>S</b> nororing   |
|--|--|--|---|---|
| <ul style="list-style-type: none"> <li>▪ Routine</li> <li>▪ Resistance</li> <li>▪ Fears</li> </ul> | <ul style="list-style-type: none"> <li>▪ Hyperactivity</li> <li>▪ Irritability</li> <li>▪ Difficulty waking</li> </ul> | <ul style="list-style-type: none"> <li>▪ Call outs</li> <li>▪ Partial Arousal</li> <li>▪ Restlessness</li> </ul> | <ul style="list-style-type: none"> <li>▪ Schedule</li> <li>▪ Age</li> </ul> | <ul style="list-style-type: none"> <li>▪ Volume</li> <li>▪ Pauses</li> <li>▪ Periodicity</li> </ul> |

Adapted from: Mindel, JA, & Owens. A Clinical Guide to Pediatric Sleep: Diagnosis and Management of Sleep Problems. Lippincott, Williams & Wilkins. Philadelphia (2003)

# When to order a sleep study

## Polysomnography (PSG)

- Snoring +
  - Pauses and gasping
  - Attention and affect dysregulation
  - Learning and behavior problems
  - Other sleep disorders (bed wetting parasomnia)
- Excessive daytime somnolence.

# Top 5 Sleep Assessment Topics

- **Difficulty falling asleep**
- **Difficulty staying asleep**
- **Daytime somnolence**
- **Defficient Sleep duration and timing**
- **Unplanned naps**
- **Snoring**

# Pediatric Sleep Disorders

| Category                       | Disorder   | Prevalence                      | Age range (yrs)                      |
|--------------------------------|--|---------------------------------|--------------------------------------|
| <b>Insomnia</b>                | Psychophysiological insomnia (307.42)<br>Behavior Insomnia of Childhood (V69.5)<br>-Sleep-Onset Association type<br>-Limmit Setting type       | ~20-50%<br>10-30%               | ~6-18<br>0.5 --8<br>0.5- ~3<br>~1--8 |
| <b>Sleep Related Breathing</b> | Primary Sleep Apnea of Infancy (770.81)<br>Obstructive Sleep Apnea, Pediatirc (327.23)<br>Congential Central Alveolar Hypoventilation (327.25) | 0.5%(healthy)<br>~3-5%<br><.01% | 0-0.2<br>0.2-18<br>Birth             |
| <b>Hypersomnia</b>             | Narcolepsy (347)<br>Kleine Levin Syndrome (327.13)<br>Behav Induced Insufficient Sleep Syndrome (307.44)                                       | >.02%<br>>.01%<br>?             | ?<br>~14<br>?                        |



# Pediatric Sleep Disorders

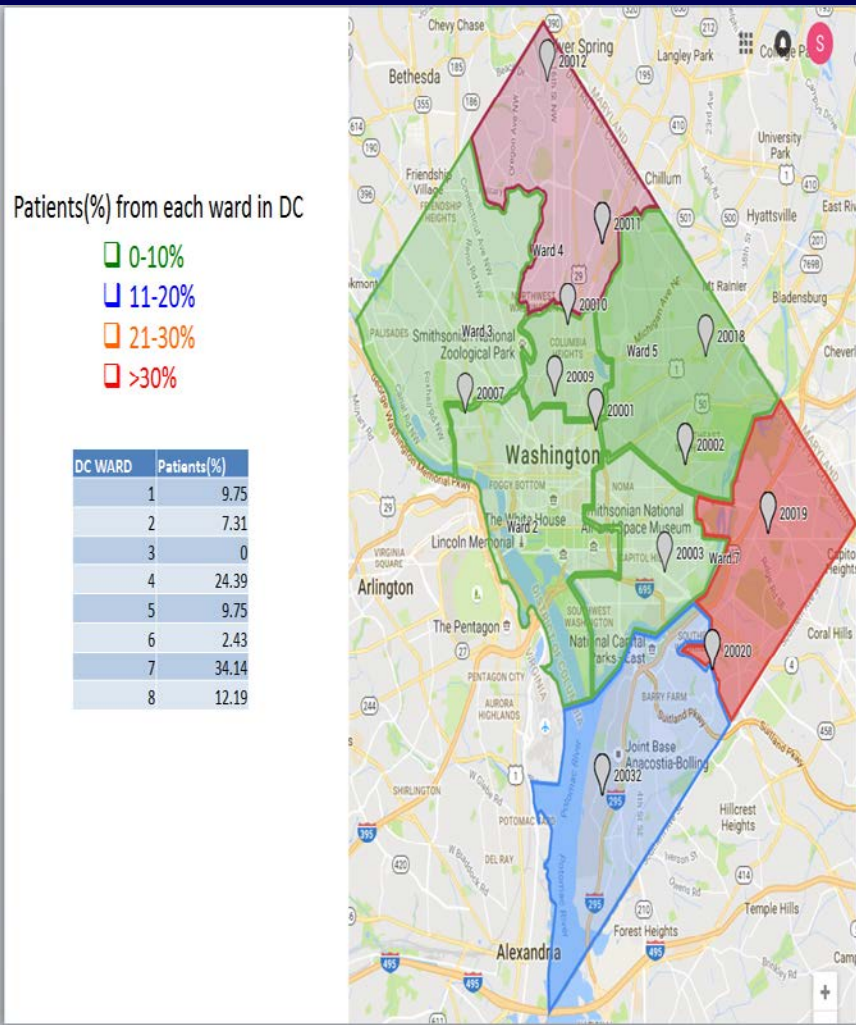
| Category                               | Disorder   | Prevalence                       | Age range (yrs)               |
|--|--|----------------------------------|-------------------------------|
| <b>Circadian Rhythm Sleep Disorder</b> | Delayed Sleep Phase Syndrome<br>Advanced Sleep Phase Syndrome  | >16%<br>?                        | >12<br>.5-6                   |
| <b>Parasomnias</b>                     | Confusional Arousals (327.41)<br>Sleep Walking (307.46)<br>Sleep Terrors (307.46)<br>Sleep Enuresis (788.36)                   | 17.5%<br>17%<br>1-6.5%<br>By age | <3-13<br><3-18<br><3-18<br>>4 |
| <b>Sleep Related Movement Disorder</b> | Restless Legs Syndrome (333.99)<br>Periodic Limb Movement Disorder (327.51)<br>Sleep Related Rhythm Movement Disorder (327.59) | <16%<br>?<br>3-6%                | ?<br>?<br>>.5                 |

# Pediatric Sleep Disordered Breathing

- Spectrum of disorders ranging from snoring to severe central and obstructive sleep apnea syndrome
- Definition: Partial and complete obstruction/cessation of airflow
- Prevalence of Obstructive Sleep Apnea (OSA)
  - 1.1-2.9% of 4-5 year-olds (Ali, 1993)
  - 4.7% of 8-11 year olds (Spillsbury, 2003)
    - 5.1 OR for residents of low SES neighborhoods
    - 3.9 OR for African American Children (1.9 after SES adjustment)
  - 13-33% of overweight children (Beebe, 2006)
  - 18% of children w/ behavior & academic problems (Gozal 2001)
- Prevalence of Primary Snoring
  - up to 12% children
- Upper airway resistance syndrome?

# OSA – Disparities

Sasukumar Kilakode-Cheruveettara & Gustavo Nino,  
American Thoracic Society Meeting, 2017



African American Children  
Median onset of symptoms  
for 24 months (IQR 12-43  
months), which was the  
double of that in  
Caucasian/White.  
Moreover, severe  
hypoxemia due to OSA  
(SaO<sub>2</sub> nadir <75%) was  
significantly more common  
in AA/black (n=39, 64%)

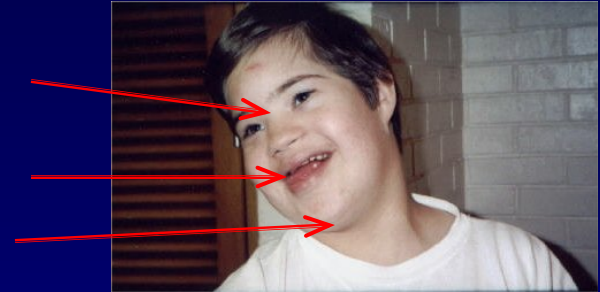
# Pediatric OSAS: Signs and Causes

- **Signs:**

snoring, snorting,  
gasping, airflow  
cessation

**Causes:**

obstructed or  
narrow upper  
airway



# OSA Treatment

- Adenotonsillectomy improves snoring and can be effective in up to 79%
- 42% remission after 7 months when OSA is mild.
- For persistent OSA CPAP is treatment of choice.

- [N Engl J Med](#). 2013 June. **A randomized trial of adenotonsillectomy for childhood sleep apnea.**
- [Marcus CL](#)<sup>1</sup>, et al [Childhood Adenotonsillectomy Trial \(CHAT\)](#).
- [Chest](#). 2015 Mar 26. **Prognosis for Spontaneous Resolution of Obstructive Sleep Apnea in Children.**
- [Chervin RD](#), et al

# Insomnia: Essential Features

“Frequent and persistent difficulty initiating or maintaining sleep that results in general sleep dissatisfaction...despite adequate sleep opportunity”

*International Classification of Sleep Disorders, 3<sup>rd</sup> Edition., American Academy of Sleep Medicine, Darien, Illinois (2014), p. 23*

# Behavioral Insomnia of Childhood 6 months -6 Years

- Identify and eliminate reinforcers or cues that delay an independent wake-sleep transition
- Positive Routines
- Sleep hygiene training
- Establish appropriate bed times
- Establish appropriate bedtime routines

# Cognitive Behavior Therapy for *Insomnia* (*CBTI*)

- Sleep Hygiene
  - Sleep related habits
  - Prioritization of sleep
- Sleep Education
  - Sleep schedule, duration and continuity
- Stimulus Control
  - Dissociate stimulus (e.g., bed) associated with frustration/activation
- Cognition
  - Address sleep-related misconceptions, predictions
  - Tools to decrease cognitive arousal
- Sleep Restriction
  - Limit TST to weekly average
  - Setting a fixed sleep window
- Relaxation Therapy
  - Tools to decrease physiological and cognitive activation



# Circadian Rhythm Disorder

## Delayed Sleep Phase Syndrome

- Definition:  
A shift of the sleep phase to a later period that conflicts with academic and work schedules & social norms
- Prevalence:  
affects 7% of adolescents

## TWO-WEEK SLEEP RECORD

PATIENT'S NAME \_\_\_\_\_ PARENT'S NAME \_\_\_\_\_

PATIENT'S DATE OF BIRTH \_\_\_\_\_ ADDRESS \_\_\_\_\_

DATE OF SLEEP RECORD: FROM \_\_\_\_\_ TO \_\_\_\_\_ TELEPHONE NUMBER \_\_\_\_\_

### INSTRUCTIONS:

|   |   |
|---|---|
| Leave blank the periods your child is awake.              | Mark your child's bedtimes with downward-pointing arrows. ↓                                     |
| Mon   | Tue   |
| Fill in the times your child is asleep with shaded boxes. | Mark the times your child gets up in the morning and after naps with arrows pointing upwards. ↑ |

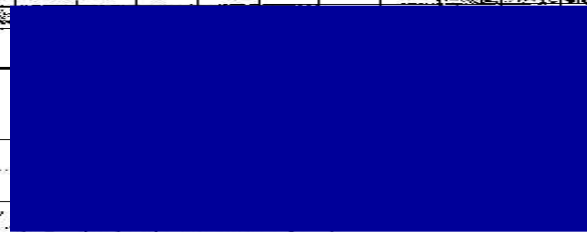
| Day   | Midnight | AM   |      |      |      |       | PM   |      |      |      |      | Midnight |       |
|-------|----------|------|------|------|------|-------|------|------|------|------|------|----------|-------|
|       |          | 2:00 | 4:00 | 6:00 | 8:00 | 10:00 | Noon | 2:00 | 4:00 | 6:00 | 8:00 |          | 10:00 |
| SUN   |          | ↓    | ↓    | ↓    | ↓    | ↓     | ↓    | ↓    | ↓    | ↓    | ↓    | ↓        | ↓     |
| MON   |          | ↓    | ↓    | ↓    | ↓    | ↓     | ↓    | ↓    | ↓    | ↓    | ↓    | ↓        | ↓     |
| TUES  |          | ↓    | ↓    | ↓    | ↓    | ↓     | ↓    | ↓    | ↓    | ↓    | ↓    | ↓        | ↓     |
| WED   |          | ↓    | ↓    | ↓    | ↓    | ↓     | ↓    | ↓    | ↓    | ↓    | ↓    | ↓        | ↓     |
| THURS |          | ↓    | ↓    | ↓    | ↓    | ↓     | ↓    | ↓    | ↓    | ↓    | ↓    | ↓        | ↓     |
| FRI   |          | ↓    | ↓    | ↓    | ↓    | ↓     | ↓    | ↓    | ↓    | ↓    | ↓    | ↓        | ↓     |
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| SUN   |          | ↓    | ↓    | ↓    | ↓    | ↓     | ↓    | ↓    | ↓    | ↓    | ↓    | ↓        | ↓     |
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| SAT   |          | ↓    | ↓    | ↓    | ↓    | ↓     | ↓    | ↓    | ↓    | ↓    | ↓    | ↓        | ↓     |
| SUN   |          | ↓    | ↓    | ↓    | ↓    | ↓     | ↓    | ↓    | ↓    | ↓    | ↓    | ↓        | ↓     |
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| TUES  |          | ↓    | ↓    | ↓    | ↓    | ↓     | ↓    | ↓    | ↓    | ↓    | ↓    | ↓        | ↓     |
| WED   |          | ↓    | ↓    | ↓    | ↓    | ↓     | ↓    | ↓    | ↓    | ↓    | ↓    | ↓        | ↓     |
| THURS |          | ↓    | ↓    | ↓    | ↓    | ↓     | ↓    | ↓    | ↓    | ↓    | ↓    | ↓        | ↓     |
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| SAT   |          | ↓    | ↓    | ↓    | ↓    | ↓     | ↓    | ↓    | ↓    | ↓    | ↓    | ↓        | ↓     |
| SUN   |          | ↓    | ↓    | ↓    | ↓    | ↓     | ↓    | ↓    | ↓    | ↓    | ↓    | ↓        | ↓     |
| MON   |          | ↓    | ↓    | ↓    | ↓    | ↓     | ↓    | ↓    | ↓    | ↓    | ↓    | ↓        | ↓     |
| TUES  |          | ↓    | ↓    | ↓    | ↓    | ↓     | ↓    | ↓    | ↓    | ↓    | ↓    | ↓        | ↓     |
| WED   |          | ↓    | ↓    | ↓    | ↓    | ↓     | ↓    | ↓    | ↓    | ↓    | ↓    | ↓        | ↓     |
| THURS |          | ↓    | ↓    | ↓    | ↓    | ↓     | ↓    | ↓    | ↓    | ↓    | ↓    | ↓        | ↓     |
| FRI   |          | ↓    | ↓    | ↓    | ↓    | ↓     | ↓    | ↓    | ↓    | ↓    | ↓    | ↓        | ↓     |
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SPECIAL OBSERVATIONS AND NOTES: \_\_\_\_\_

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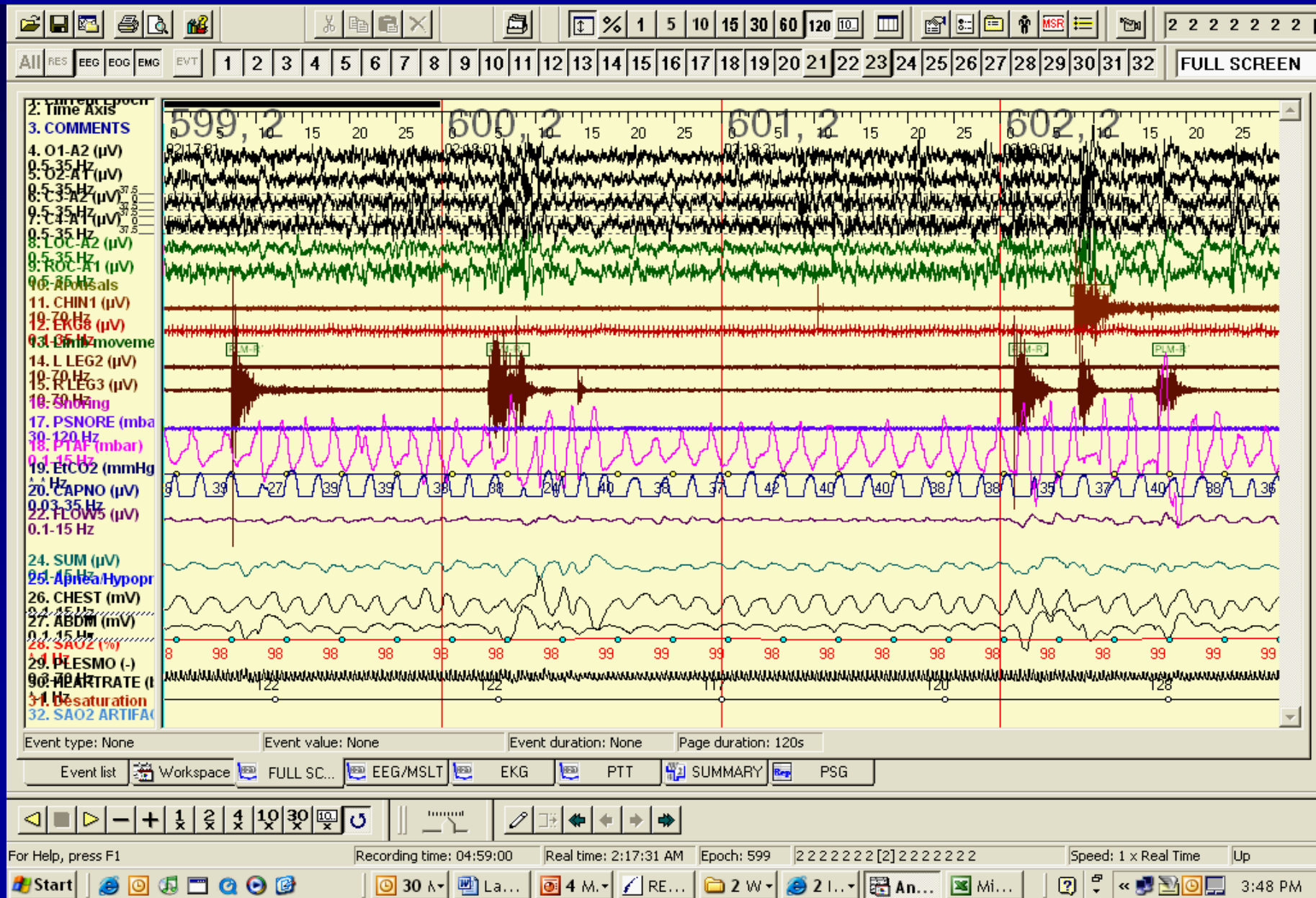


# Circadian Rhythm Disorder Treatment

- Advance sleep phase by focusing on wake times that differ no more than 1.5 hours (social jet lag)
- Eliminate naps longer than 15 minutes
- Eliminate Caffeine after noon
- Dim lights – PM / Bright light AM
- No Electronics within 30 minutes of target bedtime.

# Non-REM Parasomnias

- Disorders of Arousal – Sudden arousals from deep sleep (confusional arousals, night terrors, sleep walking)
- Prevalence decreases w/ age
- Treatment – **Safety-Safety-Safety-Safety**
  - Parent education
  - Sleep schedule modification to Increase TST
  - Afternoon naps
  - Scheduled awakenings



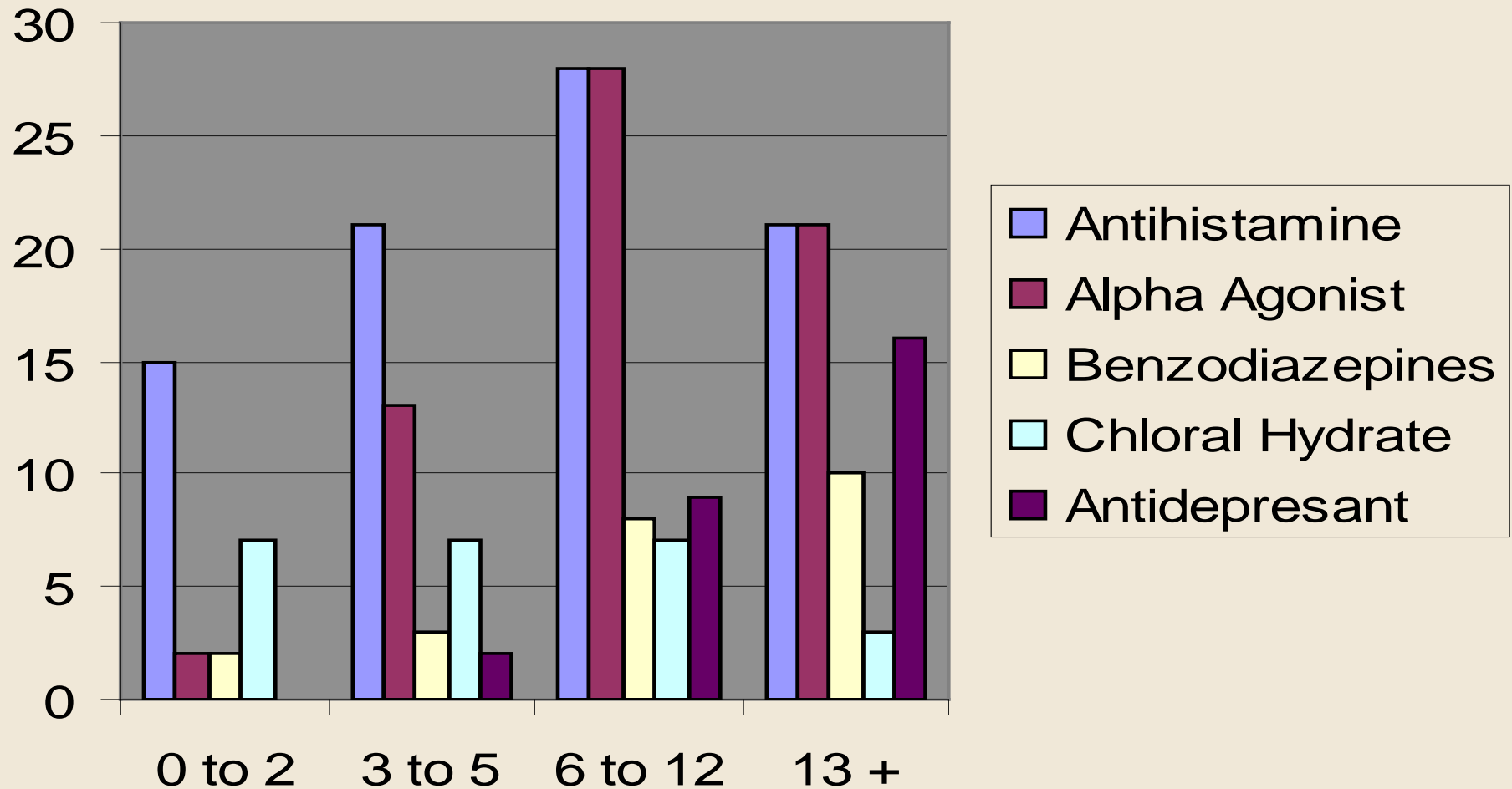
# Restless Legs Syndrome (RLS)

- RLS is a clinical diagnosis involving uncomfortable sensations in the limbs that are relieved by movement.
  - In a referred sleep disorder sample of 538, 28% were diagnosed with RLS. Inattention was present in 25% and low serum ferritin below 50 was present 83%. Kotagal S., et al. Annals of Neurology. 56(6):803-7, 2004 Dec
- RLS and PLMD Co-occur about 80% of the time
- When Ferritin is <50ng/ml supplement with ferrous gluconate or ferrous sulfate (3-6mg/kg of elemental iron\_

# Top Sleep Tips

- Regular sleep timing and duration
- No electronic media in the bedroom and within an hour of bedtime
- Regular bedtime routines
- Quiet and together time before bedtime
- Comfortable sleep environment
- Cut out Caffeine
- NEVER DRIVE SLEEP DEPRIVED!

# Percentage of Physicians Prescribing Specific Medications for Sleep Problems



Owens, Rosen, Mindell 2002







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202-476-6209



# THANK YOU

# Sleep Resources

- National Institutes of Health - [Starsleep.nhlbi.nih.gov](http://Starsleep.nhlbi.nih.gov)
- National Sleep Foundation - [Sleepfoundation.org](http://Sleepfoundation.org)
- American Academy of Sleep Medicine - [AASM.org](http://AASM.org)
- A Clinical Guide to Pediatric Sleep: Diagnosis and Management of Sleep Problems (Jodi Mindell & Judith Owens)
- Sleeping Through the Night – Jodi Mindell
- Solve Your Child's Sleep Problems - Richard Ferber

# Pediatric Sleep Resources & Suggested Bibliography

- American Academy of Sleep Medicine - [AASM.org](http://AASM.org)
- National Institutes of Health - [Starsleep.nhlbi.nih.gov](http://Starsleep.nhlbi.nih.gov)
- National Sleep Foundation - [Sleepfoundation.org](http://Sleepfoundation.org)
- A Clinical Guide to Pediatric Sleep: Diagnosis and Management of Sleep Problems (Jodi Mindell & Judith Owens)
- Sleeping Through the Night – Jodi Mindell
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