

New Ideas in Pediatric Sleep Medicine

*“We tried **Cry it Out**, now both
of us are crying all night.”*

Parent’s Refrain



JOHNS HOPKINS
M E D I C I N E

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ALL CHILDREN’S HOSPITAL



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Disclosures

None

Learning Objectives

1. Recognize normative data for pediatric sleep from infants to adolescents
2. Describe the social and cultural influences that contribute to pediatric sleep disorders
 - a. Infant awakenings
 - b. Co-sleeping toddlers
 - c. Adolescent sleepiness
3. Normative polysomnographic data for infant sleep
4. Unique infant respiratory physiology

Sleep Disorders by Age of Presentation

Infant

Safe Sleep
Awakenings

Toddler

Sleep-onset
Awakenings
Rhythmicity
Short sleep

Pre-School

Sleep-onset
Awakenings
Rhythmicity
Sleep Terrors
Nightmares
Fears

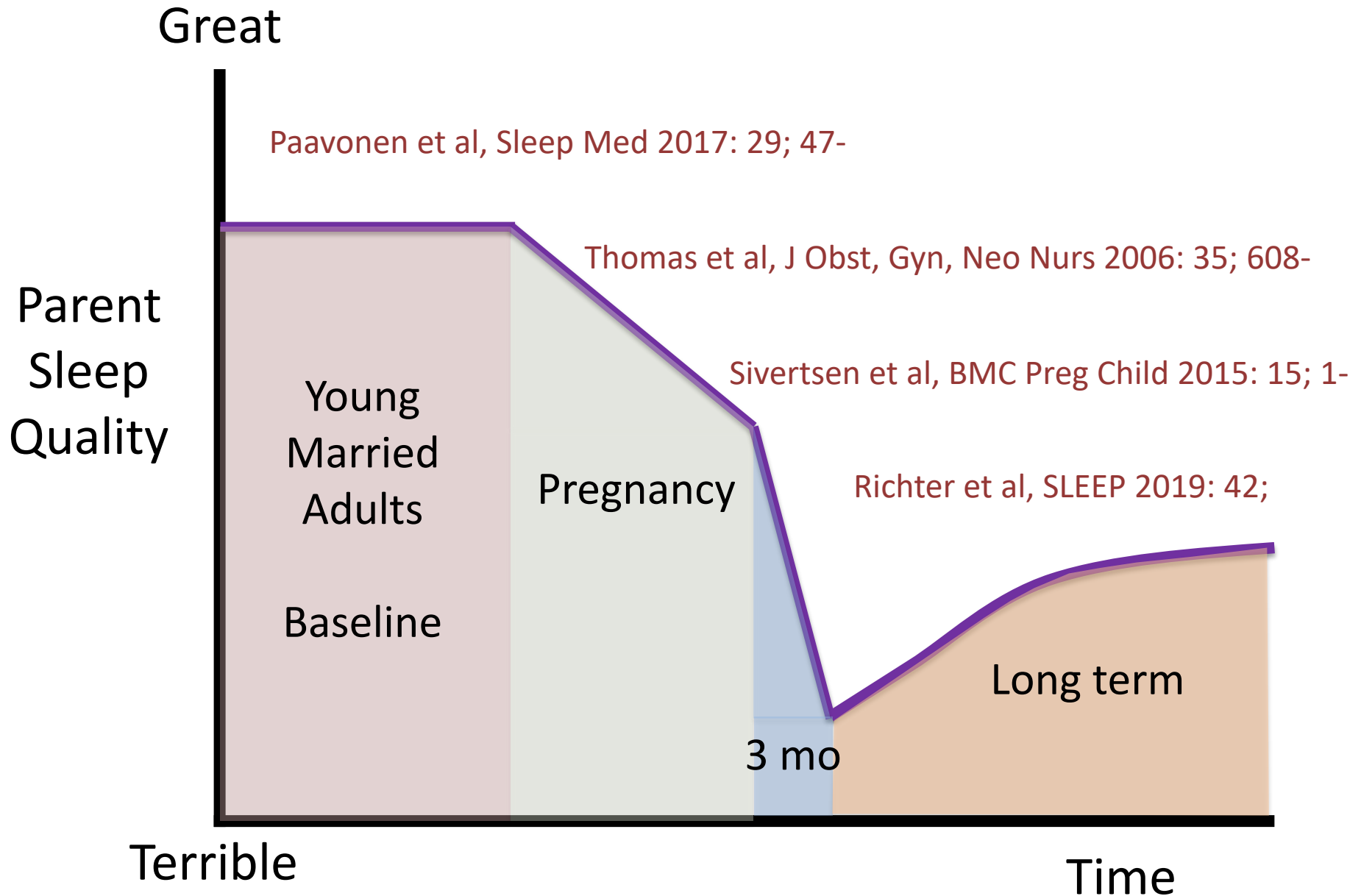
School-Age

Awakenings
Sleep-onset
Confusional arousals
Insufficient sleep
Poor sleep hygiene
Sleep walking
Enuresis
Bruxism
Narcolepsy
Insomnia
Anxiety

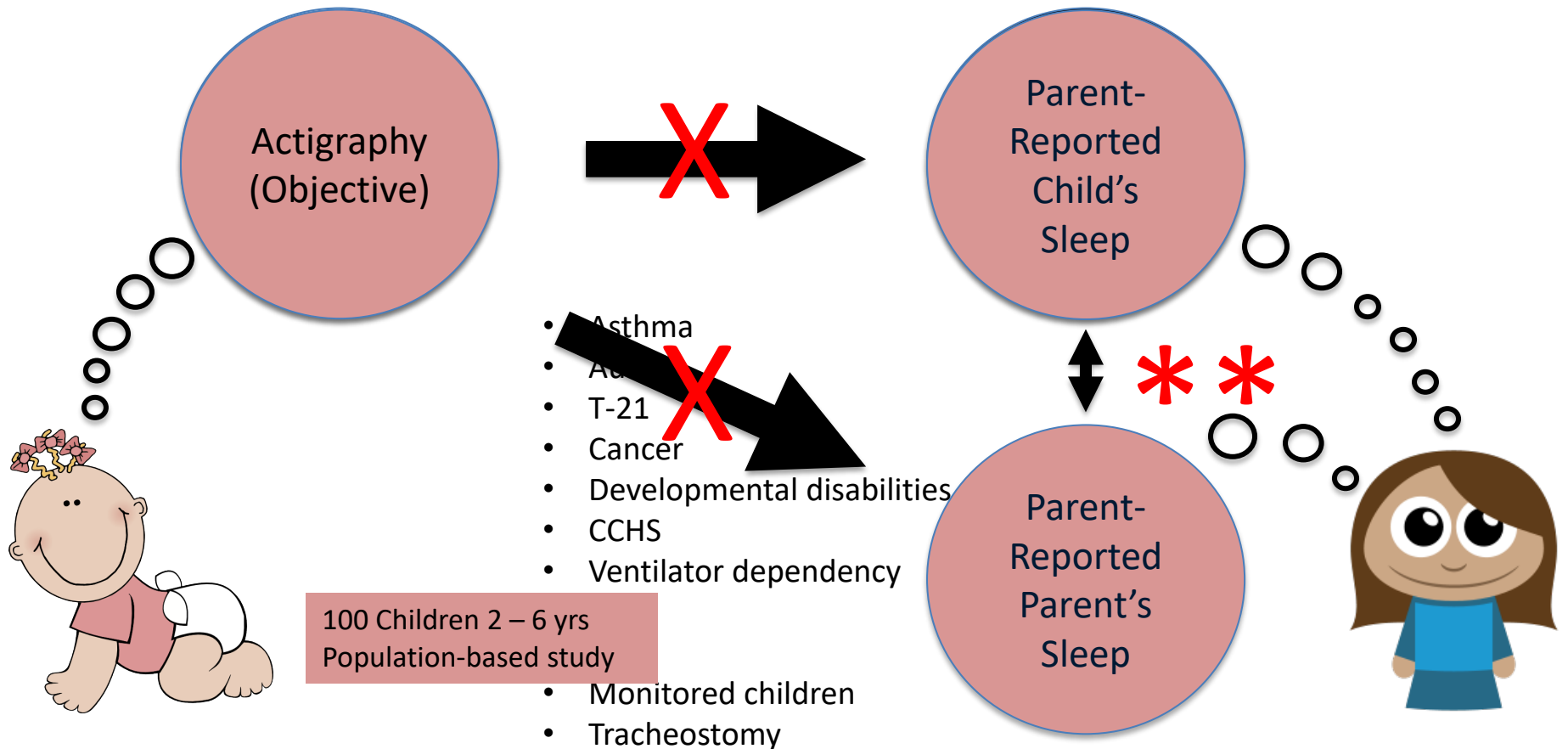
Teenage

Insufficient sleep
Poor sleep hygiene
DSPS
Insomnia
Sleep walking
Narcolepsy
Anxiety
Depression
Long sleepers

Who's the Patient? Parent or Infant



Influence of Pediatric Illness on Caregivers Sleep



Ronnlund et al, Peds 2016; 137: EPUB

Meltzer J Pediatr Psychol 2016
Paddeau Sleep Breathing 2015
Meltzer J Clin Sleep Med 2015
Feeley J Pediatr Nursing 2014

Infant Behavioral Sleep: An RCT

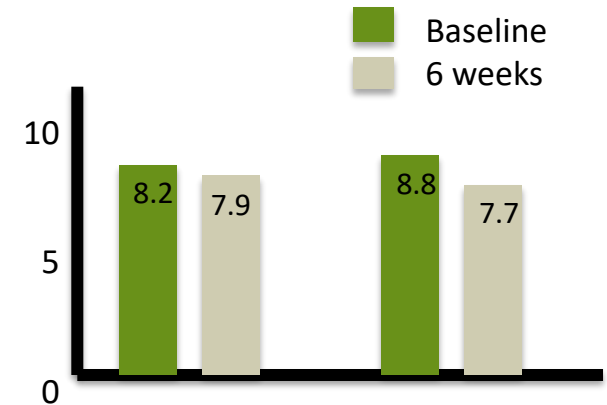
Study Group

- N = 235
- “Behavioral Sleep Problem”
- 6-8 months-old
- Questionnaires & Actigraphy

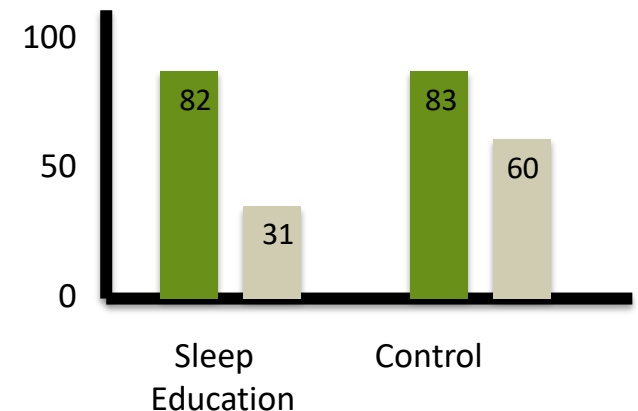
Intervention (6 weeks trial)

- Sleep Education
- Normal sleep patterns
- Sleep onset associations
- Children’s sleep effect on caregivers
- “Controlled comforting”

Objective
Actigraphy
(# wakings
Per night)



Parent Report
of
Night
Waking
≥2



The Quagmire

- 1/3 of mothers and 1/2 of father's report that their infant has a sleep disorder Hiscock, Pediatr 2001; 107; 1317-
Bayer, J Paed Ch Health 2007: 43; 66-
Lozoff, Pediatr 2006: 75; 477-
- Most infants with a 'sleep disorder' are actually sleeping normally, growing well, and developing typically.
- How to deliver this spectacular news to parents?
- Parenting practices have diverged for the environment of evolutionary adaptiveness

What is Normal Baby Sleep?

- Parent report: At 3 mo, 70% of babies “settle,” rising to 85% by 6 mo
Moore, Arch Dis Child 1957:32; 333
- Half of “settled” infants “unsettle” in the second 6 mo
Anders, Peds 1979: 63:860-
- Objectively, most “settled” infants actually awakening at night
Hall, Front Psych 2015:6;1-
- Hunter-gatherer infants don’t consolidate sleep in the first year AND their infants don’t have sleep disturbances
Super, Cross-cultural Research at Issue, 1982; 47-
Morelli, Dev Psych 1998: 62; 604-
- Conclusion: Spontaneous arousals & brief awakenings are built into the fabric of normal human sleep

Infant Sleep ↔ Parent Factors

Bidirectional Effect

Parents psychological traits pre-delivery predict which families will report their infant has a sleep disorder.

Baird, SLEEP 2009: 32; 566-

O'Connor, Early Hum Dev 2007:83; 451-

Infant Sleep: Consider

- Hunter-gatherers don't report infant sleep d.o.

Morelli, Dev Psych 1998: 62; 604-

- Traditional cultures carry their infants constantly and respond to baby signals immediately

Super, Int J Behav Dev 1986: 9; 545-

- Parents of solitary sleeping infants don't have an accurate idea of night awakenings

Camerota, SLEEP 2018: 41; 302-

- Many western parents report sleep deprivation despite infants sleeping 12-18 hrs/day

Historical Perspective: Cry it Out?

“How is an infant to be managed that cries from temper, habit, or to be indulged?”

It should simply be allowed to ‘cry it out’”

L. Emmett Holt, 1884

“Occasionally, as parents increase the time they wait before responding, their child cries so hard that he vomits. If that happens, go in even though the time isn’t up yet. Clean your child up and change the sheets and pajamas as needed. But do so quickly and matter-of-factly, and then leave again.”

Richard Ferber, 1986

The Choice

Comfort the Kid

- Attachment Parenting

Cry it Out

- Extinction
- Gradual extinction
- Extinction with parental presence
- Sleep training
- Systemic ignoring
- Controlled crying
- Progressive waiting
- 'Checking'
- Anticipatory sleep guidance
- Positive sleep habits
- Promoting independence
- Sleep education

Behavioral Insomnia of Childhood (Sleep-onset Association type)

“Children with this disorder associate sleep onset with specific soothing procedures or objects. When such objects are absent, they experience difficulty falling asleep at both bedtime and following nighttime arousals”

International Classification of Sleep Disorders (ICSD)

Behavioral Insomnia of Childhood

- “sleep is normal when certain conditions are present”
- “the number of nighttime awakenings may seem excessive to the caretakers, but their actual frequency is normal”
- Symptoms in Parents
 - “caretakers’ loss of sleep with subsequent anger”
 - “less warmth and decreased nurturance”
 - “parents may form negative feelings about their children”
 - “marital disputes & conflicts about how to respond”

Infant awakenings: Summary

- Sleep of infants with and without 'sleep disorders' is the same.
- Primary problem is not the infants' schedule *per se* but the adverse effect on the parents
- Fixing 'disordered' infant sleep often requires adjusting parental expectations & understanding normative data

Historical Perspective: Co-sleeping

“I think it’s a sensible rule not to take a child into the parents’ bed for any reason”

Benjamin Spock, 1947

“The modern Western custom of an independent childhood sleep pattern is unique and exceedingly rare among contemporary and past world cultures”

C. Joanne Crawford, Ethos 1994

“It is no historical coincidence that separate sleep arrangements and infant sleep disorders appeared simultaneously”

Eliot Katz, Comfort the Kid, 2021

Co-sleeping Nomenclature

Room sharing: Recommended by AAP ↓ SIDS risk 50%.

Moon, Peds 2016: 206; 138-

Bed sharing: Same surface. Not Recommended by AAP

Co-sleeping: Parent & Child sleeping in close enough proximity to share subtle sensory signals

Deliberate Co-sleeping: Parenting preference or no-choice

Reactive Co-sleeping: Strategy to ↓ nighttime battles

Risks of Bed sharing

- 1000's of U.S. infants die every year due to unsafe sleep
- Risk of suffocation/entrapment due to objects, crevices, or humans
- Bed-sharing on a sofa, recliner, chair, or improperly prepared adult surface is very dangerous
- Only 2% of parents report that they never bed share
Ball, Acta Paediatrica 2016;105; 628-
- Worst cased scenario if the co-sleeping occurs on a sofa or ill-prepared adult bed

Why would anyone Bed Share?

Cultures that bedshare also have low SIDS rates!

Nelson, Early Hum Dev 2001:62; 43-

Bedsharing promotes breastfeeding

Ball, Acta Pediatr 2016:105; 628-

Infant Awakenings: Parent response time for bedsharing parents 14 seconds compared to 3 min 32 secs for solitary sleeping infants

James-Roberts, Prim Health Care Res Dev 2016:17; 611-

Preferred term: infants should sleep “proximate” to their parents on a separate surface.

Co-sleeping: Summary

- Nighttime feeds are common & need to occur somewhere, which often is an unsafe bed, chair or sofa.

Tully, Mat & Child Health J 2015: 19;1

- Parents acknowledge often falling asleep with infant in unsafe places

Kendall-Tackett, Clin Lact 2010:1; 27-

- Thus, even parents attempting to follow guidelines often are not.
- In my view, premeditated, careful, intentional co-sleeping but not co-bedding is preferable over the inadvertent variety.

Toddler: Reactive Co-sleeping

Most common scenario

- Child initiates sleep in their own bedroom
- During an awakening they insist on re-initiating sleep with their parent
- Parents acquiesce due to exhaustion
- Child has no daytime symptoms
- Parent's sleep is disrupted by child

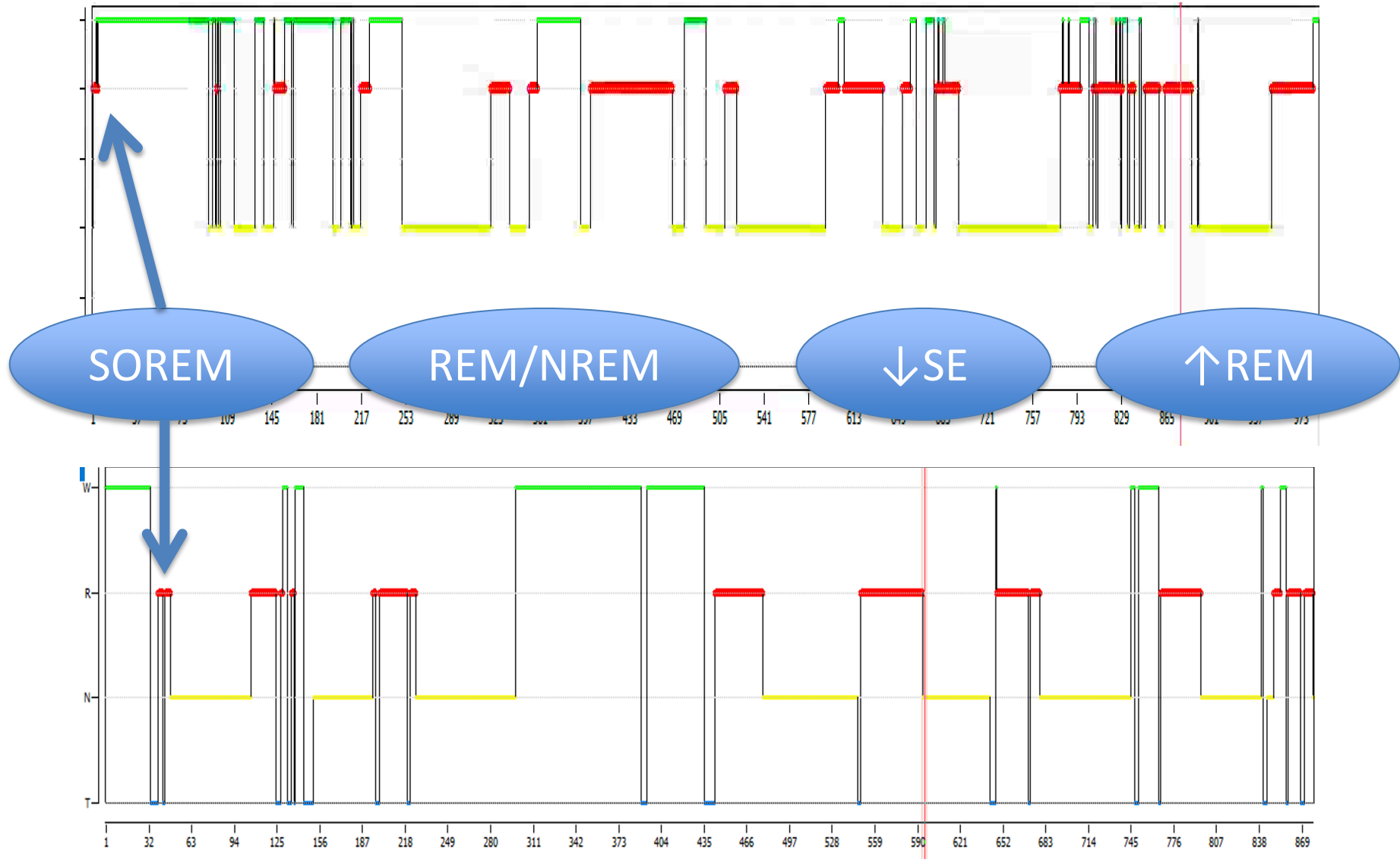
Co-sleeping Considerations

- Most of the world co-sleeps
- Before industrial revolution, everyone co-slept
- Toddlers wanting to be with parents indicates successful bonding
- ‘Secure’ attachment is a good prognostic sign
- There is nothing wrong with co-sleeping
- However, co-sleeping can be very disruptive of parent’s sleep

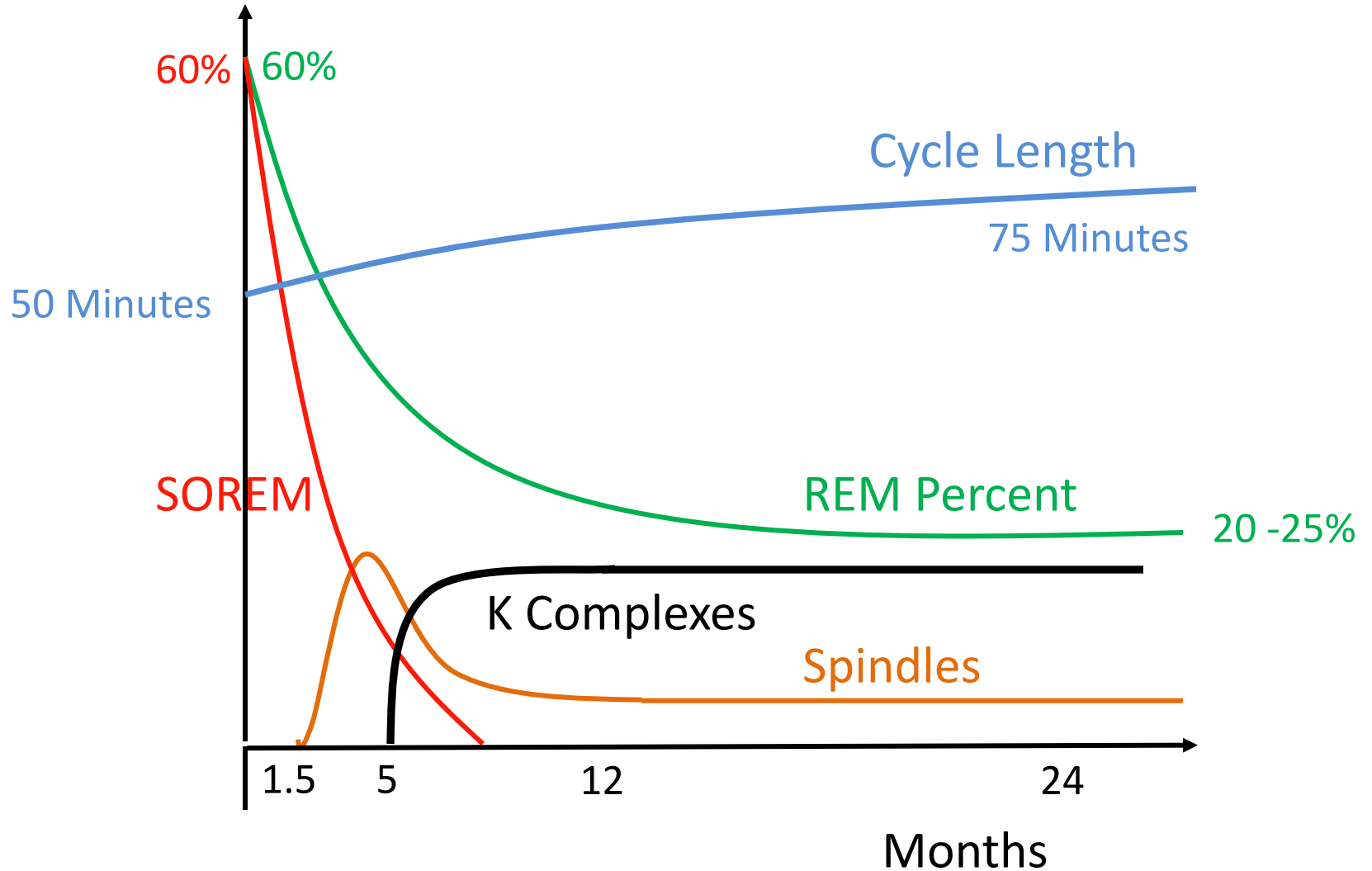
Reactive co-sleeping: What do you do?

1. Announce new sleep routine that allows kid to be with parent anytime & allow the parent to sleep all night.
2. Start during the day with child wide awake and cooperative.
3. Set-up “Nest” for child next to parent’s bed with child’s help. Together craft a cot/sleeping bag/mat on floor next to parent populated with child’s happy items (stuffy’s/blanket).
4. Clearly establish that this is the child’s spot.
5. Practice runs awake. Brush teeth, pajamas, read books in child’s room. Have child pretend to fall asleep in their bedroom and parent in their bed. Pretend that child wakes up. They can either return to sleep where they are or tip-toe into parents room & snuggle up in their “Nest.
6. Child receives effusive praise!
7. Positive Enforcement Routine (Calendar/sticker chart)

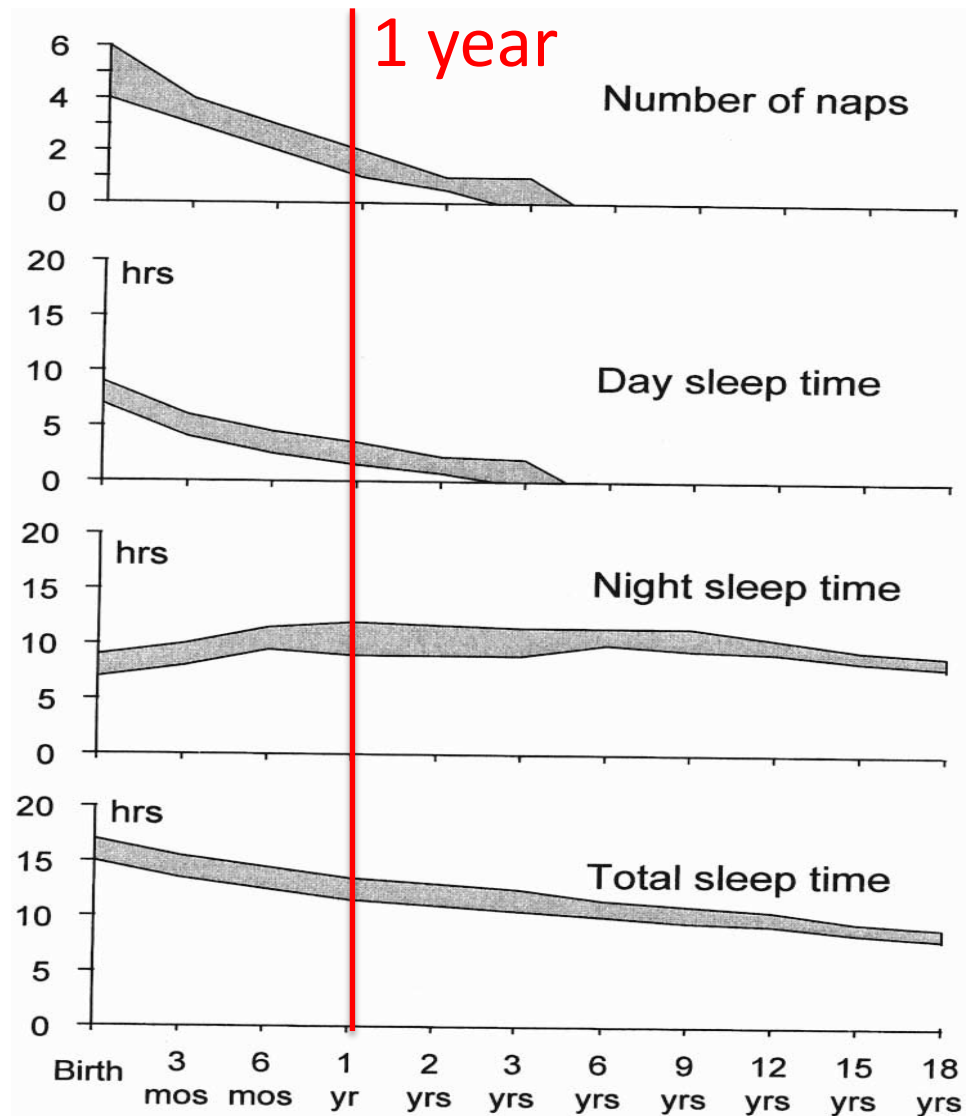
Sleep Architecture: Infancy



Sleep State Ontogeny



Naps: Normative Data



What is normal infant breathing during sleep?

Legacy Studies

Cross-sectional SIDS studies 1970-80's

Prospective SIDS studies 1980's

CHIME 1990's

Modern

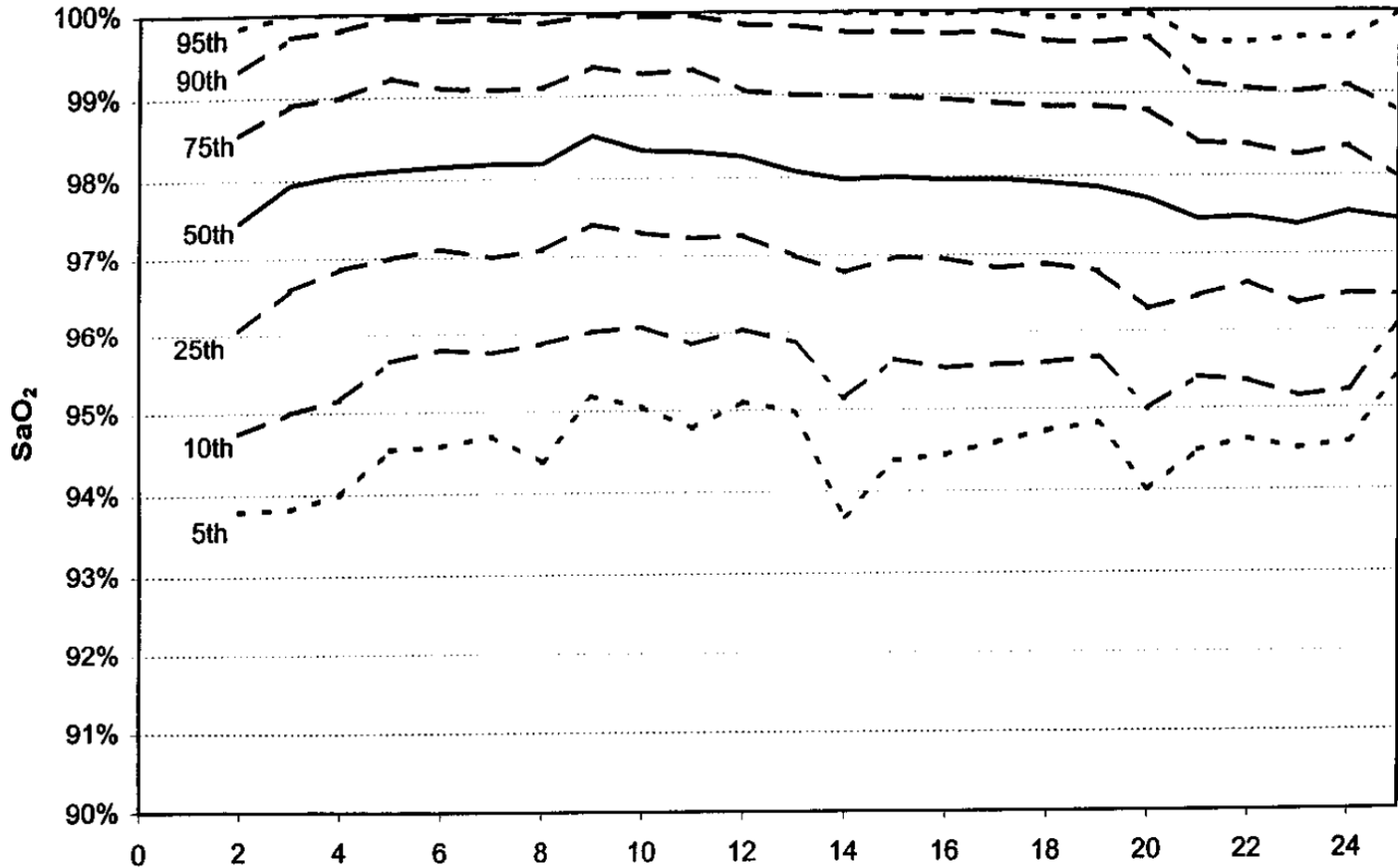
Current state-of-art Polysomnography

AASM event definitions

CHIME Study

- 1079 Infants: Healthy Infants
 Premature infants
 Siblings of SIDS
 Idiopathic ALTE
- Nightly Home Monitor x 6 months
 - Before/During/After Respiratory pauses
 - 3 Minutes per hour of non-event baseline data
- 1 Laboratory PSG night/thermistor
- Bayley Developmental Testing

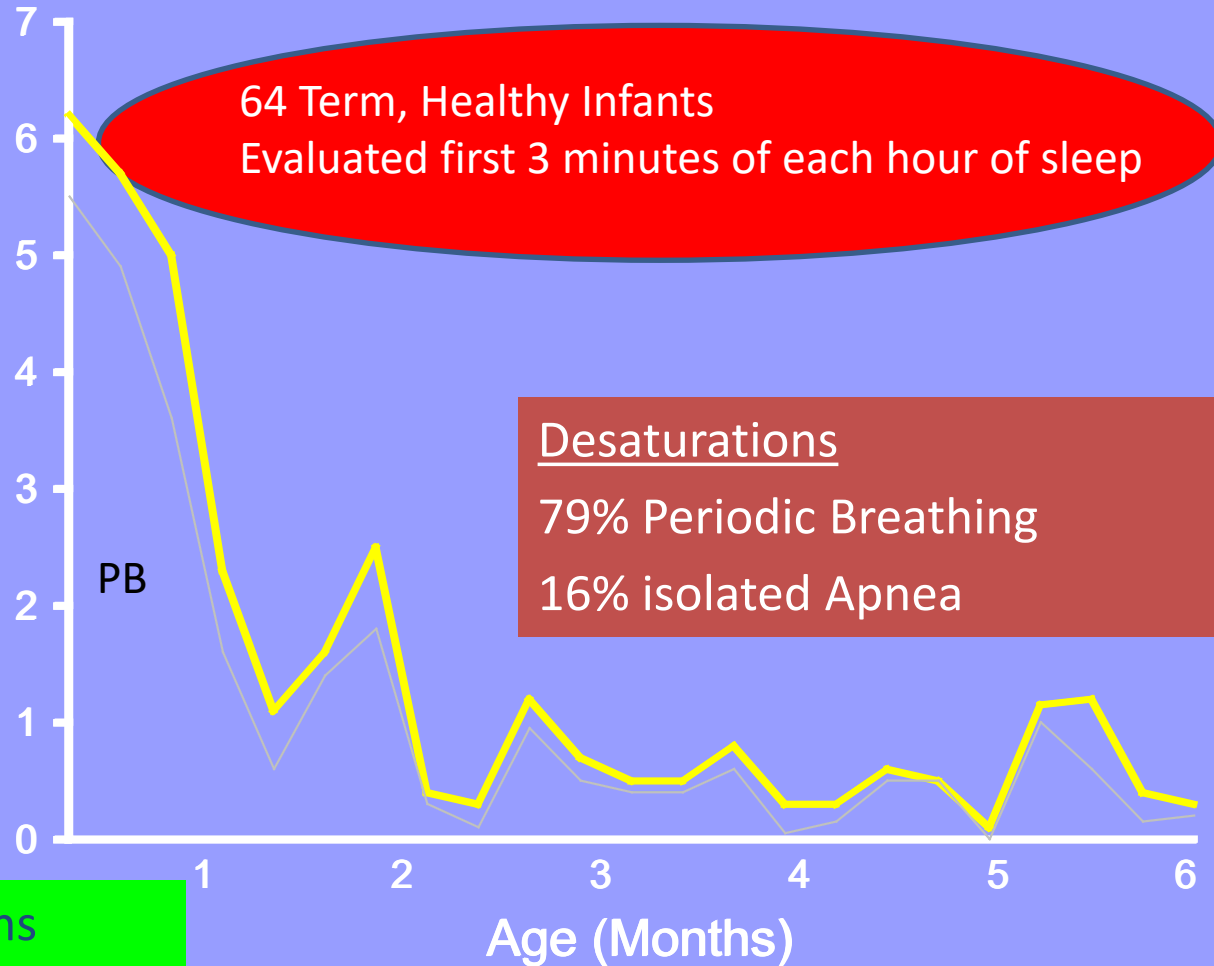
Baseline oxygenation in infants



- Median 98%
- Lower 10th % 95%
- 59% had at least 1 baseline <90%

“CHIME” Study: Acute Oxygen Drops < 90%

SpO₂ < 90%
lasting ≥5 seconds
(Seconds/Hour)



59% had acute desaturations
Median number of events = 4
Median nadir = 83% (10th ile 78%)

Infants: Event normative data

CHIME Study

Incidence

- Conventional event (apnea 20 s, Brady <80) 41%
 - Common even in term infants
 - 50% had obstructive component
- Extreme events (apnea 30 s, Brady <60) 10%
 - Common only in preterm infants
 - 70% had obstructive component
- ↑ Incidence in preterm, rare after 43 wks PCA

Infants: Modern Normative Data #1

Sleep

- 30 Healthy Infants
- Ave 20 days old
- Ave 39 weeks gestation
- Lab-based PSG

Sleep Efficiency	72% \pm 8.8
NREM	43% \pm 7.3
REM	41% \pm 7.4
Arousal Index	14 \pm 3.9
Resp Arousal Index	1.2 \pm 0.7
Awakenings	8.1 \pm 2.3

Infants: Modern Normative Data #1

Breathing

AHI	14.9 ± 9.1
CAI	5.4 ± 6.2
Obstructive AI	2.3 ± 2.5
Mixed AI	1.2 ± 1.5
Hypopnea I	6.3 ± 3.4
SpO2 nadir ave	84.4 ± 4.8
SpO2 <90%	0.5 ± 0.5
ODI	17.6 ± 11

- 30 Healthy Infants
- Ave 20 days old
- Ave 39 weeks gestation
- Lab-based PSG

Infants: Modern Normative Data #2

	<u>1 month-old (30)</u>	<u>5 months-old (25)</u>
AHI	16.9 (12.2-21.5)	4.1 (3.2-5)
Obstructive AHI	10.2 (7.4-13.1)	1.9 (1.4-2.4)
Obstructive AI	3.1 (1.6-4.6)	0.3 (0.2-0.5)
Obstructive hypopnea	5.4 (3.8-6.9)	0.3 (0.1-0.4)
Mixed AI	1.8 (1-2.6)	1.8 (1-2.6)
Central AI	6.6 (4.2-9)	2.2 (1.6-2.9)
SpO2 <90%	0.3% (0.1-0.4)	0.1% (0-0.2)
SpO2 nadir	85.5 (83.3-87.6)	87.2 (84.6-89.7)
Arousal Index	22.9 (19.9-25.8)	14.4 (12.6-16.3)
Periodic Breathing	0.5% (0.2-1.0)	0.2% (0.1-0.3)

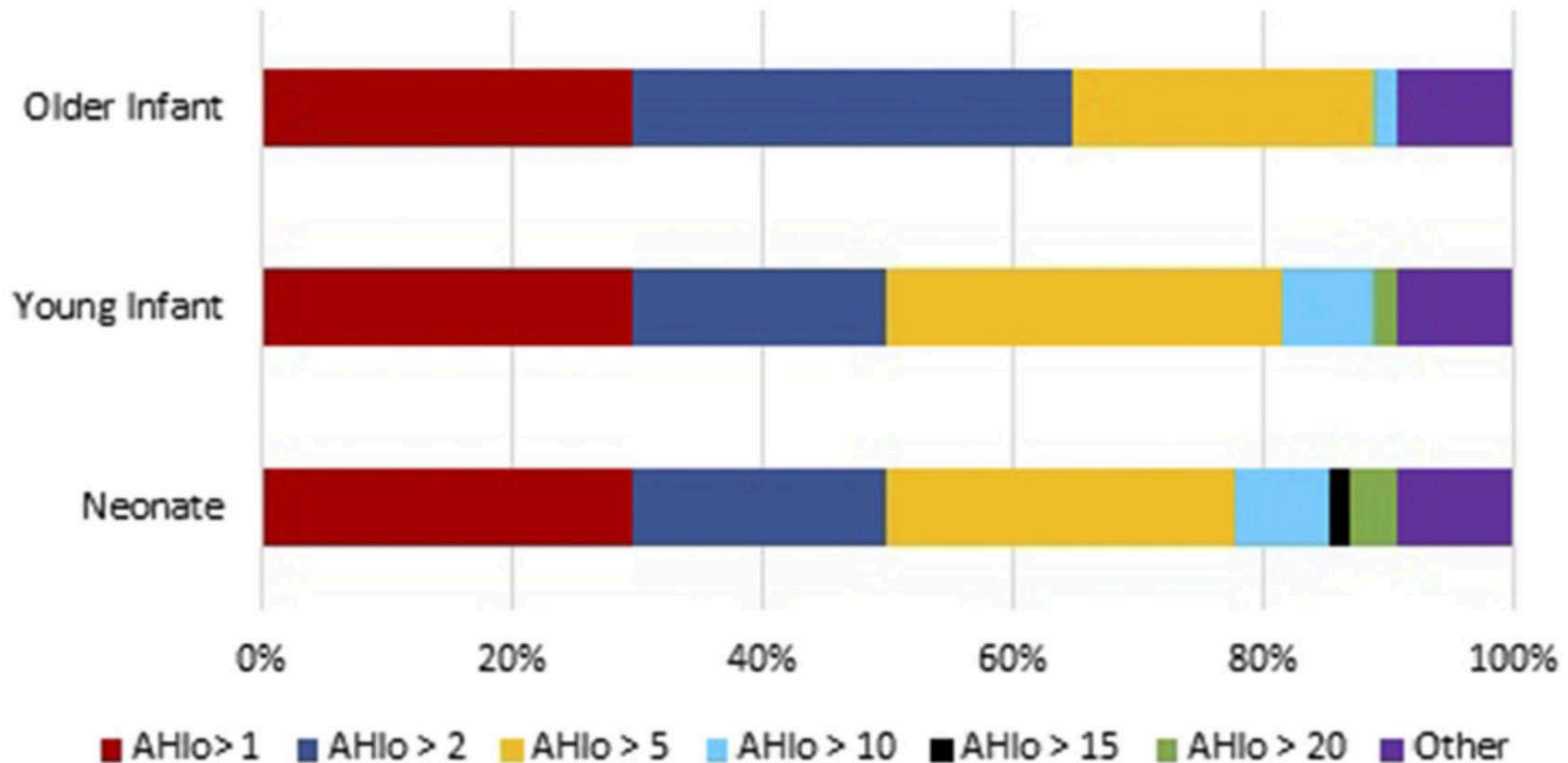
Infants: Modern “Nap” Data #3.

Breathing

oAHI	4.9	(1.7 - 19.1/hr)
CAI	0.7	(0 - 12.4/hr)
SpO2 nadir ave	91	(78 – 94%)
SpO2 <90%	0	(0 - 24%)

- 22 Healthy Infants
- Ave 5 days old
- Term
- Admitted to NICU-stable
- Lab-based “Nap” PSG
- Ave sleep: 182 mins

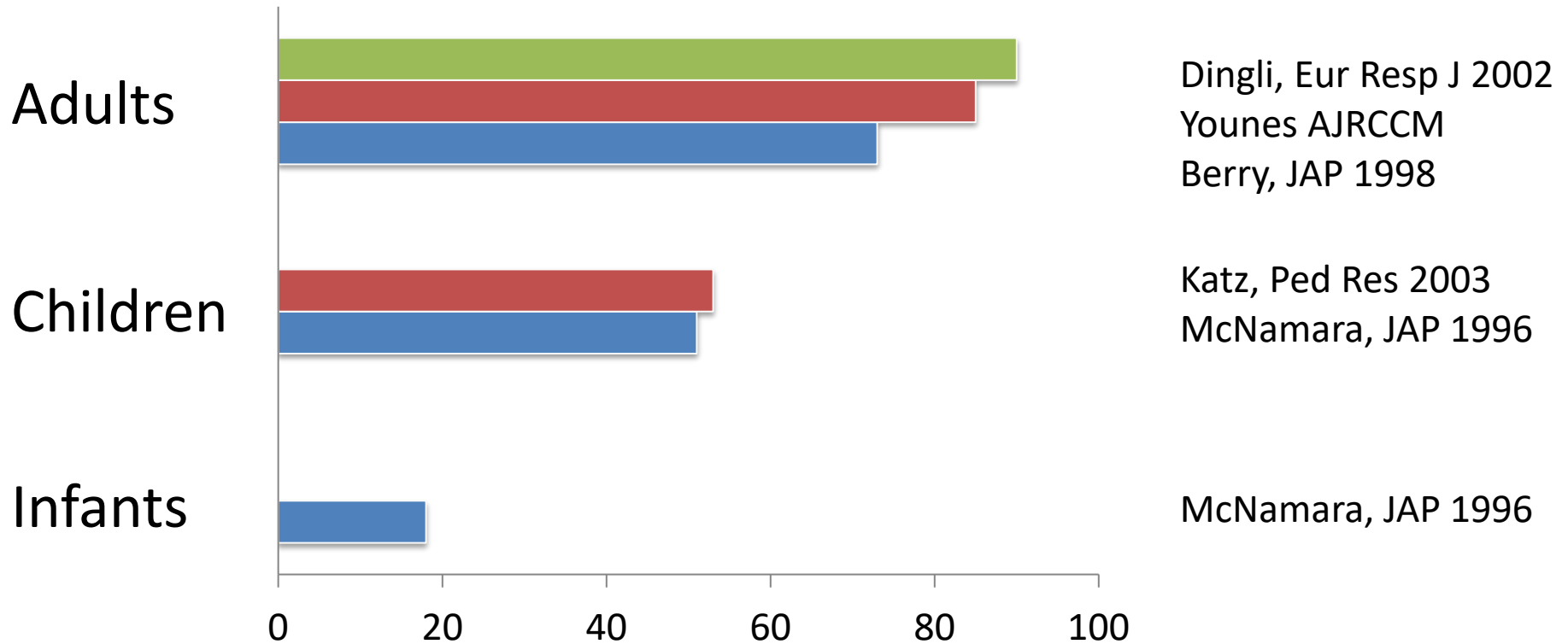
What level of obstructive AHI constitutes OSA in infants (0 – 2 mos)?



Kombathula et al, JCSM 2019: 15; 1427-

•On-line survey of 54 providers

Obstructive Events & EEG Arousals



Obstructive Events with ASDA EEG Arousals

Why are Infant's Predisposed for OSA?

1. Anatomy

- Narrower Upper Airway generally
- Specific anomalies of the nose, maxilla, & mandible
- Adverse lung mechanics

2. Loop Gain

- Ventilatory control instability
- Periodic breathing

3. Arousal Threshold

- Very high

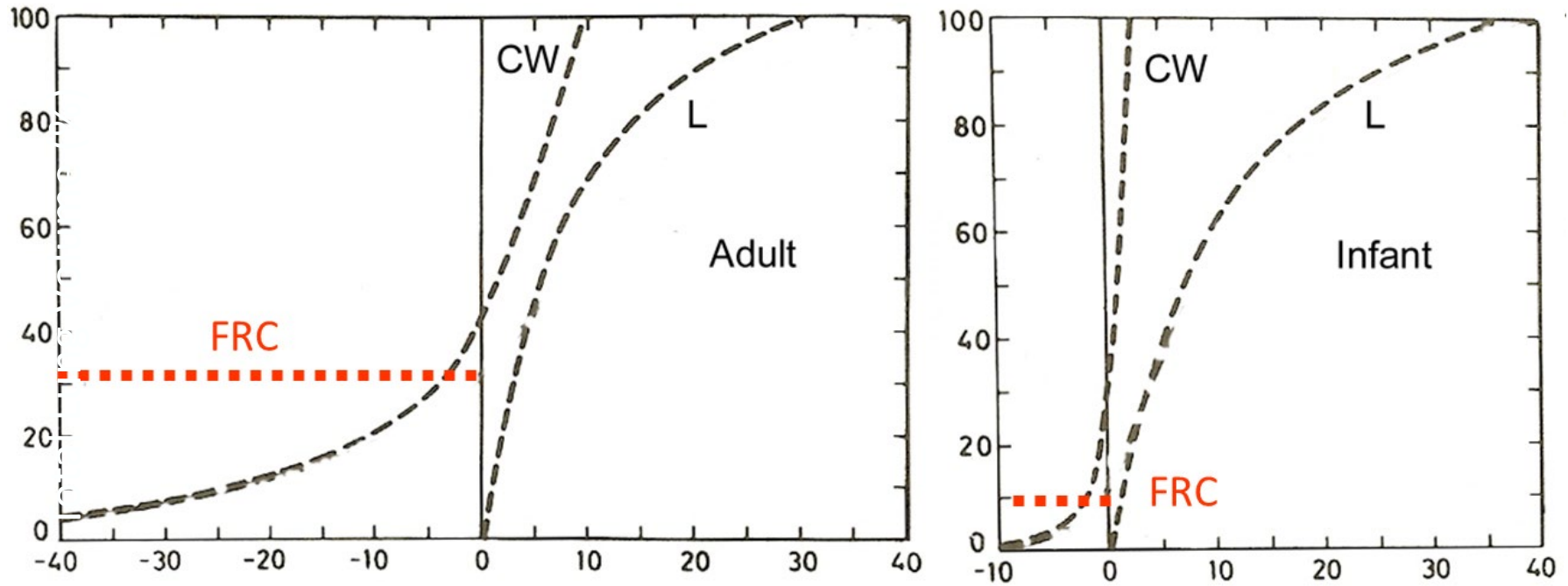
4. Neuromuscular Compensation

- ↑ muscle responsiveness
- ↑REM sleep

Why do infants breathe rapid, desaturate, sigh a lot, and obstruct their airway?

- ↓ Lung Mechanics
- ↑ Airway collapsibility
- ↑ Ventilatory control instability
- ↓ V/Q matching
- ↑ REM sleep

Lung Volume

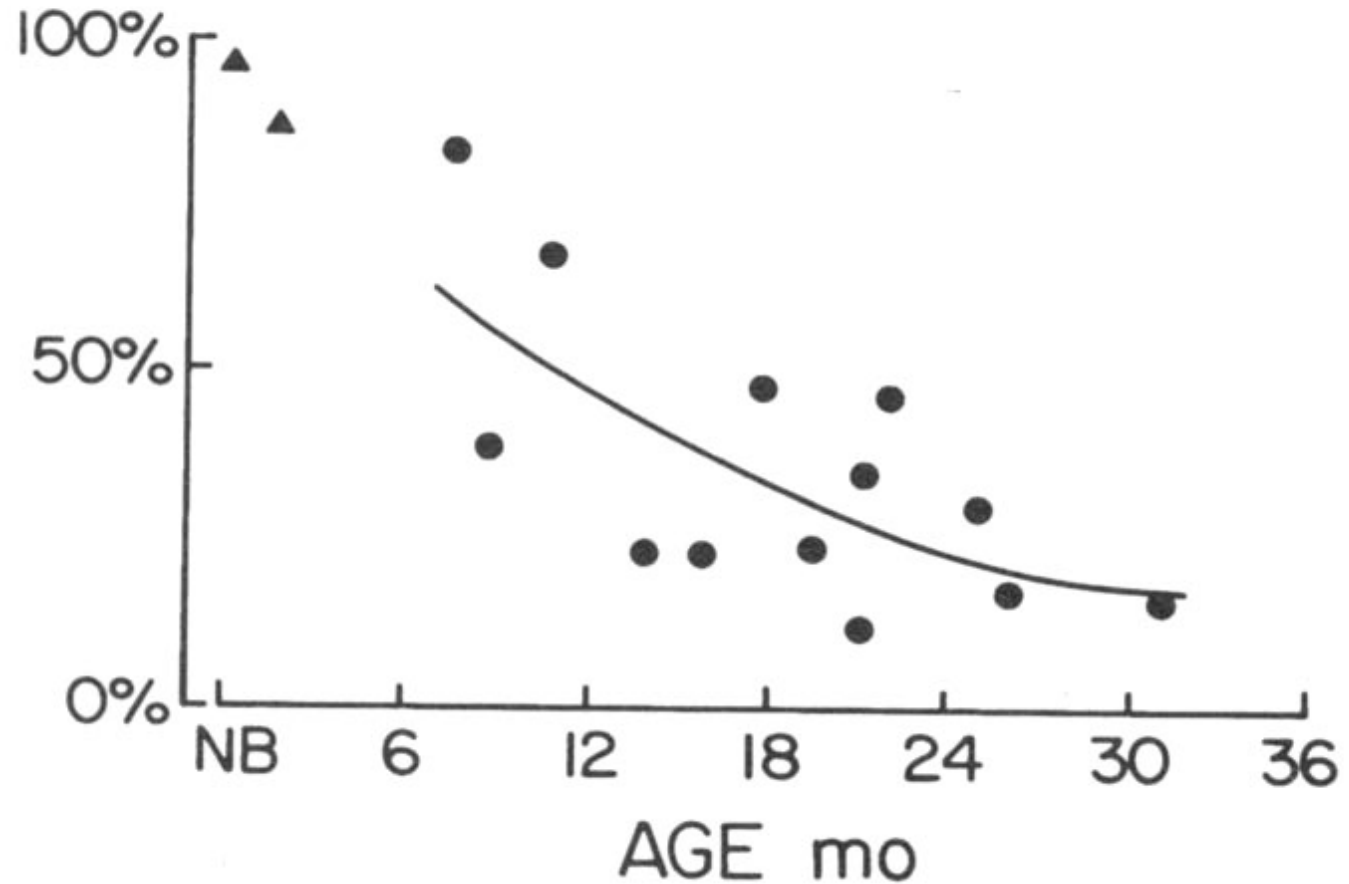


Infants

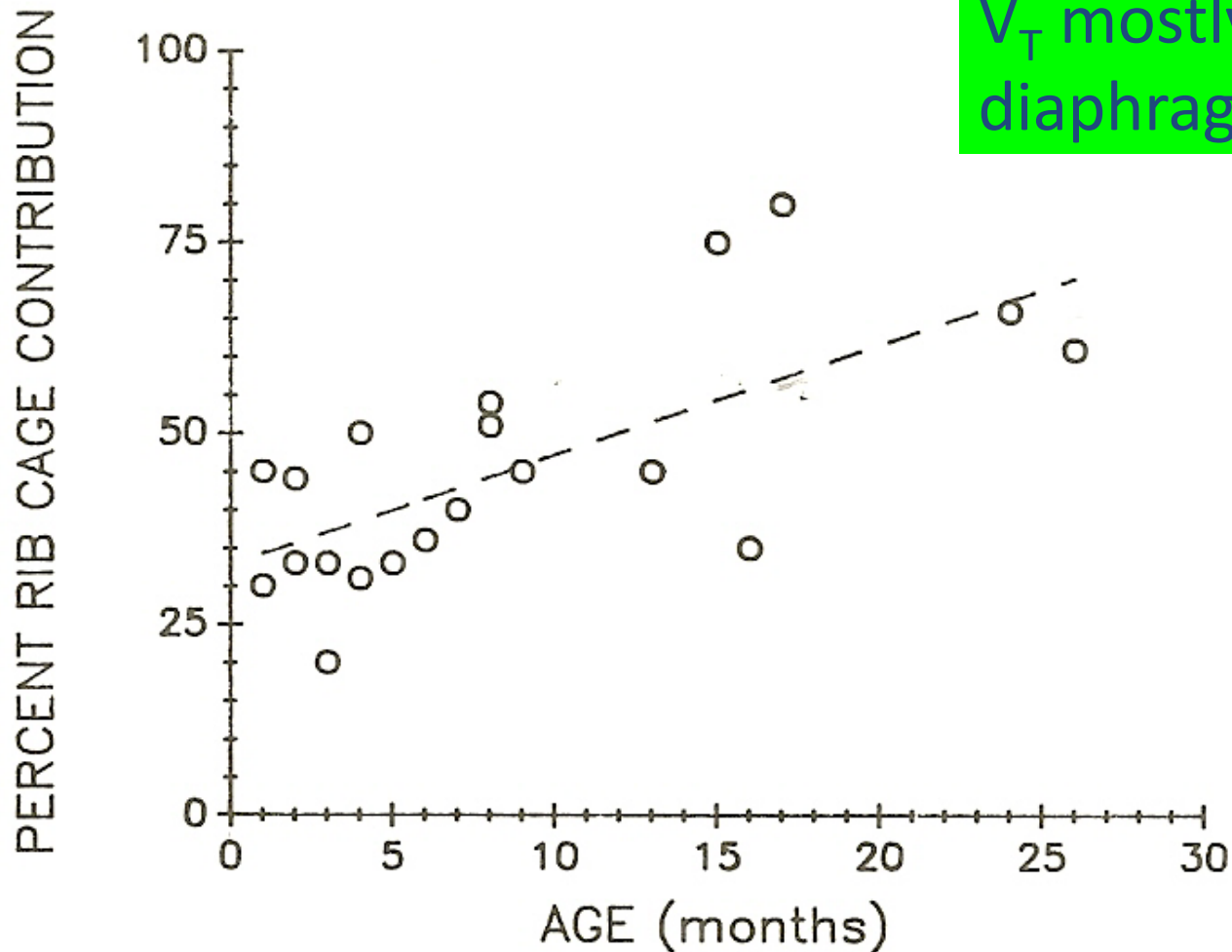
- Compliance: ↑ Chest ↓ Lung
- ↓ Passive FRC
- Active mechanisms maintain EELV
- Paradoxical respirations
- Lung volume ↓ in REM 30%

REM Paradox: Normative Data

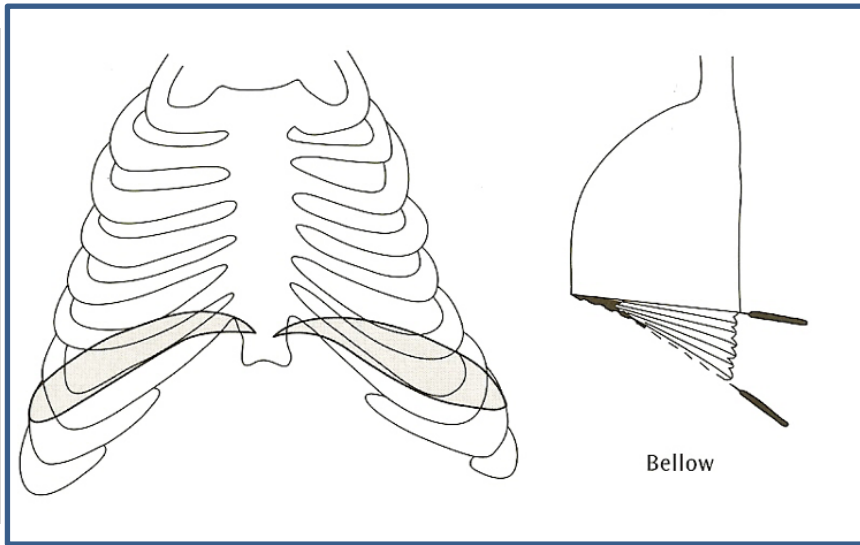
Paradox
During
REM
(%)



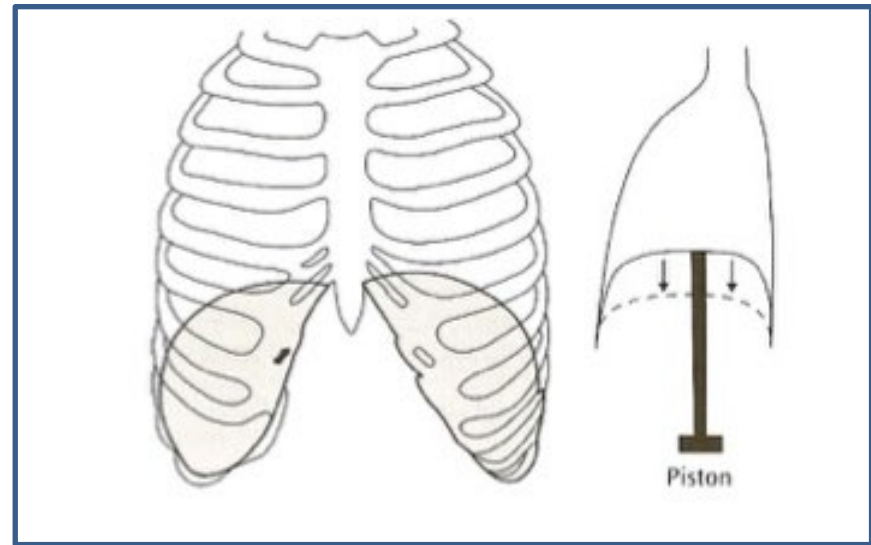
Infants: Tidal Volume



Diaphragm: Configuration

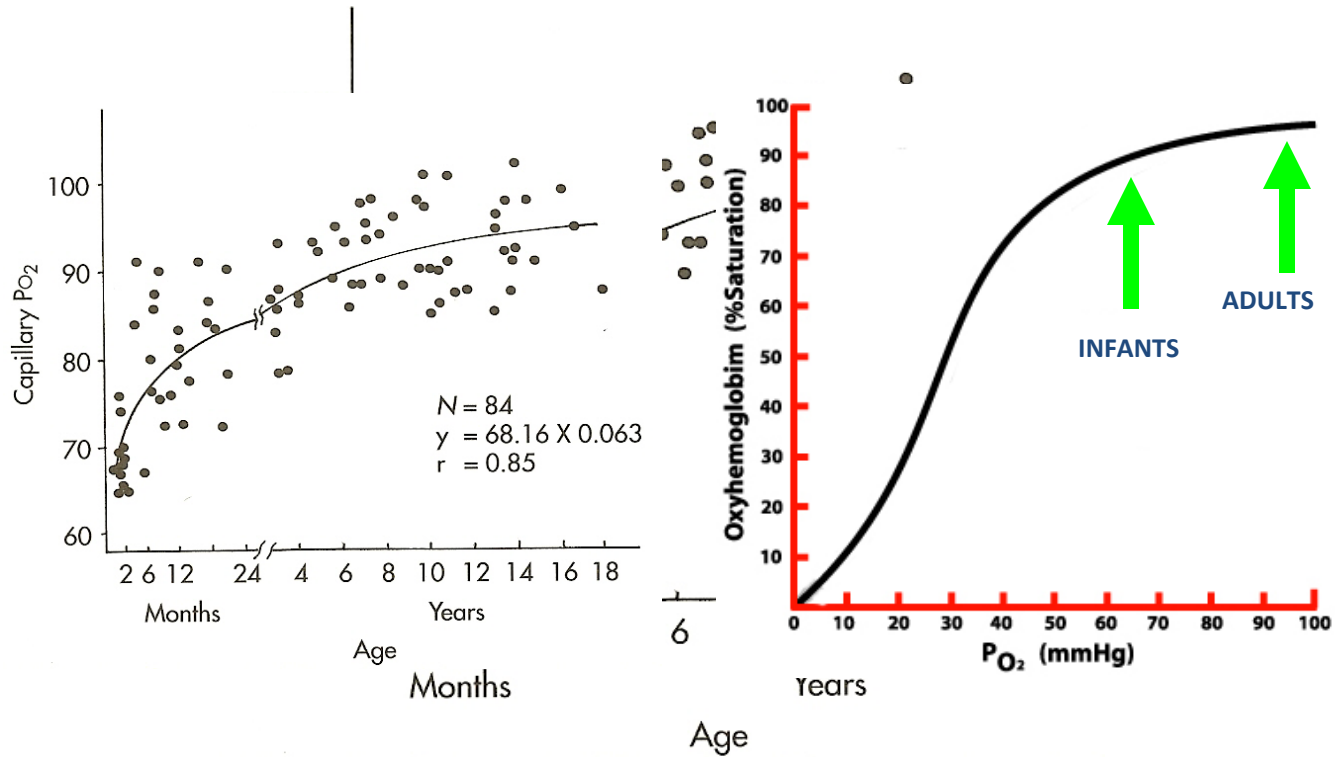


Infant



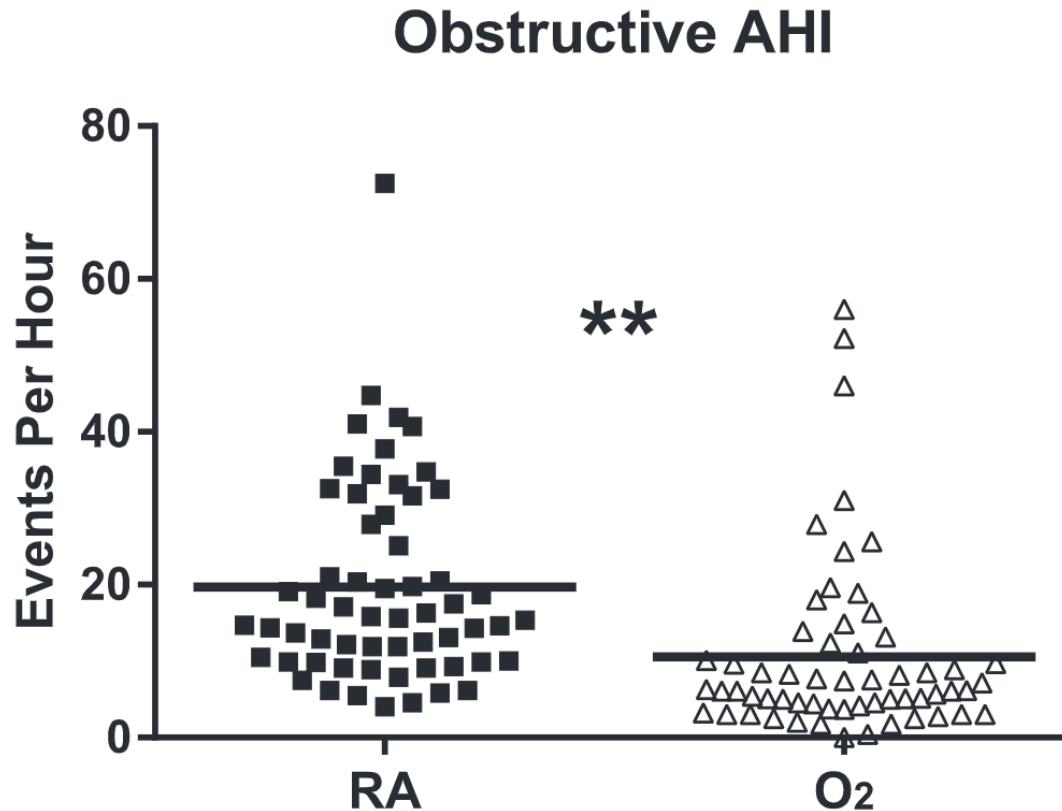
Adult

Oxygenation



Influence of supplemental oxygen on sleep-disordered breathing in infants

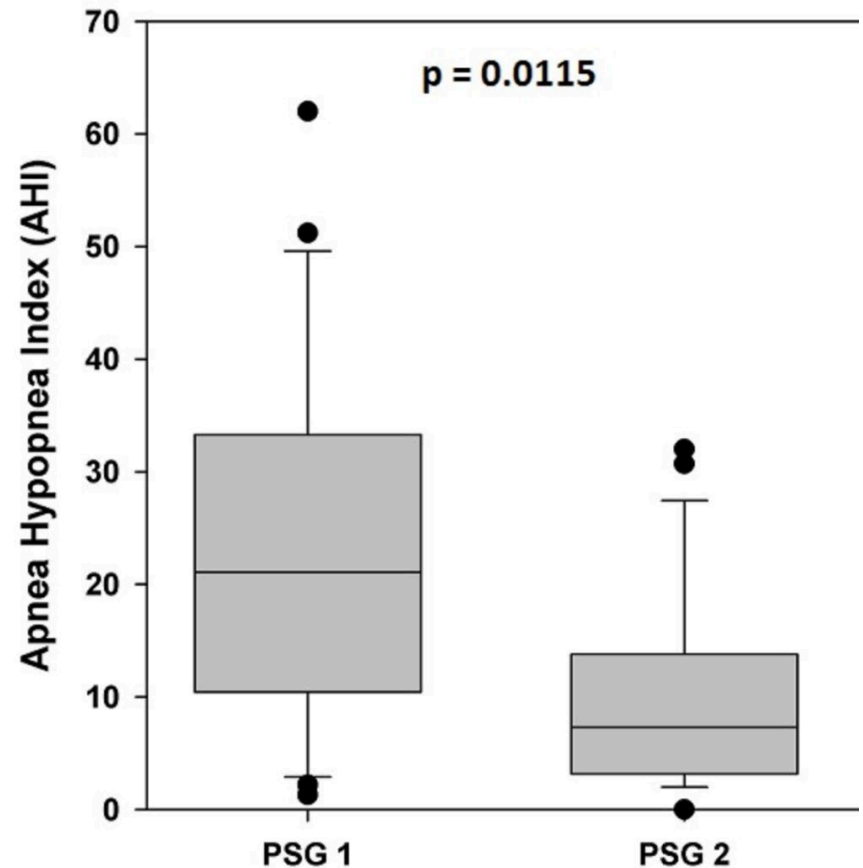
Influence of Oxygen on Infant OSA



Subjects:
N = 59
Ave 13 weeks
No Δ in CO₂

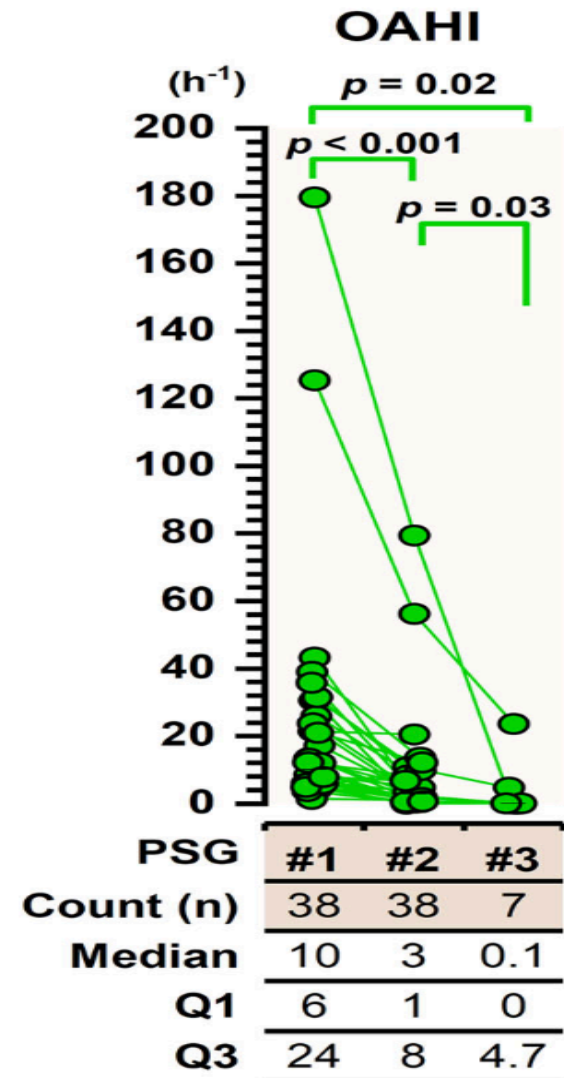
Infant OSA: Spontaneous Improvement

- Retrospective, no OR
- n= 39 infants with
 - Laryngomalacia 87%
 - Pharyngomalacia 33%
 - Tracheomalacia 10%
- Follow-up PSG in 22
AHI 23 → 10

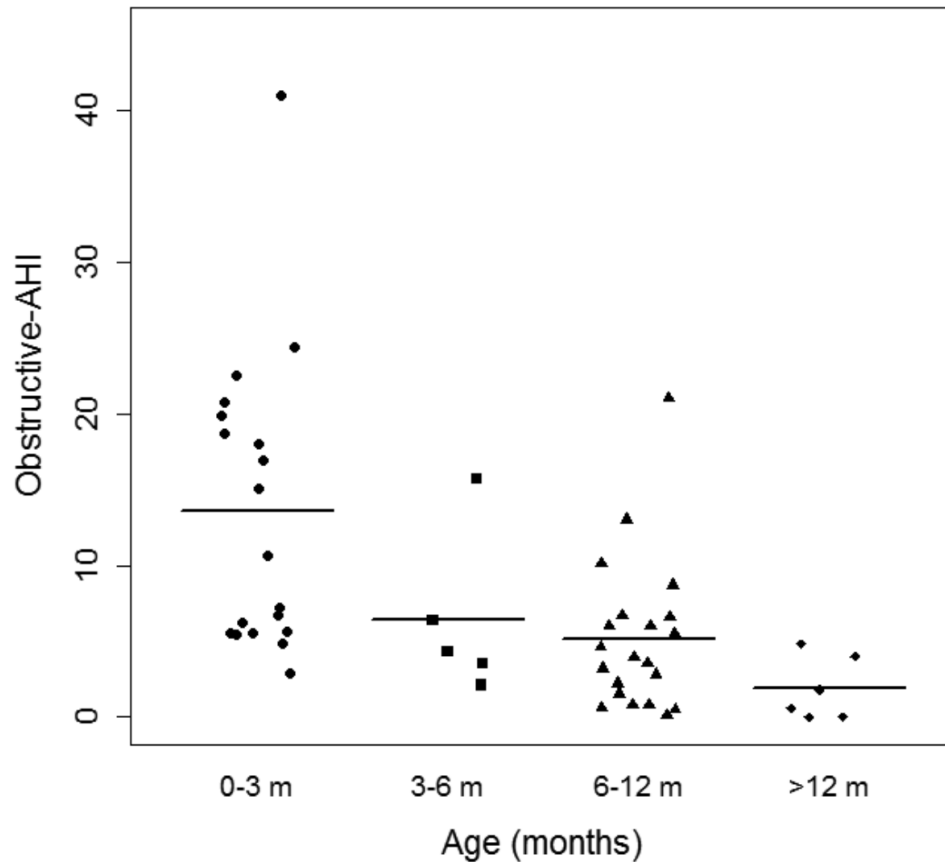


Infant OSA: Spontaneous Improvement

- Retrospective, no OR
- n= 38 infants
- Baseline 4 wks, Follow-up 11 wks
- Follow-up PSG oAHI 10 → 3



Pierre Robin Sequence: Natural History OSA



- 14 year retrospective
- 21 infants not operated
- 74% non-syndromic
- Baseline oAHI 13.4 ± 1.6
- 57% received suppl O₂
- Median resolution 15 mo
- Sleep quality also improved

Healthy Sleep Components

Sleep duration

Sleep quality

Schedule regularity

Positive bedtime routine

Environmental control (Cool, quiet, dark, comfy)

Medical/Psychiatric disorders

Not getting enough sleep?

Sleepiness

- Falling asleep in school
- Napping after school
- Extending sleep on weekends >2 hrs
- Excessive school tardiness
- Morning battle to wake-up

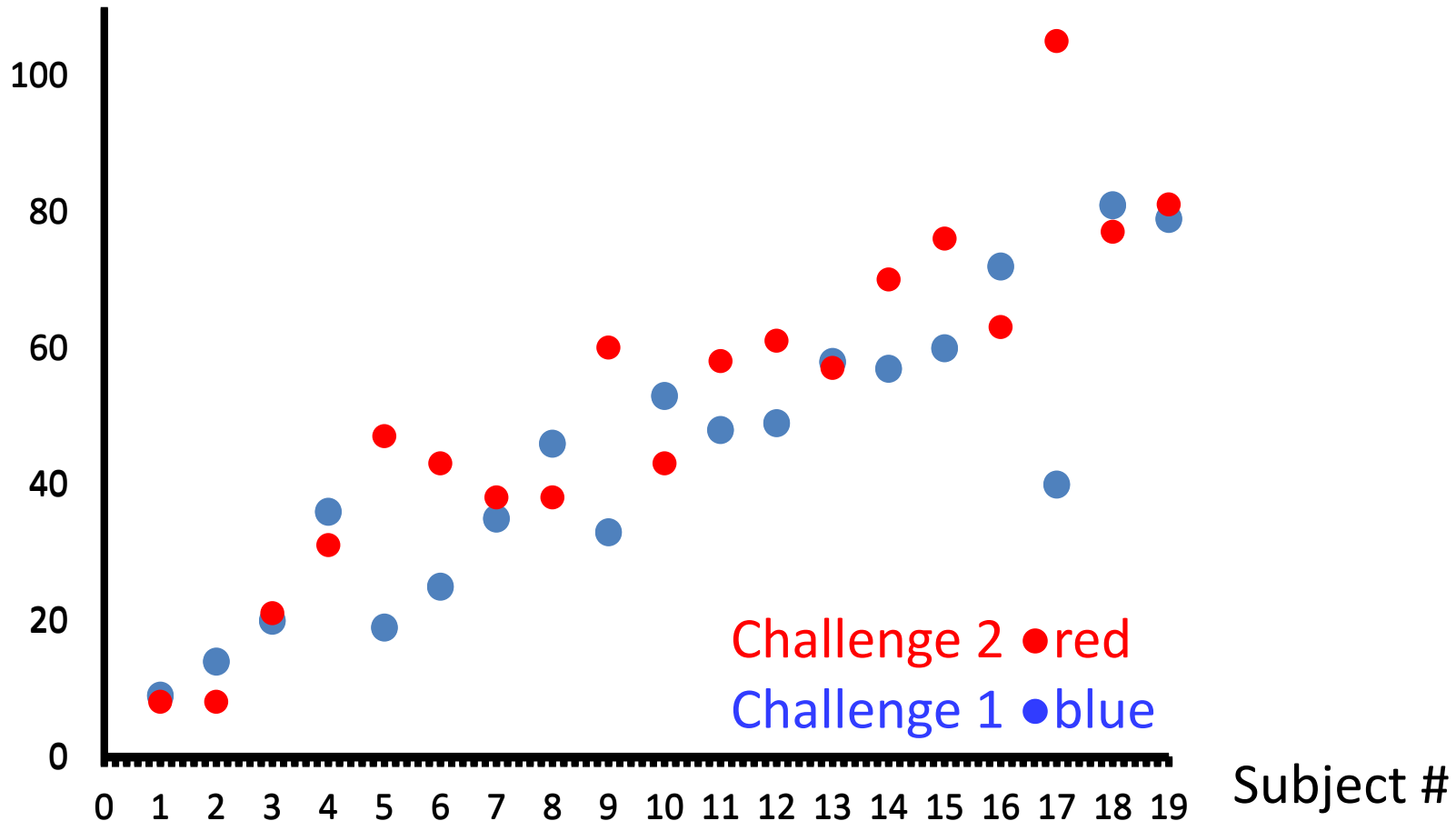
Cognitive

- School Performance Dewald, Sleep Med Rev 2010
- Attention Beebe, J Adol Health 2010
- Mood/Emotional Regulation Baum, J C P P 2014
- Impulsiveness Gruber, Peds 2012
- Eating behaviors/Weight Hart, Peds 2013

'Trait' Susceptibility to Sleep Restriction

Van Dongen et al, Sleep 2004; 27: 423-

Sleepiness

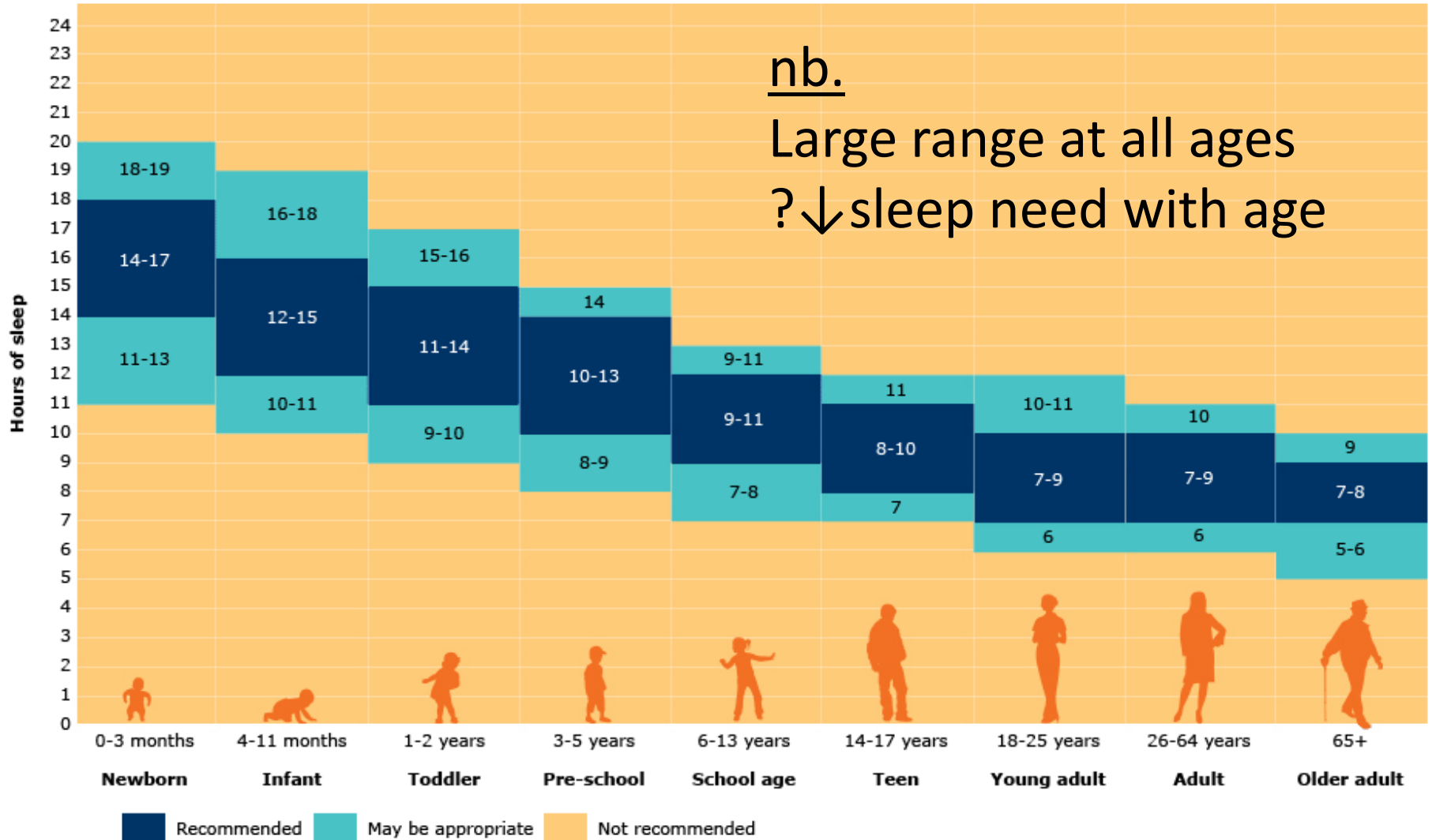


Study: 2 sleep restriction challenges of 6 hrs/day.

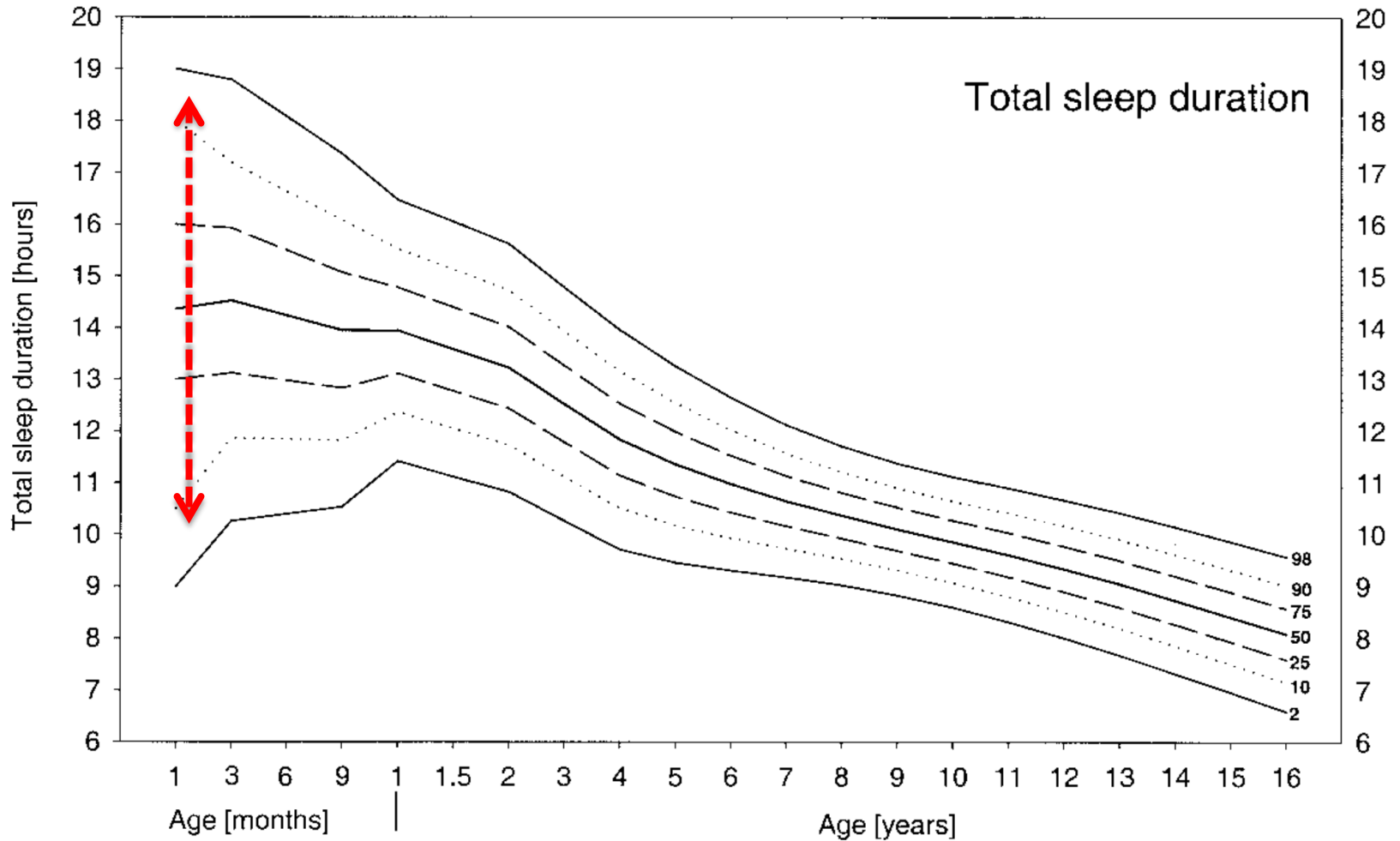
Results: Large, stable inter-individual differences ? Vulnerability trait ?

Sleep Time Recommendations

Expert Consensus



Sleep Duration



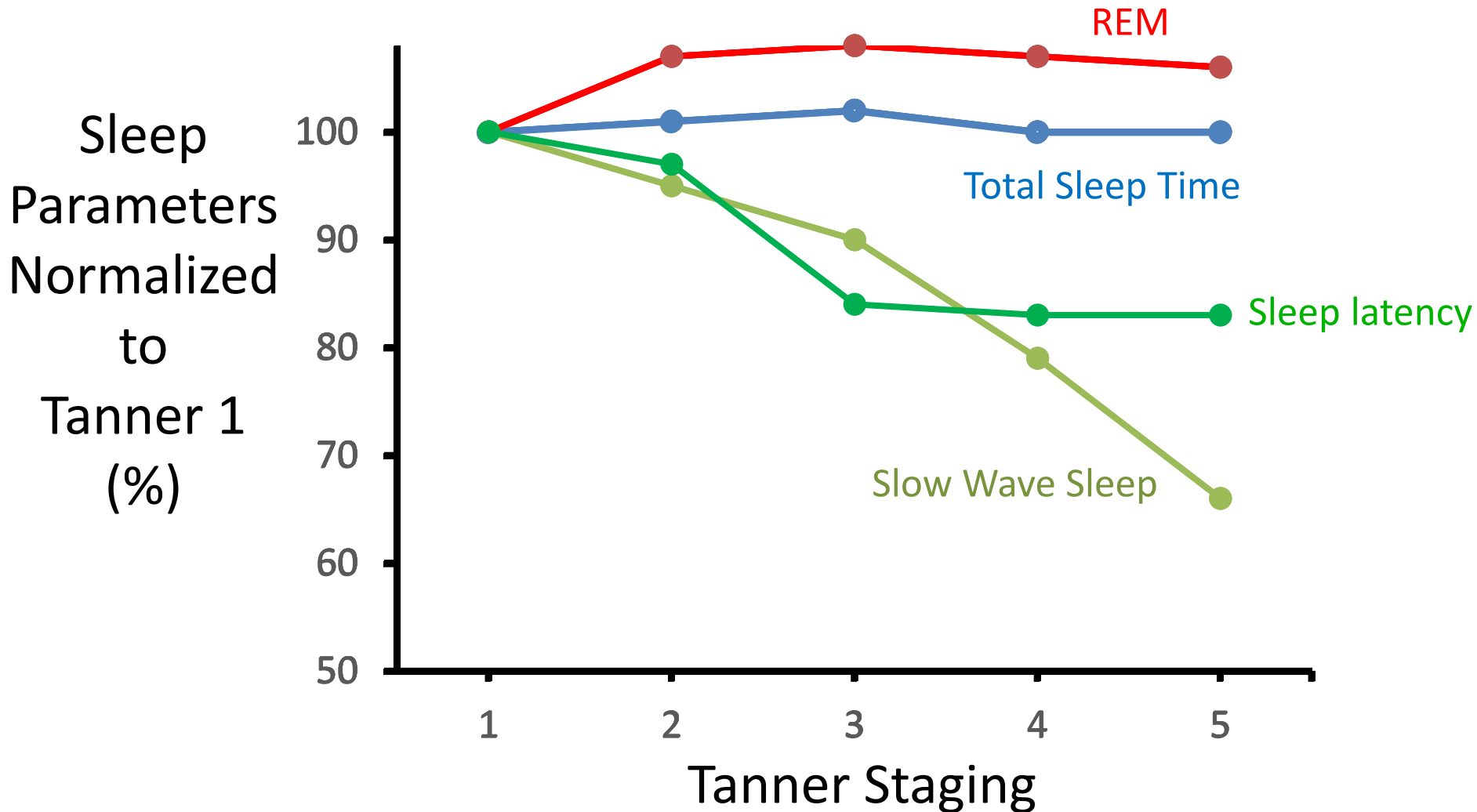
Short Sleepers

- ICSD/Insomnia
- <2 hrs below age-norms
- Normal sleep architecture
- Dx: Actigraphy/Sleep logs
- Longstanding
- Presents with parent report of “insomnia,” bedtime battles, early AM awakenings
- ‘Patients’ have no complaints
- Often young children

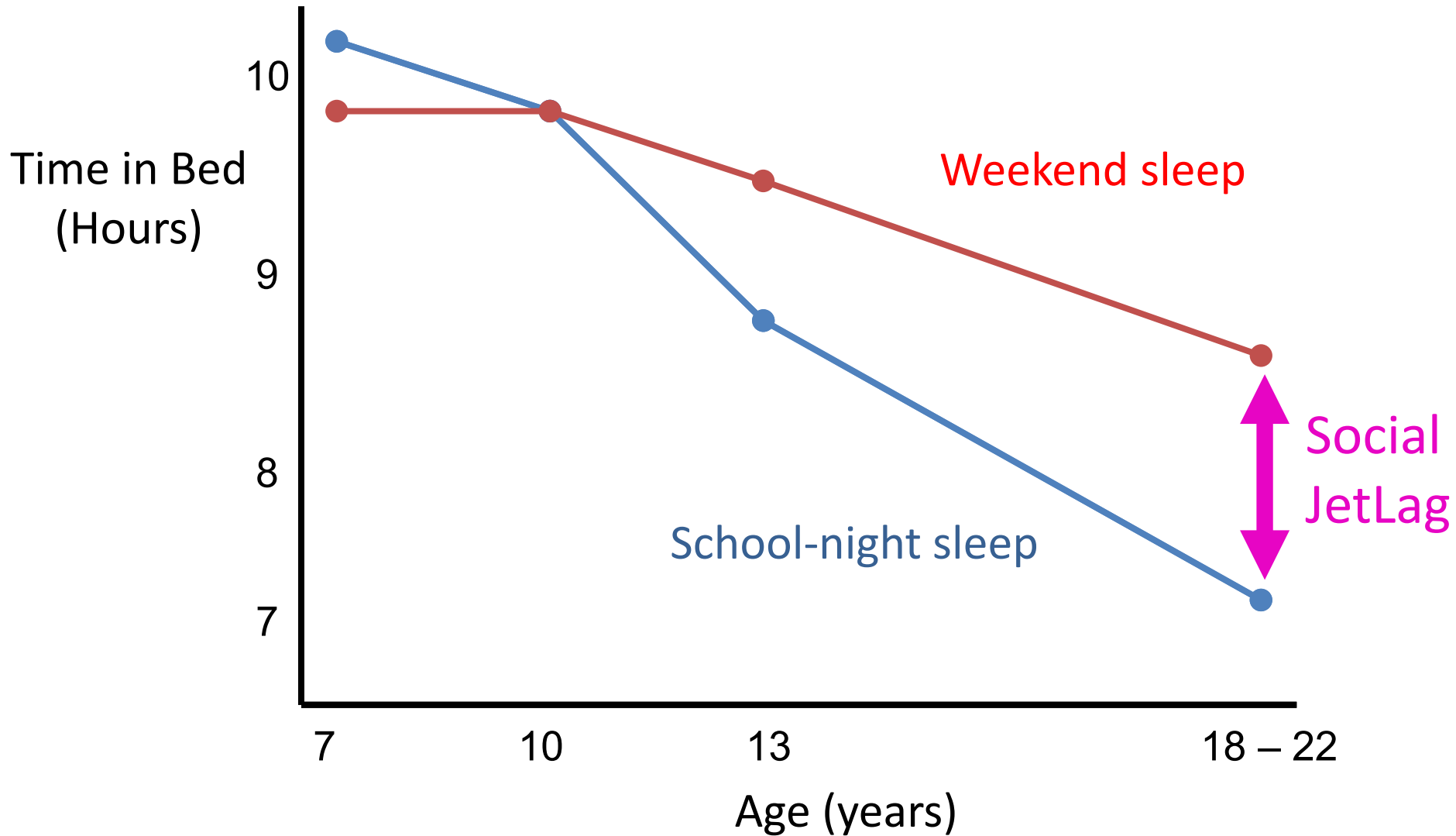
Long Sleepers

- ICSD/Hypersomnolence
- >2 hrs above age-norms
- Normal sleep architecture
- Dx: Actigraphy/Sleep logs
- Longstanding
- Usually presents with sleepiness when forced to curtail sleep
- Often Adolescents

Sleep Duration: Influence of puberty

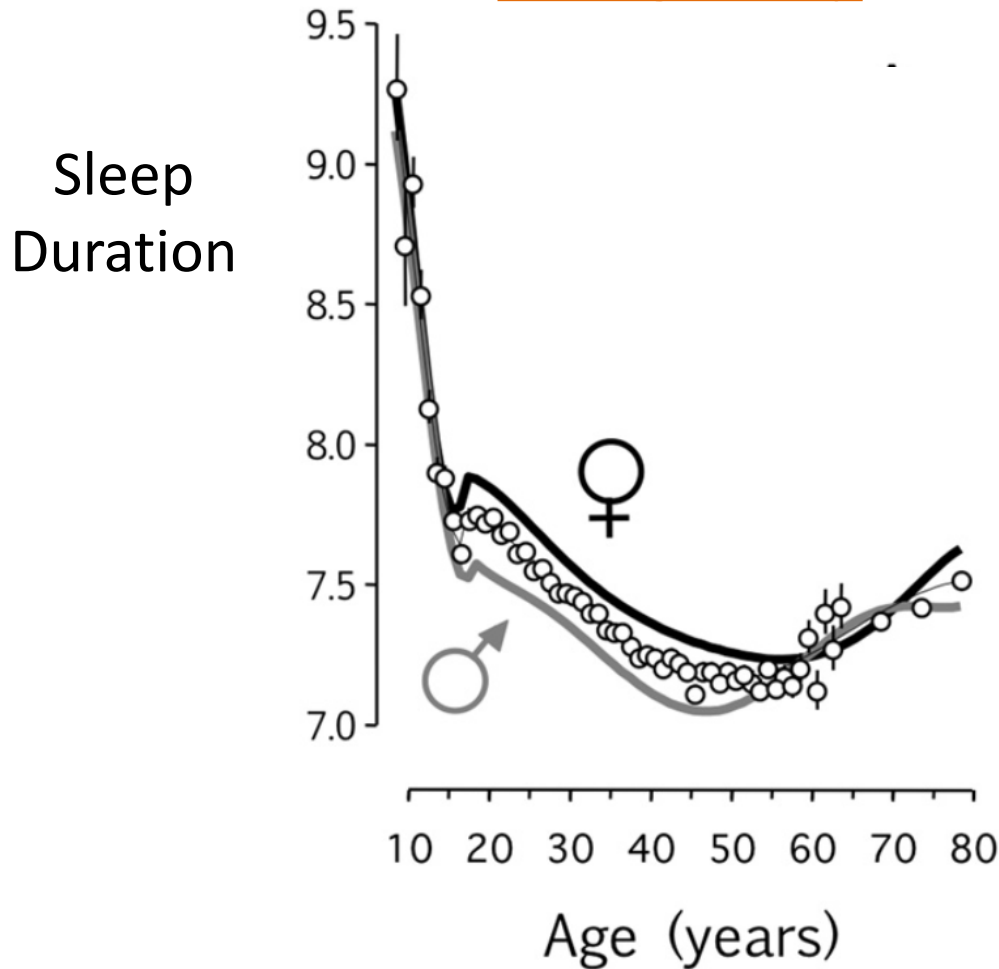


Adolescent sleep debt: Cultural Influence



Sleep Deprivation: Real World

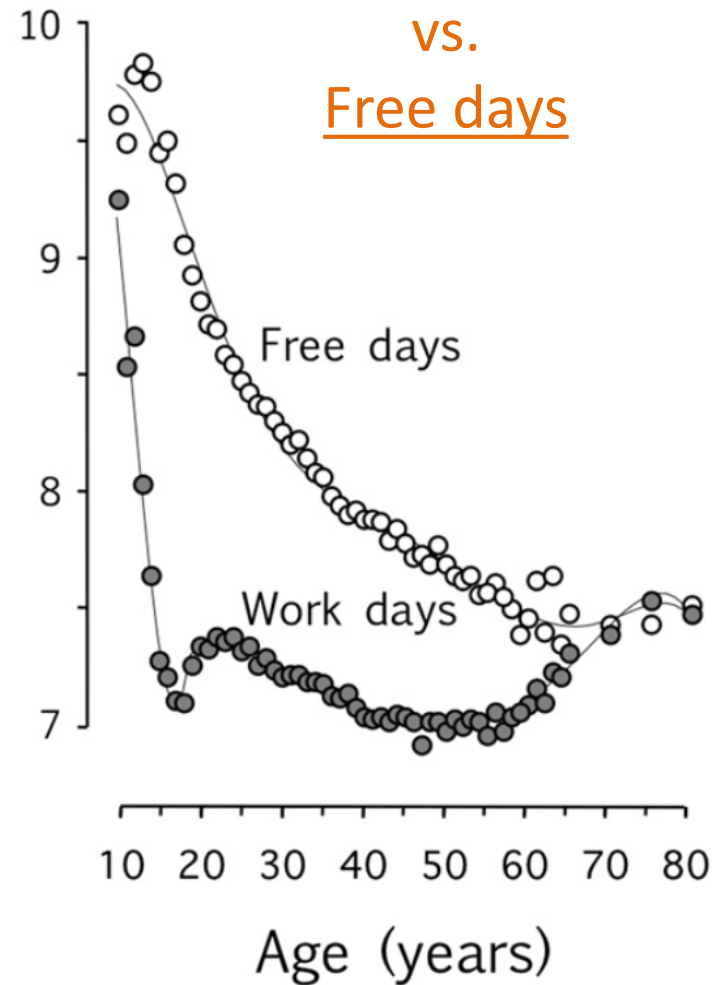
Average Sleep



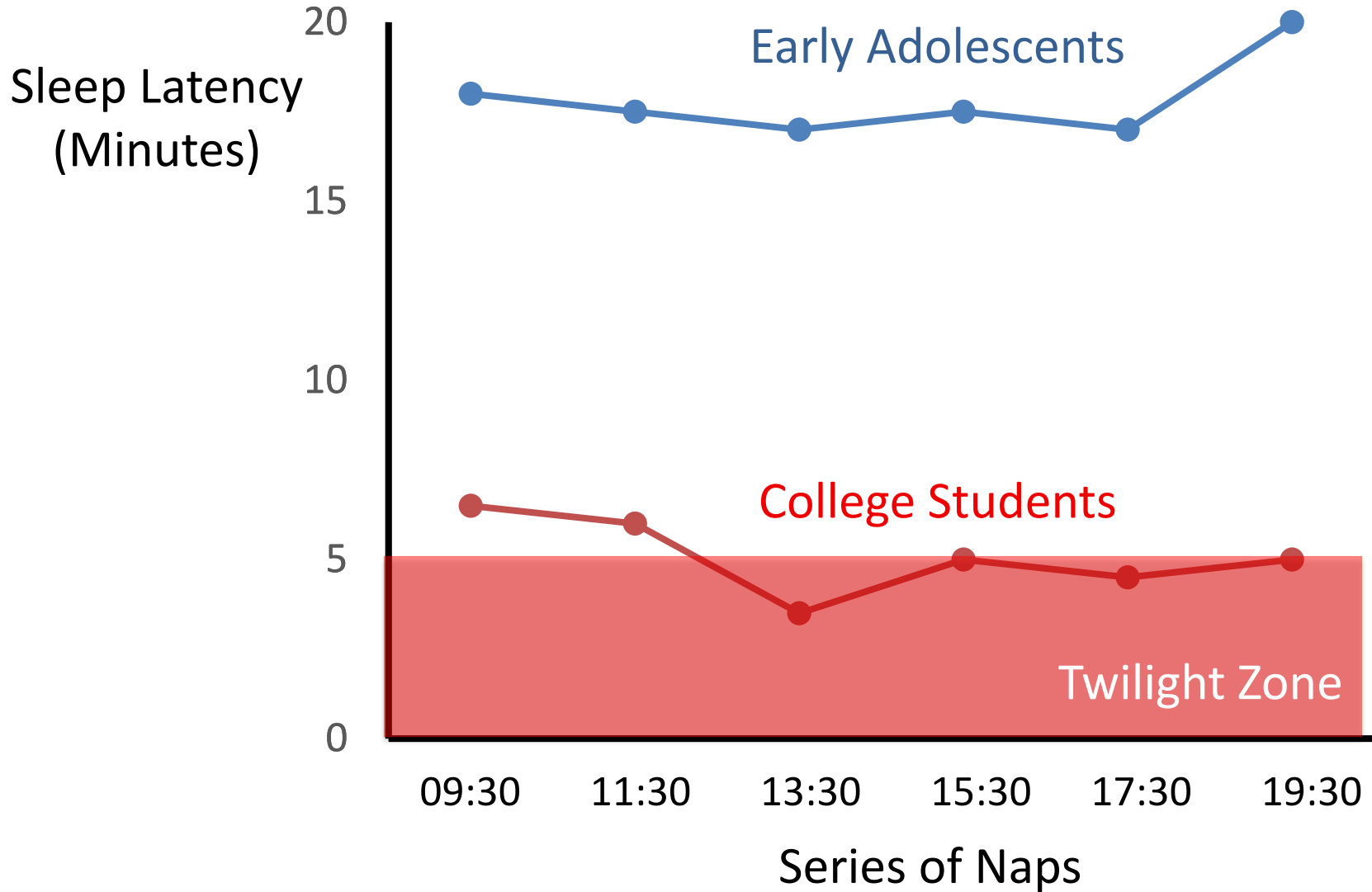
Work/School days

vs.

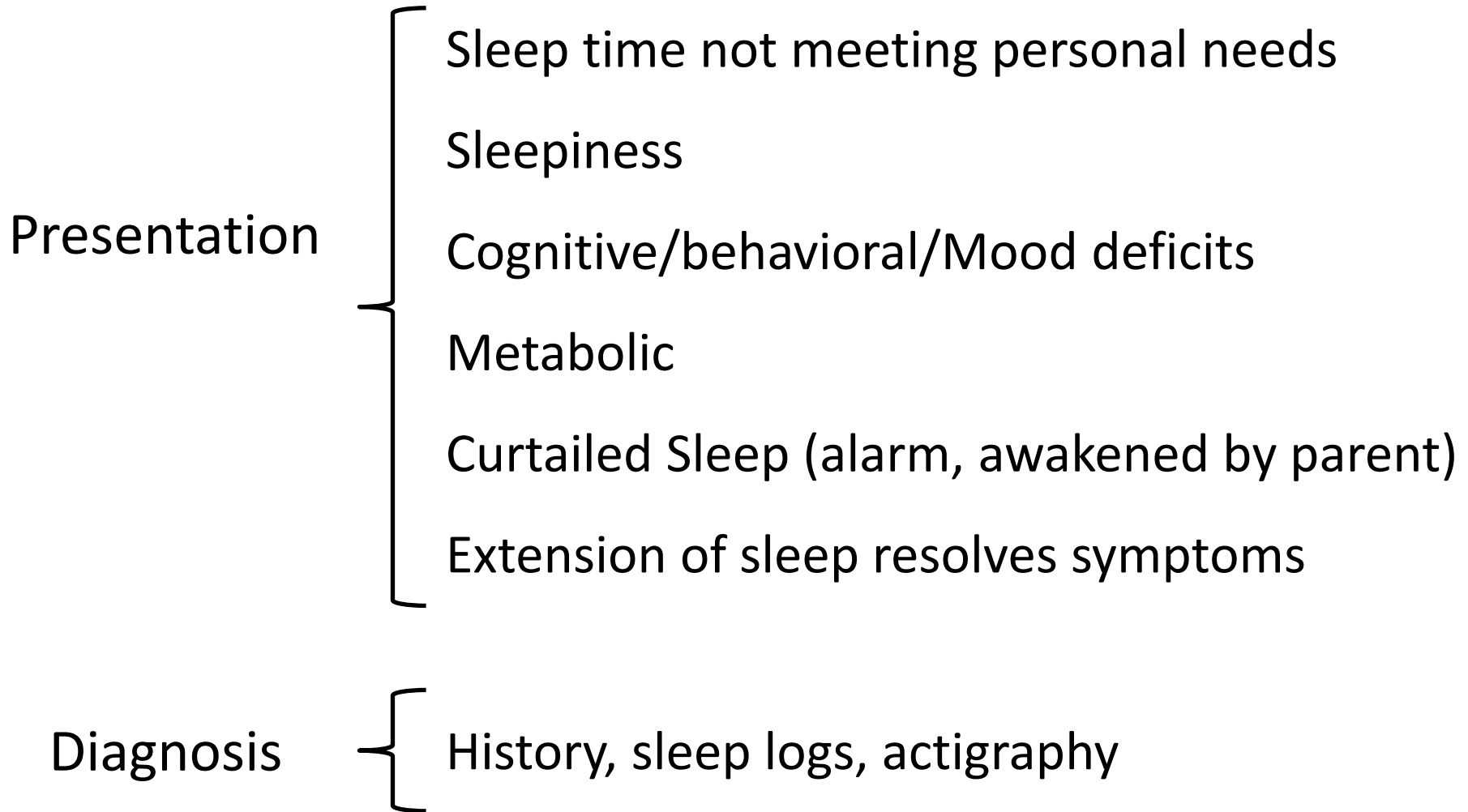
Free days



Wild-type adolescent sleepiness



Insufficient Sleep Syndrome



Insufficient Sleep Syndrome

Sleep extension has been documented to improve;

Attention

School performance

Mood/emotional regulation

Impulsiveness

Eating behaviors/weight

Hart, Behav Sleep Med 2015; 13: 424-
Hart, Peds 2013: 132; e1473-
Demos, SLEEP 2017:40;

Insufficient Sleep Syndrome

Treatment

Motivation

Goal setting: Prescribe 1–1.5 hr ↑ in Time in Bed

Problem solving/planning (social, family, school)

Self monitoring

Positive bedtime routine

Sleep hygiene

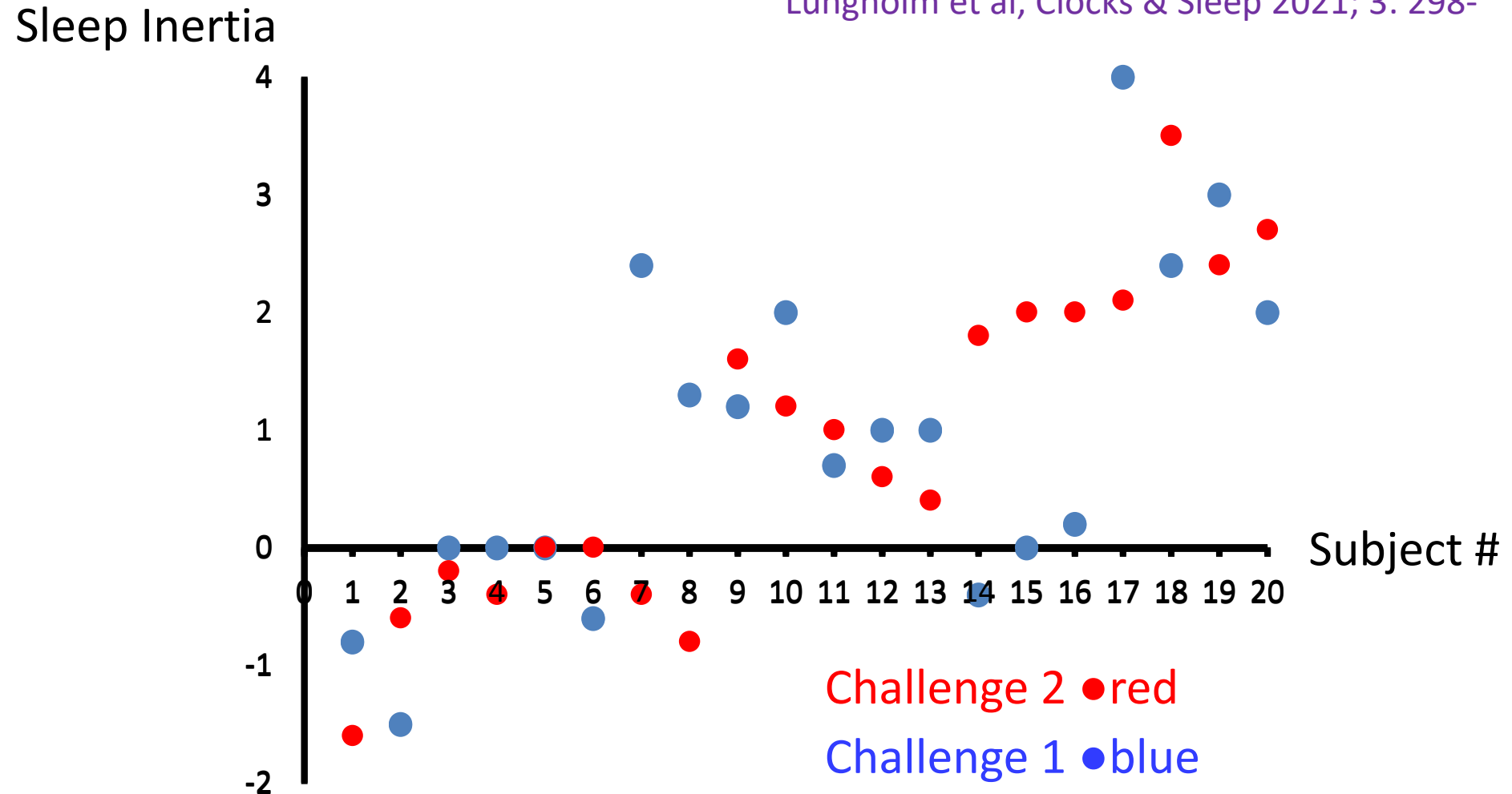
Incentives: Positive reinforcement routine

Sleep Inertia: “Waking up tired”

- Temporary sleepiness, disorientation, impaired response times, or grogginess upon awakening
- Exacerbating factors: sleep restriction, circadian
- Occurs under normal conditions
- Impairment usually exponentially dissipates over 2 hours but may be prolonged in certain individuals
- Worse in younger children
- Less severe after naps <30 minutes
- SWS > STAGE 2 > REM ?

'Trait' magnitude of Sleep Inertia

Lungholm et al, Clocks & Sleep 2021; 3: 298-



Study: 2 measurements of sleep inertia

Results: Large, stable inter-individual differences ? trait inertia?

Sleep Inertia: Clinical Presentation

Symptoms

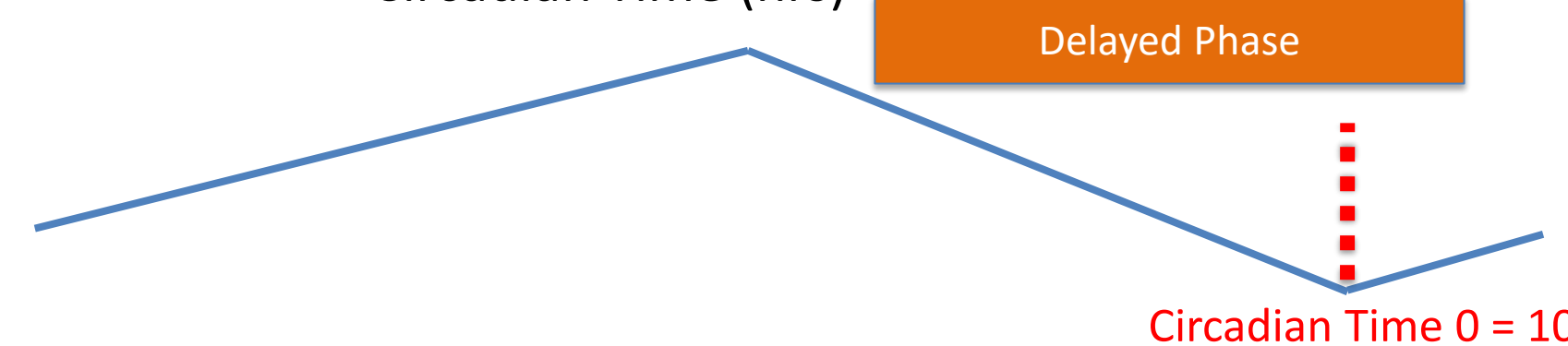
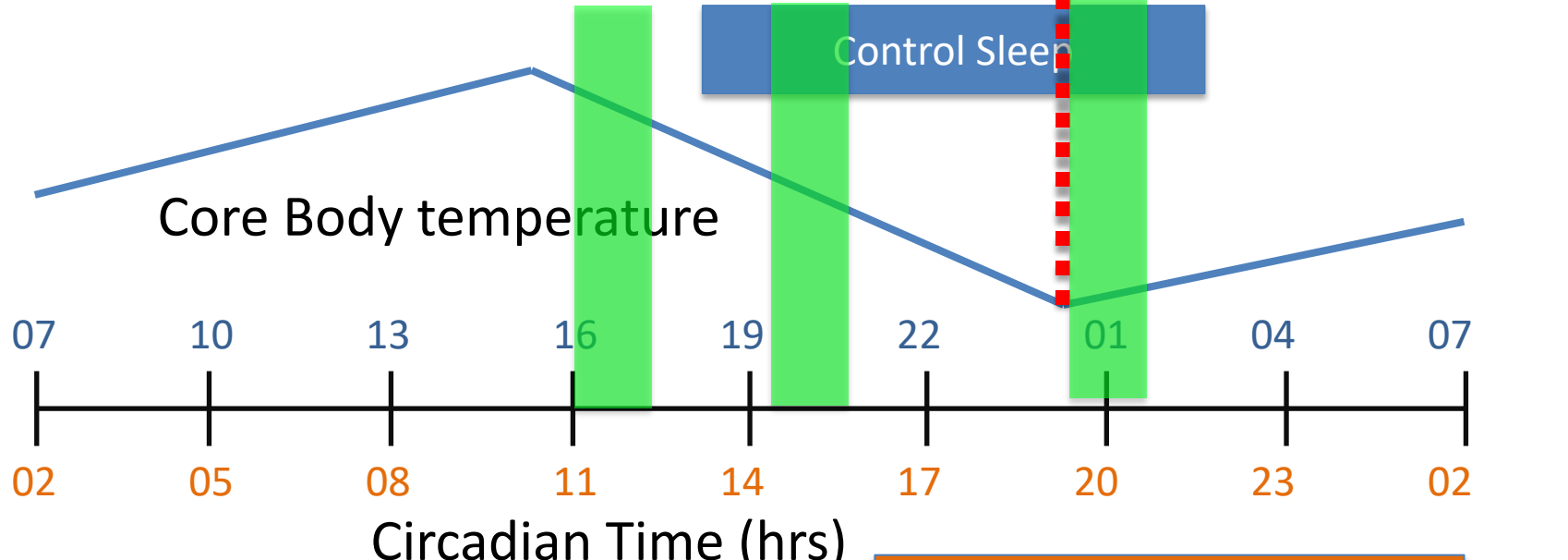
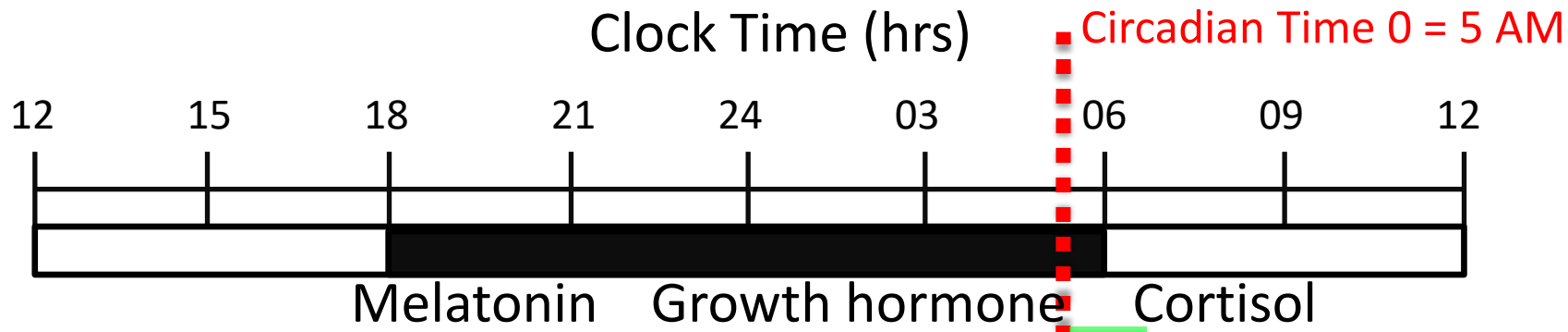
- Child difficult to arouse in AM
- Moodiness upon awakening
- Parents perceive child had poor quality sleep
- Exacerbated by Delayed Sleep Phase Syndrome (DSPS)

Treatment

- Distinguish from Insufficient Sleep/DSPS & Reassure
- Avoid sleep deprivation & irregular sleep timing

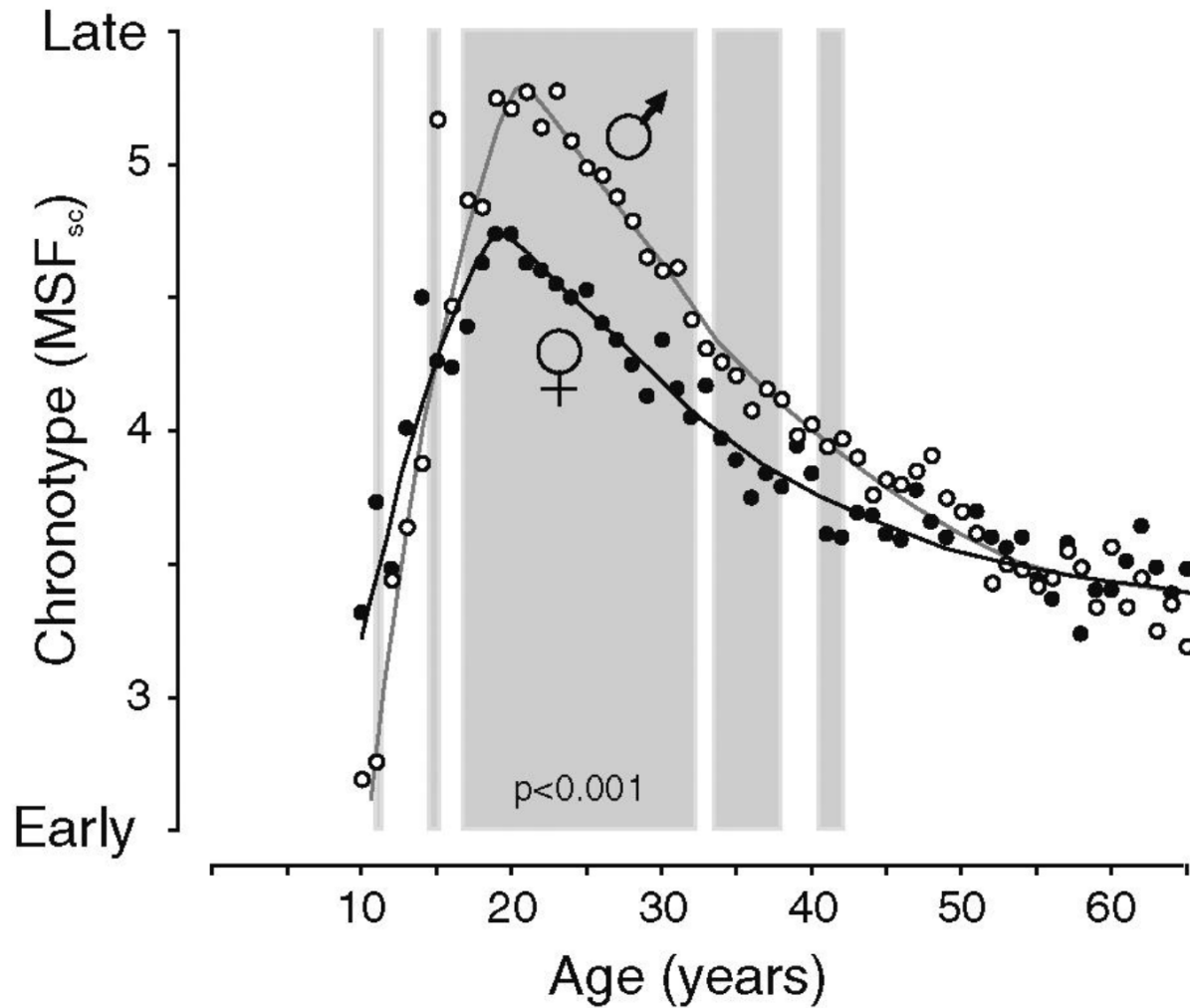
Circadian Considerations

- Physiological rhythms of \cong 24 hours include temperature, hormonal, behavioral, & biochemical
- Humans preferred bedtime is 1-2 hours after the rise in evening melatonin
- Toddler's melatonin surge varies by 3.5 hours in the population [bedtime range 6:30 – 10:00 PM]
LeBourgeois, J Bio Rhyth 2013: 28:322-
- One bedtime does not fit all
- A child with a later than average melatonin surge may present with difficulty falling asleep

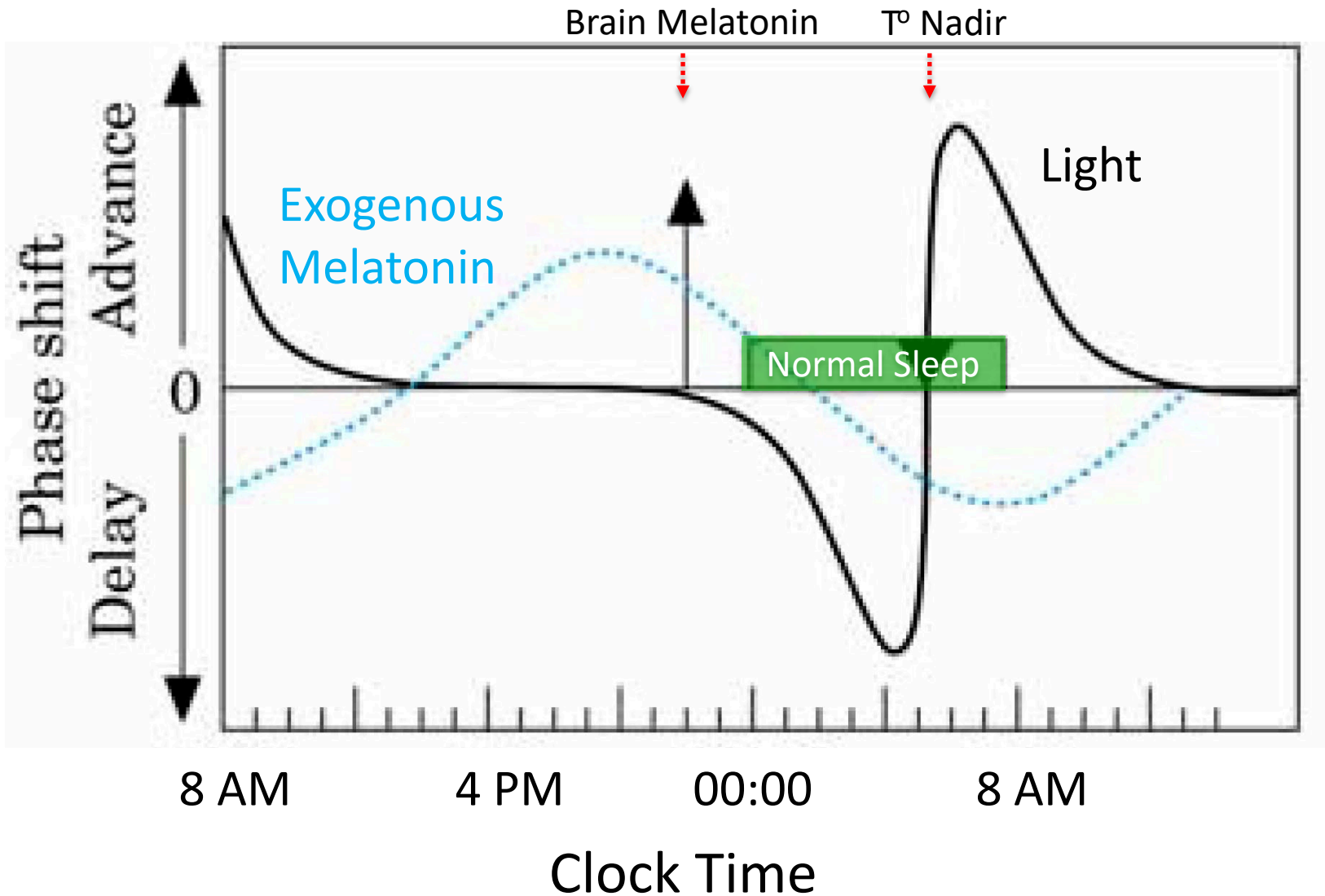


Circadian Phase

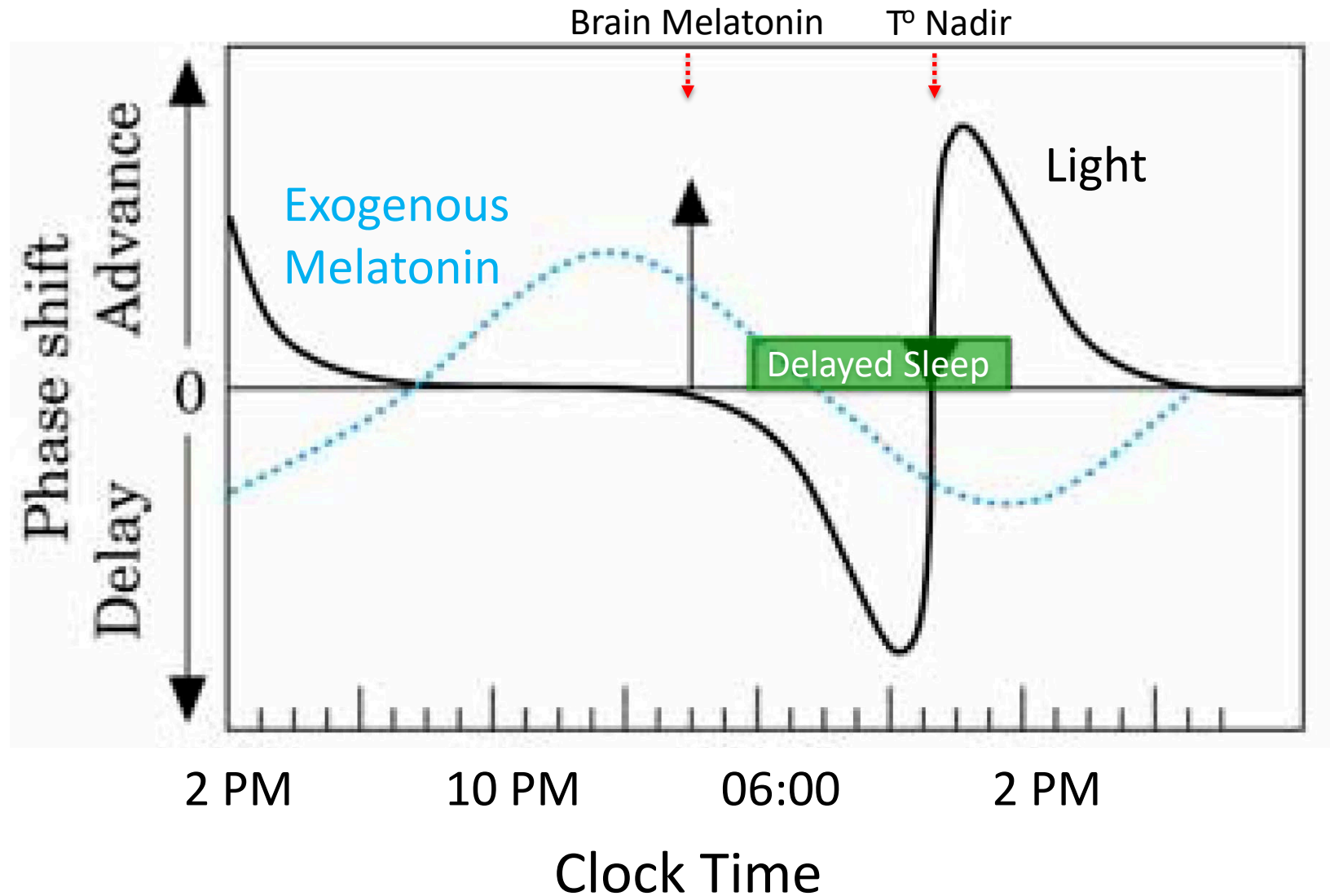
Mid-Sleep
on
Free days



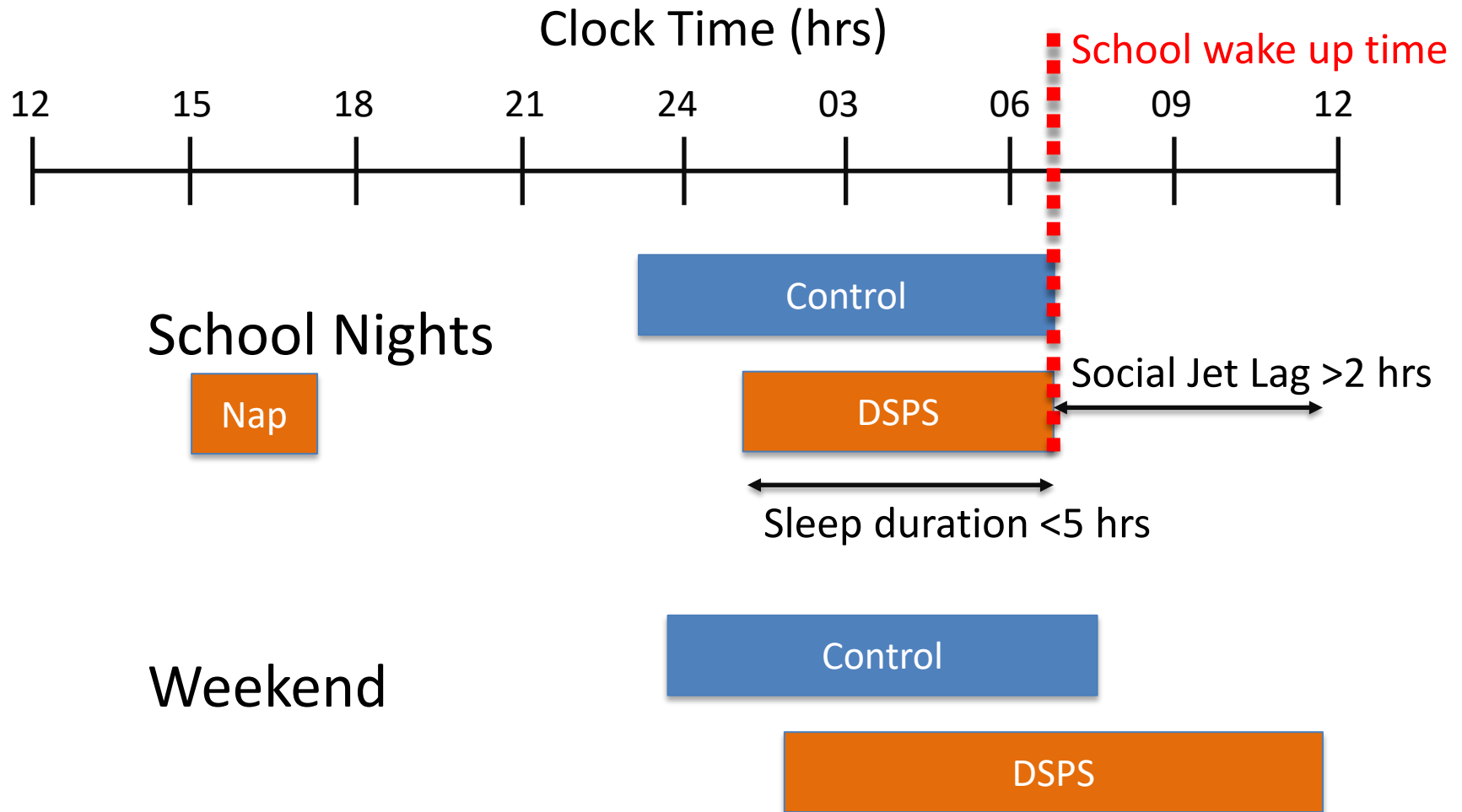
Phase Response Curve: Normal Sleeper



Phase Response Curve: Delayed Sleep



Delayed Sleep Phase Syndrome (DSPS)



Delayed Sleep-Wake Disorder

ICSD-3

Must have A-E

- A. Significant delay falling asleep and difficulty awakening
- B. >3 months
- C. Improved sleep quality of allowed to self-select schedule
- D. Sleep Log or actigraphy with delayed sleep
- E. Not better explained by another sleep disorder

Sub-type: “Motivated” DSPS – Symptoms often exaggerated with little motivation to accept treatment due to mood/anxiety disorder, ADHD, learning disability [Secondary Gain, Social/Psych Factors]

DSPS: Management

Sleep habits:

No caffeine, naps, nicotine

Limit evening exercise, screen activity

Awaken on weekend within 30 min of weekday time

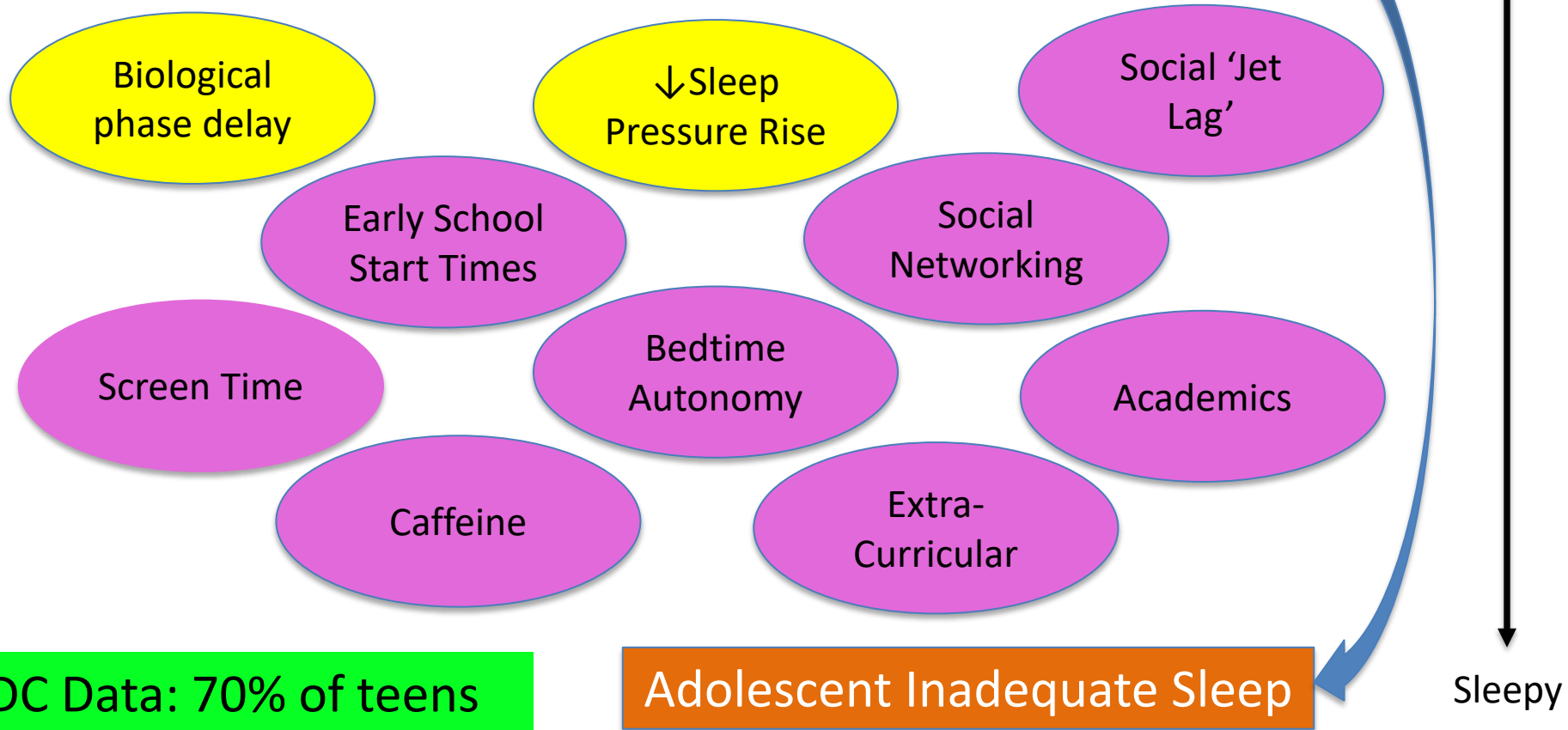
Delay school start time

Light Therapy: 10,000 Lux, 45 minutes in biological AM, advanced 30 minutes/day from habitual wake time until desired wake time is reached

Melatonin: 0.5-1 mg 4-6 hours prior to desired bedtime

Adolescent Sleep: The Perfect Storm

Prepubescent Adequate Sleep



CDC Data: 70% of teens get insufficient school night sleep (<8 hrs)

Adolescent Sleep: The Perfect Storm

Sleep regulatory Δ 's + Psychosocial Δ 's = Inadequate sleep
(Modifiable) (Non-modifiable) (Consequences)

Consequences

- Sleepiness, mood disorders, anxiety/depression
- Behavioral problems, substance abuse
- Motor Vehicle accidents
- Poor school performance
- Weight gain

Approach to Pediatric Sleep Disorder

- Consider the cultural context – Who's the Patient?
- Sanction age-appropriate behavior
 - Awakenings
 - Companionship
 - Parasomnias
- Evaluate individual traits
 - Sleep Duration (Actual/Needed)
 - Biological Bedtime/Phase preference
 - Sleep inertia
- Co-morbidities
 - Anxiety, depression
 - Sleep-disordered breathing, neurological impairments

Questions?

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