

# Evening Shift

- **Evening shift workers on average sleep more than day shift workers (7.6 vs. 6.8 hours/night) with equal sleep efficiency**
- **Prevalence of complaint of insomnia or excessive daytime sleepiness (shift work sleep disorder) not different in day and evening shift workers<sup>5</sup>**

# Rotating Shifts

- **Best – fast forward (2 days morning, 2 days evening, 2 days nights)**
- **Worst – slow backward (1 week nights, 1 week evenings, 1 week days)**

# Other Countermeasures

## ■ Stimulants on shift

Wesensten et al., 2005

- Caffeine
- Other stimulant drugs, e.g., modafinil
- Stimulants (caffeine, d-amphetamine, modafinil) appear equivalent for first few hours in clinically acceptable doses

## ■ Sleep-inducing drugs when sleeping off shift

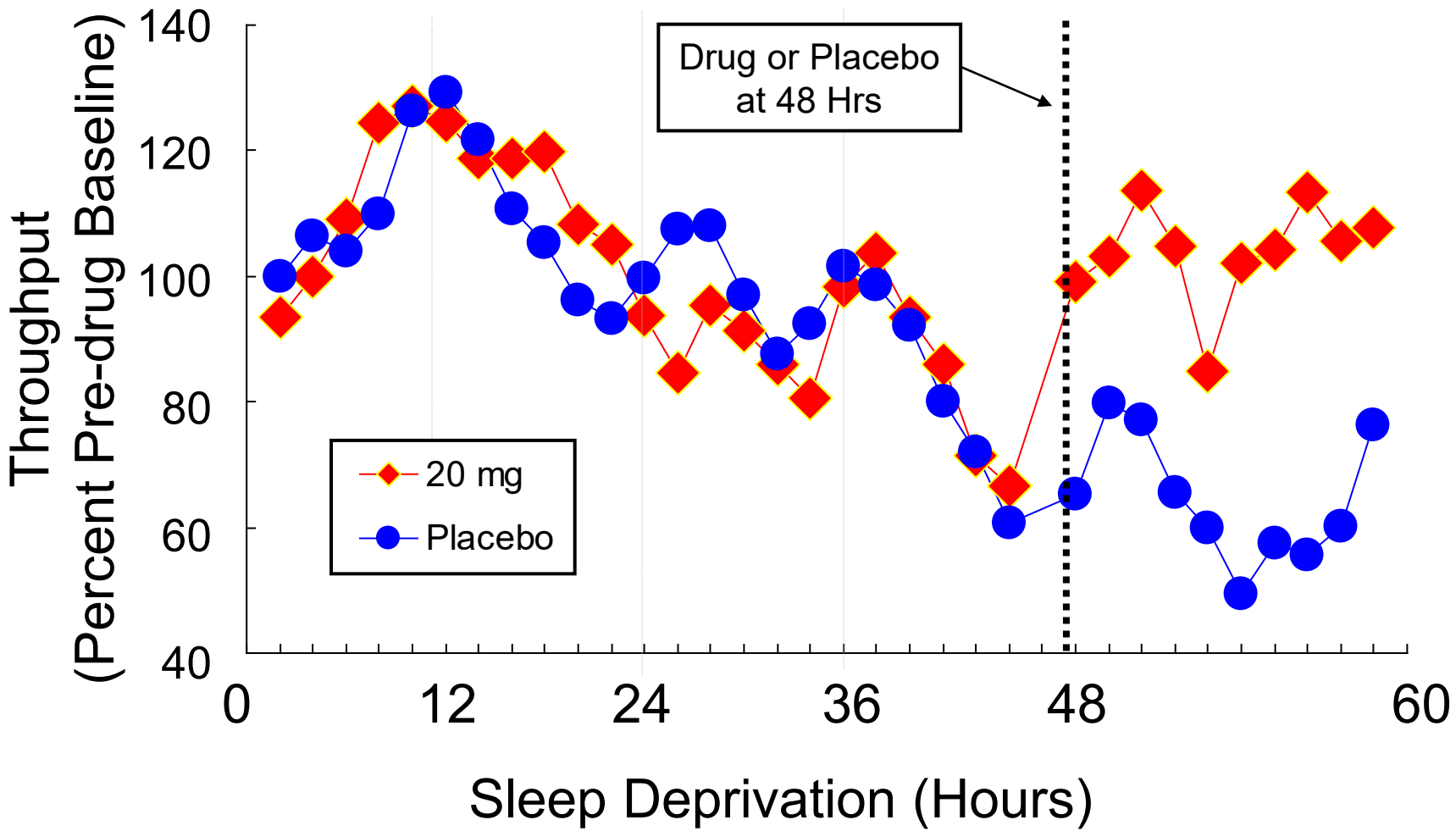
- BZD receptor agonists
- Melatonin and melatonin analogues

## ■ Naps on shift

## ■ Bright (blue) light on shift

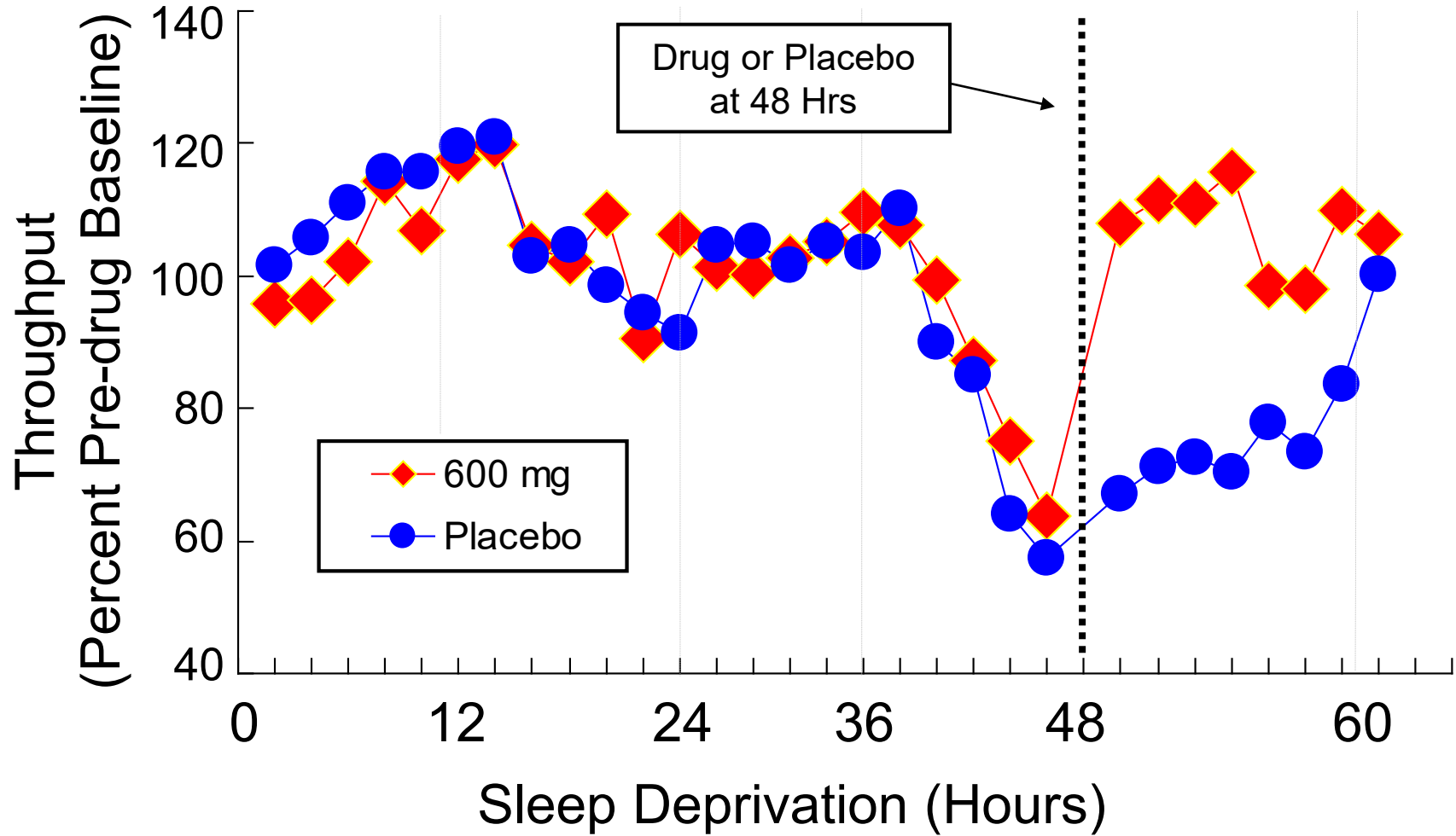
## ■ Strict environmental control when sleeping off shift

# ***d-Amphetamine 20 mg: Effects on Complex Mental Operations***

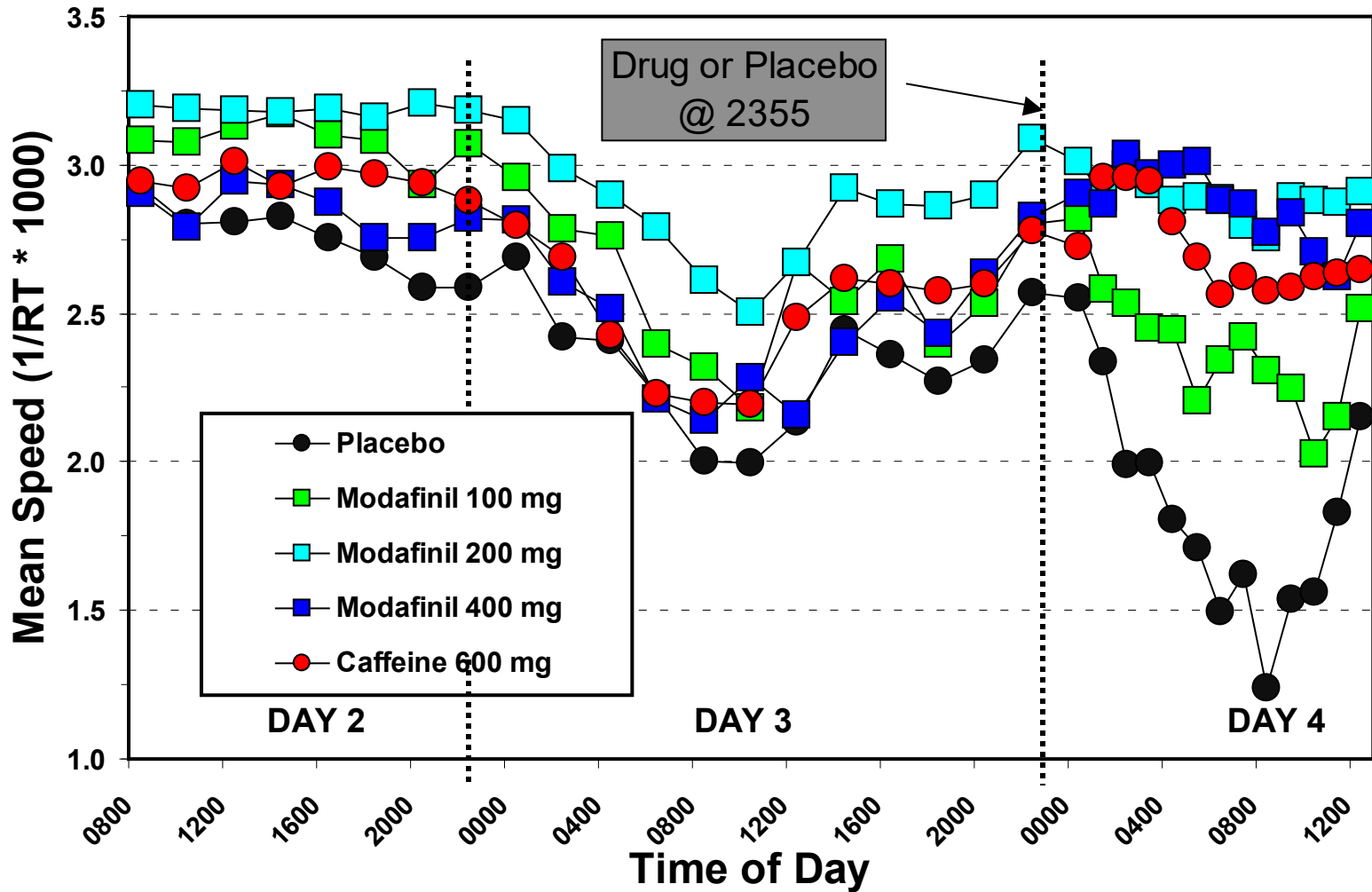




# ***Caffeine 600 mg: Effects on Complex Mental Operations***

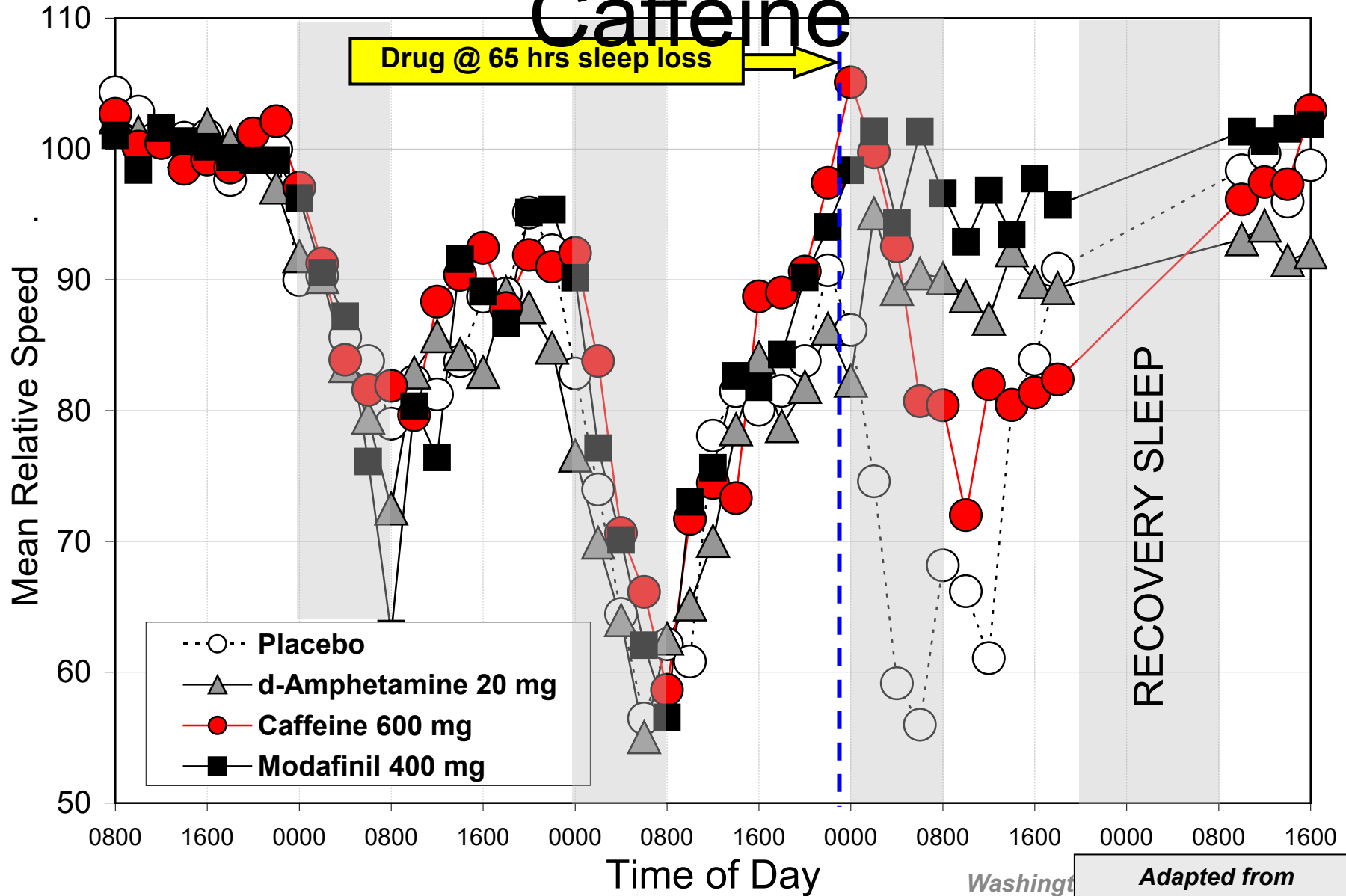


# Modafinil vs. Caffeine



# Amphetamine vs. Modafinil vs.

## Caffeine



# Summary: Shift Work and Sleep

- **Working night and early morning shifts is associated with disrupted and truncated sleep**
- **In some individuals this leads to insomnia during available sleep opportunity and excessive sleepiness while awake**
- **A function of circadian influences on sleep propensity limiting sleep even when there is adequate opportunity for sleep**
- **A variety of behavioral and pharmacological measures may**



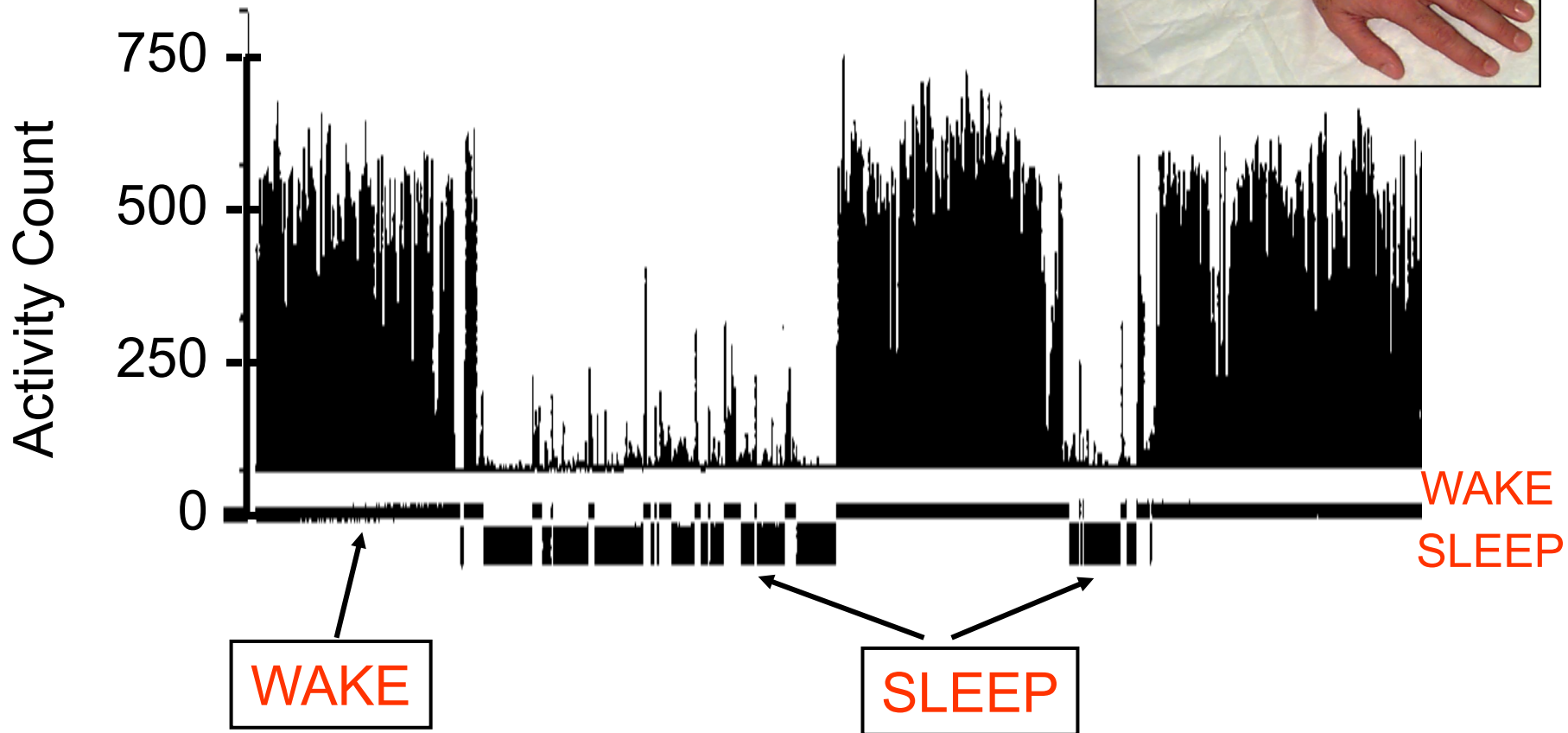
# Tools to Measure Sleep and Measure and Predict Performance in the Operational Environment

# Tools to Measure Sleep and Performance in the Field



- **Actigraph / Sleep Watch to monitor sleep/wake history**
- **Unobtrusive, robust wristwatch-sized device**
- **~\$400-800**
- **Accurately measures total sleep time**
- **Psychomotor Vigilance Task (PVT) is a 5 or 10 minute test**
- **Portable, convenient, robust**
- **~\$350**
- **Accurately measures performance**

# Sleep Watch Measurement of Sleep



# U.S. Army National Training

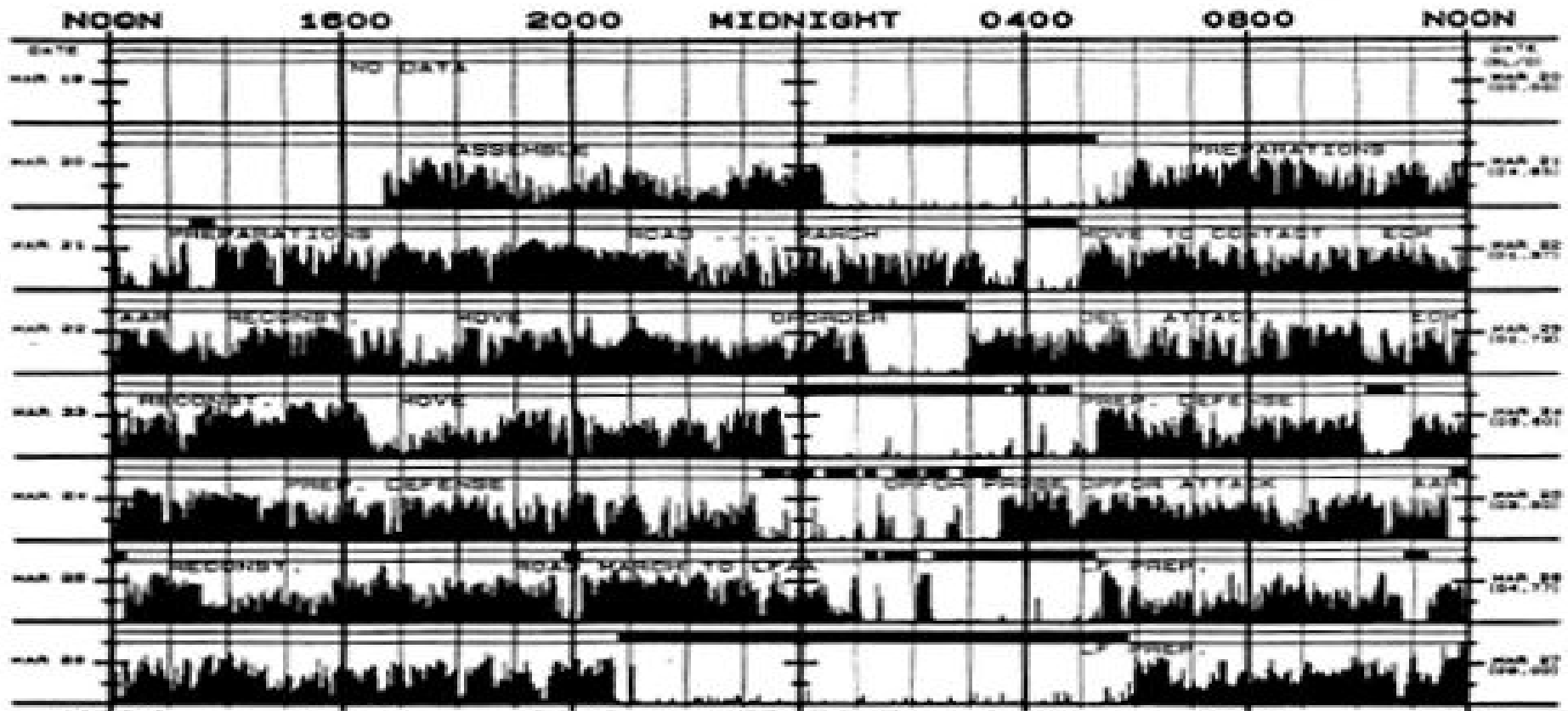
## Center:

### Armor Officer Actigraph



NTC SLEEP STUDY  
ARMOR - BATTALION STAFF OFFICER

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12. 0000 0000 0000 0000  
13. 0000 0000 0000 0000  
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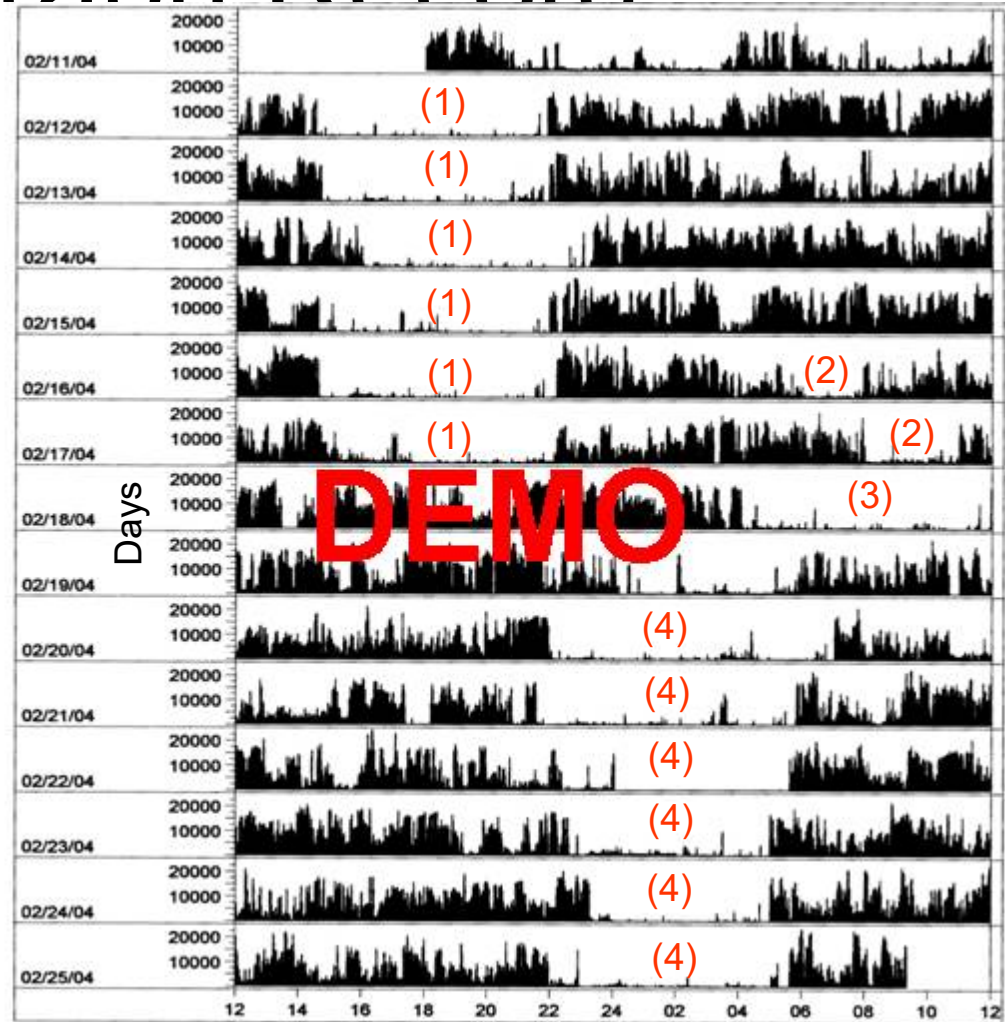


NTC SLEEP STUDY  
ARMOR TASK FORCE SCENARIO - PAGE 1

PAGE 1 DEPT. OF BEHAVIORAL SCIENCE, WALTER REED ARMY INSTITUTE OF RESEARCH, WASHINGTON, DC 20315-5000 USA

# Transmeridian Travel: Actigraph Record

- **Overseas Travel**
  - 2/11: Leave Eastern US
  - 2/12 - 2/16: SWA
  - 2/17: Germany
  - 2/18 - 2/19: Hawaii
  - 2/20: Arrive Eastern US
- **Sleep in afternoon (EST) (1) and some divided sleep (2) during time in SWA and Germany**
- **Sleep in mid-morning hours (EST) (3) during time in Hawaii**



Eastern Standard Time (EST)

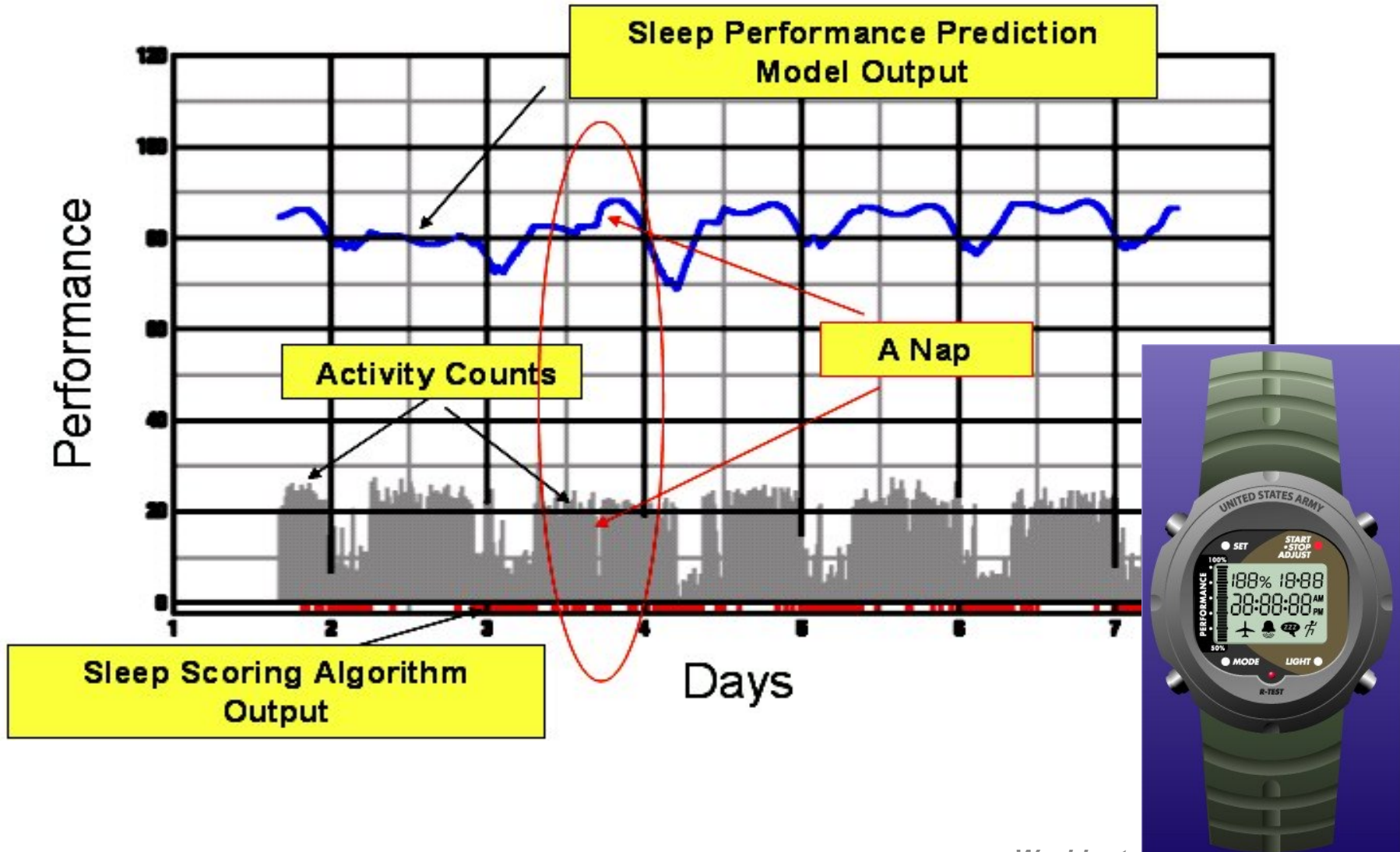
# Mathematical Models to Predict Performance

# Application of Mathematical Models in the Management of

## Sleep to Sustain Performance

- Diagnostics and prognostics for the performance of the human-in-the-loop
- Logistics and human performance in the Army of Alexander the Great
- An Army battalion commander manages fuel to sustain operational effectiveness
  - Fuel is an item requiring resupply
  - Know how much you have on hand and how far it will take you (a simple model –  $Km/(Km/L) = L$ )
  - Plan for timely resupply
- Sleep is also an item requiring resupply
  - But to manage you need to measure and predict

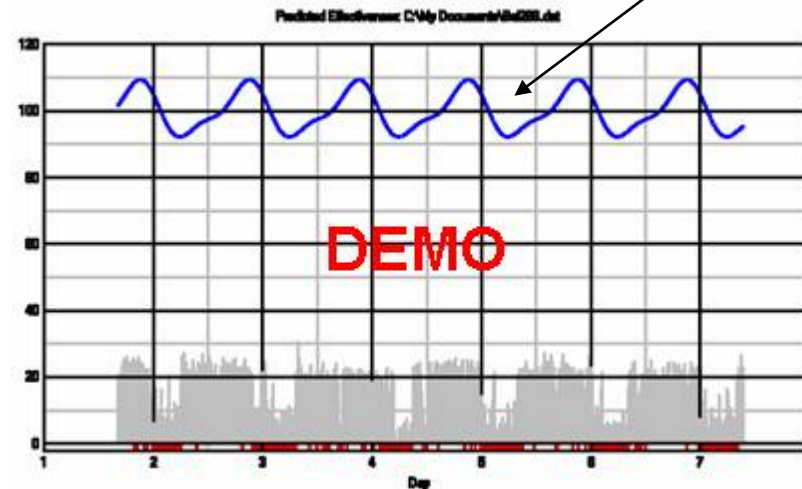
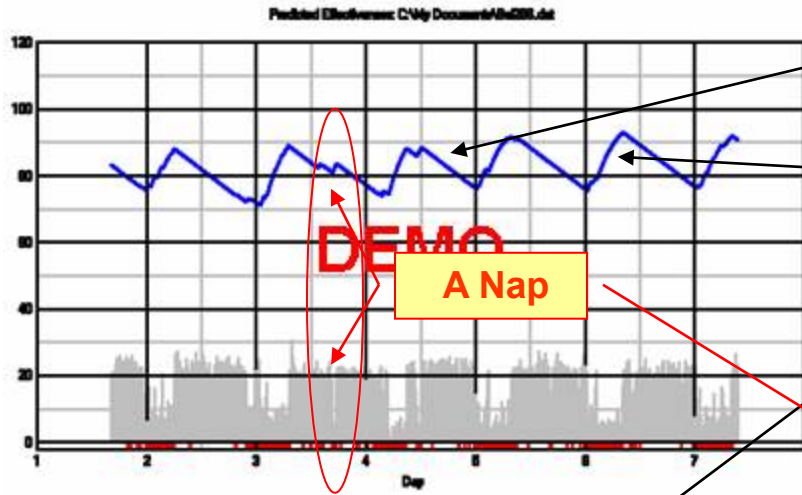
# The Sleep Watch in Real-World Application



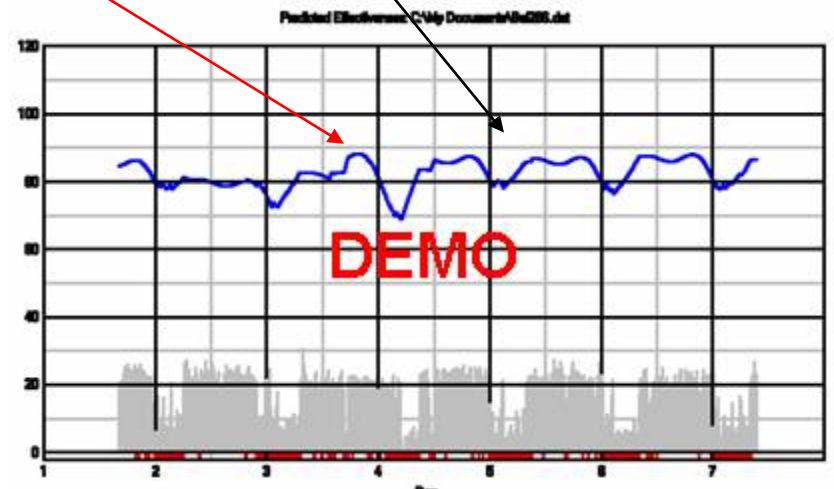


# Sleep Performance Model Based on Leading Facts

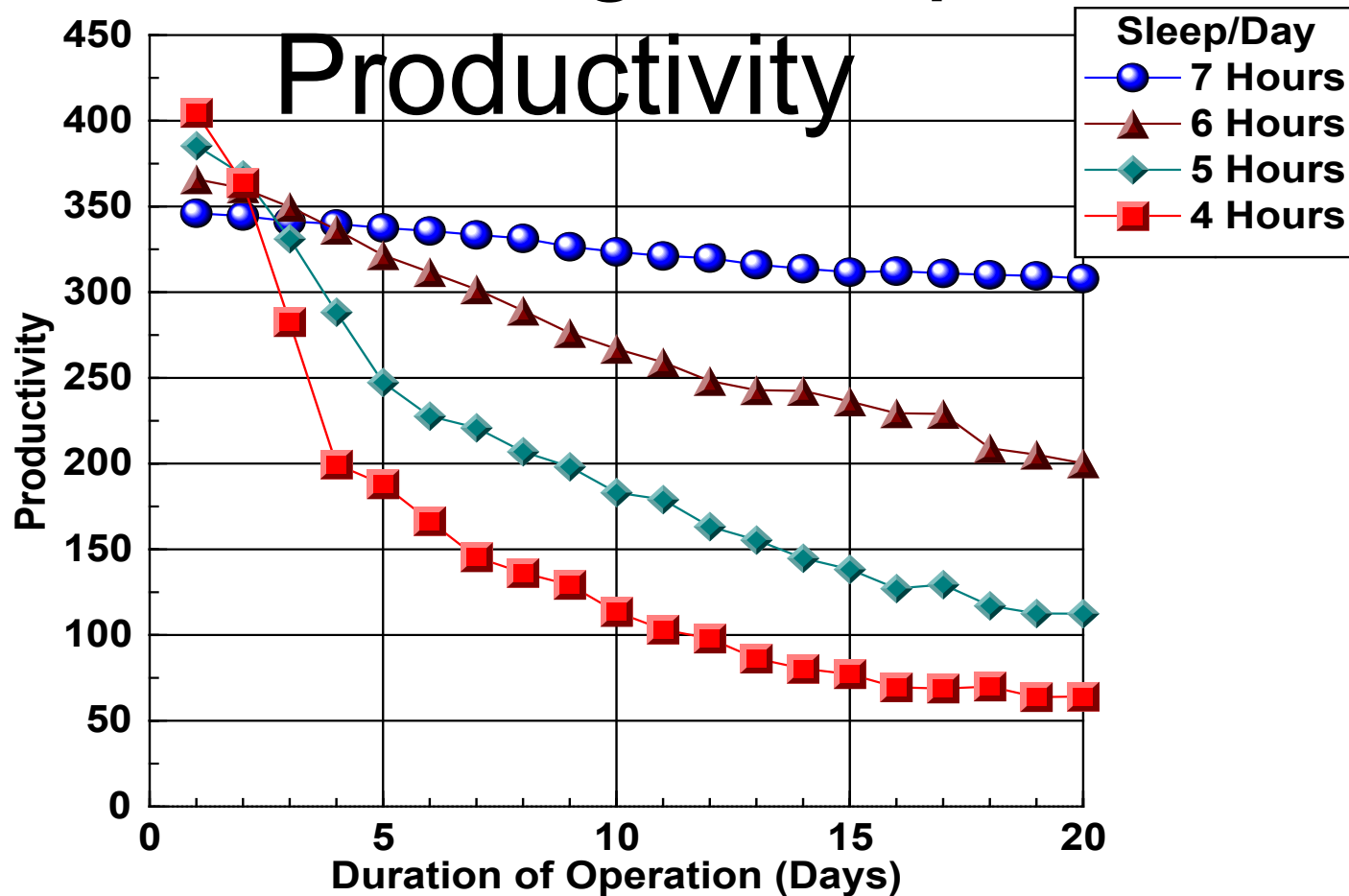
## Research



- Linear Decline during Waking
- Charging Function during Sleep
- Circadian Rhythm
- Combined (decline, charge, circadian)



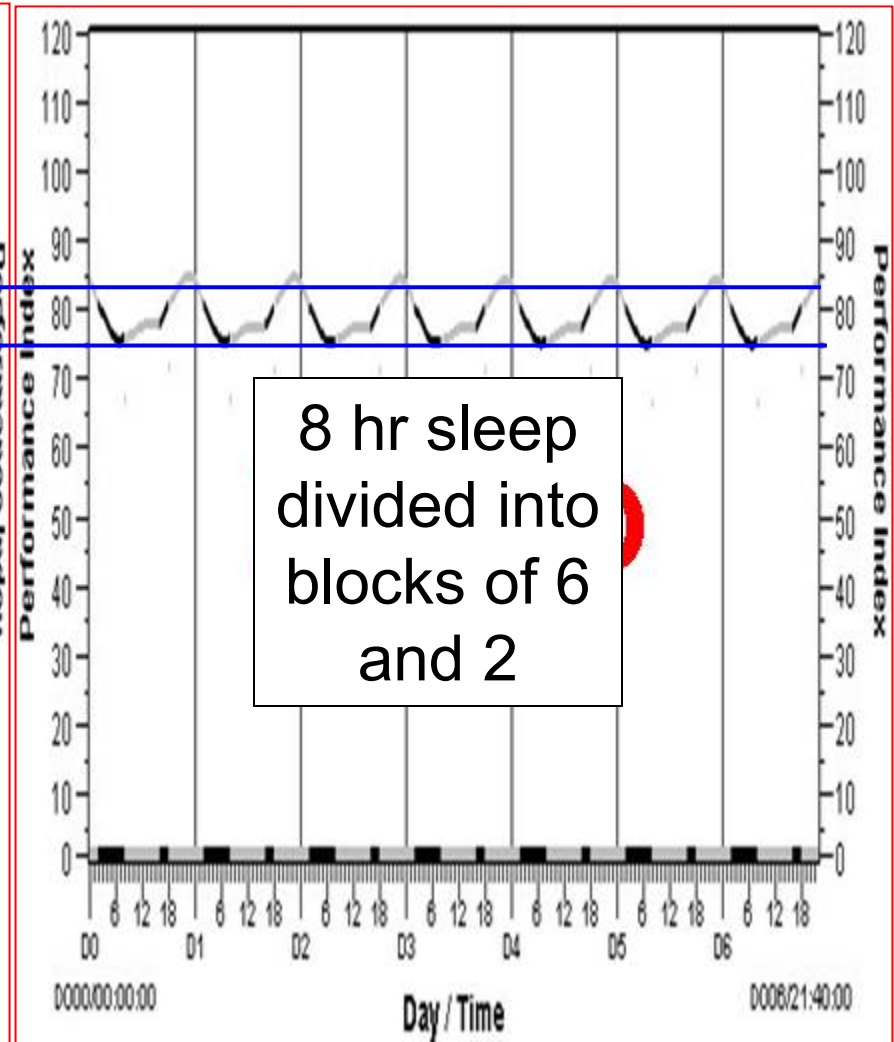
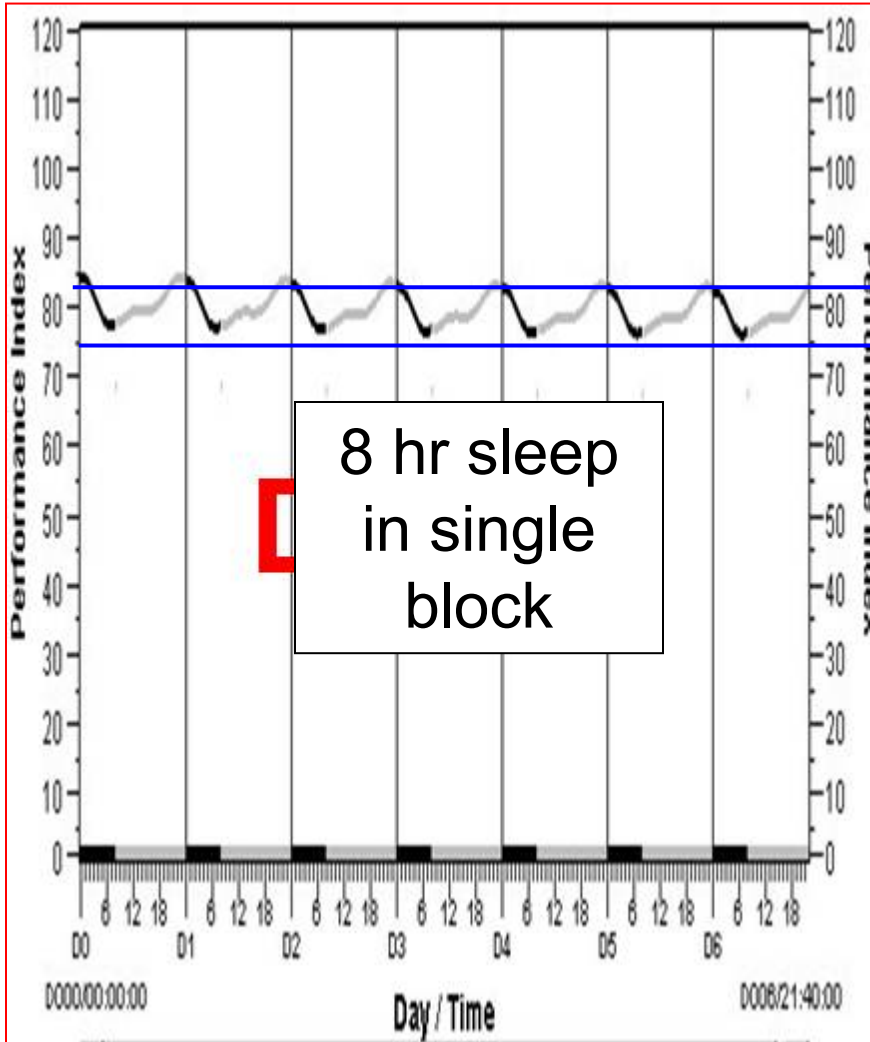
# Sleep Performance Prediction Model Applied to Predicting Group



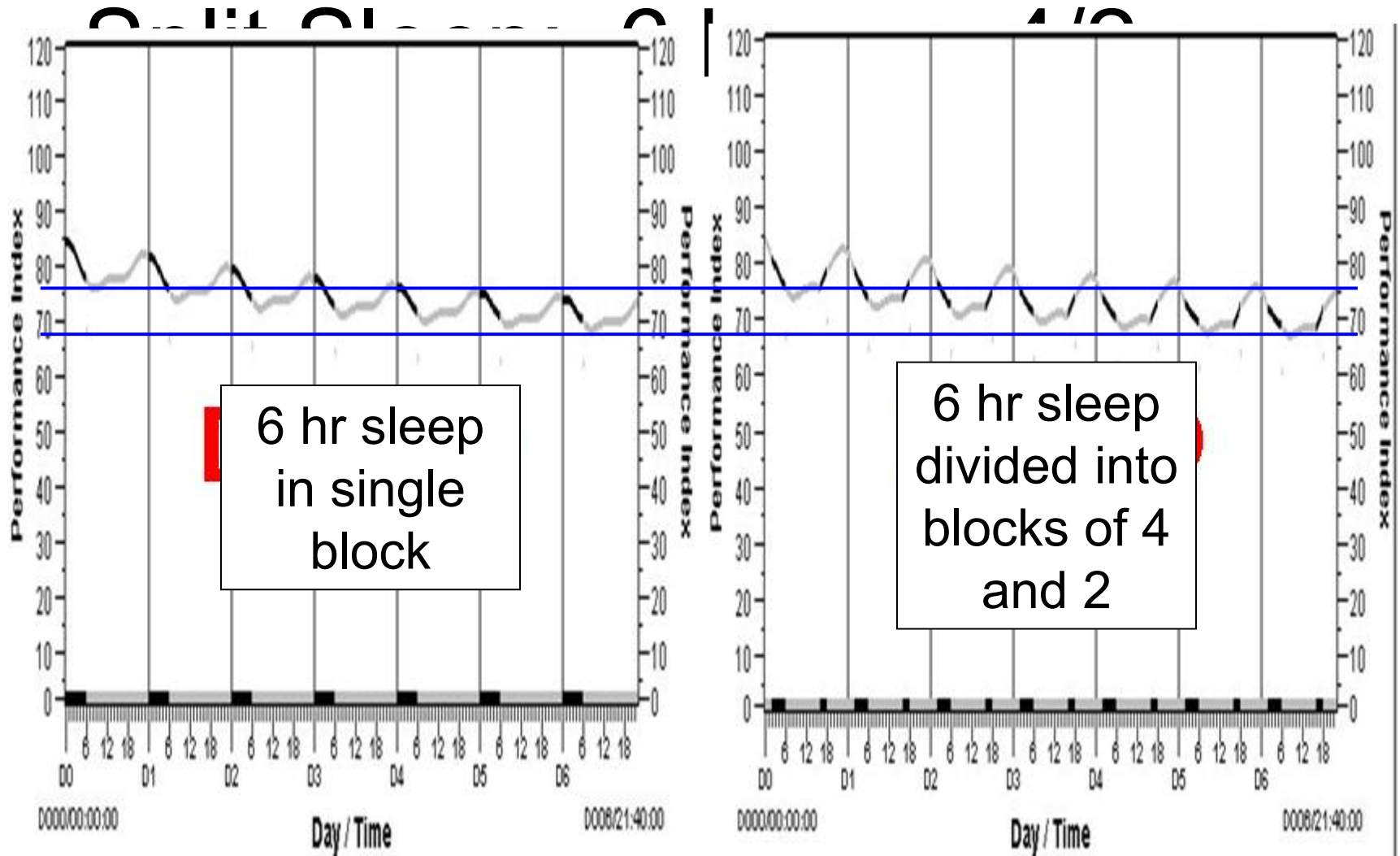
# Application of Modeling to a Current Controversy: Split or Consolidate Sleeper Berth

- **Current Federal Motor Carrier Administration hours of service rules for commercial trucking**
  - **Non-scheduled irregular route drivers**
    - 14 hours on duty
    - 10 hours off duty
  - **Rule requires 8 and 2 split of off-duty time**
  - **Is this consolidated 8 hours in the sleeper berth necessary?**
- **Alternative**
  - **Drive while alert**
  - **Sleep when sleepy**
  - **Driver determines how to divide time off within 14 hours/10 hours framework**
    - **For example – sleeper berth periods of 6 and 4 hours**

# Sleep Performance Prediction Model Applied to



# Sleep Performance Prediction Model Applied to



# The New Science and Art of Fatigue Risk Management

# Regulation & Prescriptive

## Hours of Service Rules

- **Currently, rigid, single-line of defense against fatigue related errors, incidents and accidents**
  - Hours of service regulations promulgated by regulatory bodies (governmental, international)
  - Fix shift duration and timing; break duration; e.g. 14 on/10 off
  - Context is typically labor management relations
  - Focus is enforcement
- **Assumption – if you live within the regulations you will be safe; assumes congruence between permitted and safe**
  - Ignores local conditions
  - Ignores individual differences

# Fatigue Risk Management

- **Embed within corporate safety management system (SMS)**

- **Move fatigue issues from labor/management to safety**

- **Safety enhances productivity (and the reverse)**

- **SMS has built-in structure, yields economies of scale**

- **Fatigue risk management systems (FRMS)**

- **Multi-layered defense against fatigue-related error, incident, and accident**

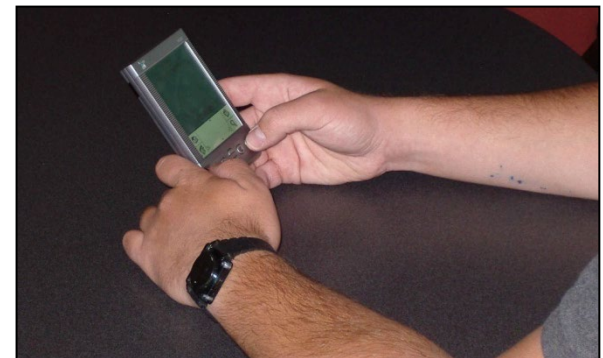
- **Each layer “sloppy” but in the Swiss cheese**



# Fatigue Risk Management System (FRMS)

- Five-tiered defense-in-depth to prevent fatigue related errors, incidents, and accidents
- Tier 1 – Does system of shift timing and duration allow for adequate opportunity for sleep?
  - Computer-based rostering
  - Predictive Modeling
- Tier 2 – Do employees take advantage of the sleep opportunity?
  - Self-report
  - Wrist-worn actigraph (sleep watch)
- Tier 3 – In the workplace, do they maintain adequate alertness and performance?
  - Self-report & co-worker report
  - Palm Pilot Psychomotor Vigilance Task (PVT)
  - Embedded performance metrics

*Dawson &  
McCulloch 2005*



# Summary and Implications

- **Science-based fatigue risk management systems (FRMS) integrated into safety management systems (SMS)**
- **Five-tiered approach**
- **Technology for monitoring actual sleep and real-time performance**
  - External measures
  - Embedded measures
- **Diagnostics and prognostics for the human-in-the-loop**
- **Integrate with rostering and more generally with industrial process optimization**
- **Complement with engineering fixes and other ways of working around human limits**

# Reprise of Sleep Physiology

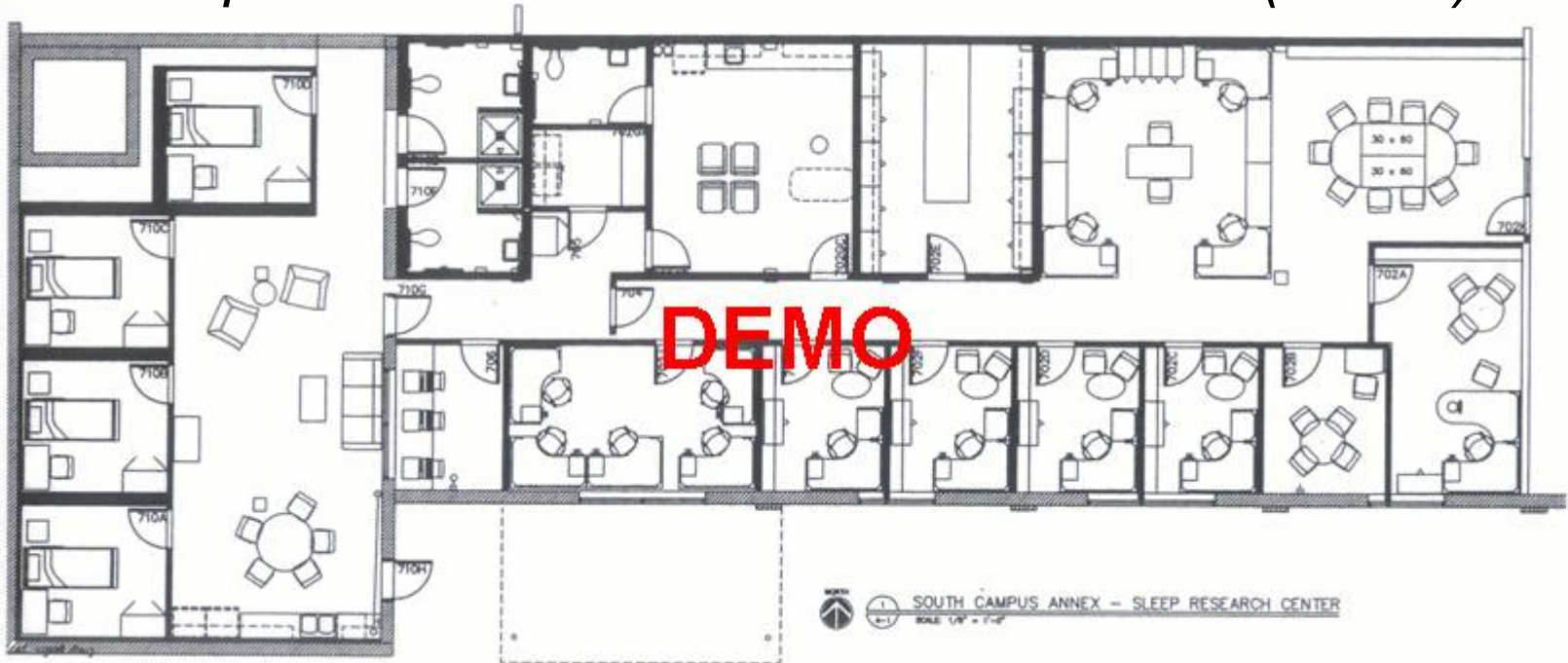
## and Performance

- **Sleep loss degrades performance**
- **Sleep restores it**
- **All performance degrades**
  - **Complex (anterior/forward in the brain) performance degrades more**
  - **Example of anterior/posterior gradient – seeing a cup or other common object**
  - **Evidence from objective brain imaging**
  - **Perseverance slips into perseveration**
- **Two states of sleep (NREM, REM)**
  - **By EEG, different from each other as each is from waking**
  - **50-year scramble to find unique function for REM**
- **Total sleep time determines performance**
  - **Naps add to total sleep time**

*You snooze,  
You win!*



## *Sleep and Performance Research Center (SPRC)*



# Point of Contact

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