Sleep and Fatigue

Impact on Medical Trainees

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ACGME Common Standards for Resident Duty Hours (2003)

- 80 hour limit/week, averaged over four weeks
- One day in seven off
- Adequate rest (10 hours) between duty periods
- In-house call no more than every 3rd night
- 24 hour limit on continuous duty (+ up to six hours) for transfer of care
- Moonlighting must be approved by the program director
The Problem

- Sleep deprivation tolerance is strongly “individual”
- Every one is vulnerable, no heroes or heroines
- Genetic influences, such as genes mediating adenosine and catecholamine metabolism
- Sleep is a biological need, small amount of “banking” only
- Sleep deprivation is unhealthy (glucose metabolism, feeding behaviors, increased sympathetic drive)
- Circadian dysregulation is pretty bad, too, but not focus of this talk
Sleepiness in residents is equivalent to that found in patients with serious sleep disorders.

Papp et al, Academic Medicine, 2002
Mustafa et al, Sleep and Breathing, 2005
Outline

- **Mechanism of Somnolence**
  - 4 points
    - Homeostatic Sleep Drive
    - Circadian Phase
    - Total Amount of Sleep Over Time
    - Sleep Inertia

- Recent Literature

- Implications for Training
Homeostatic Sleep Drive

Scammell T, *Sleep Neurobiology In A Nutshell*, Utilized with permission from the author
Traffic Accidents

CIRCADIAN RHYTHM IN SLEEP RELATED TRAFFIC ACCIDENTS  (Israel, 1984-1989)

Figure 3.12.  Hourly distribution of traffic accidents in Israel caused by falling asleep while driving for 6 consecutive years, 1984–1989, in comparison with hourly distribution of all traffic accidents for the same time period.
Sleep Fragmentation Affects Sleep Quality

NORMAL SLEEP

ON CALL SLEEP

Morning Rounds
Sleep Deprivation Decreases Attention

Van Dongen et al, Sleep, 2003
The Effects of Sleep Loss are Cumulative

Psychomotor vigilance task (PVT) performance during baseline (B), sleep restriction (P) and recovery (R)

Dinges et al, SLEEP, 1997
Sleep Inertia

Wertz et al, JAMA, 2006
Outline

- **Mechanism of Somnolence**
  - 4 points
    - Homeostatic Sleep Drive
    - Circadian Phase
    - Total Amount of Sleep Over Time
    - Sleep Inertia

- **Recent Literature**
- **Implications for Training**
Motor Vehicle Crashes-Interns

- Barger LK, et al.
- *Extended Work Shifts and the Risk of Motor Vehicle Crashes among Interns*
- NEJM, 352(2), 125-34, 2005
- Prospective, Web-based survey
- Monthly
- Case-crossover analysis
Motor Vehicle Crashes-Interns

Motor Vehicle Crashes--Interns

## Risk of Motor Vehicle Crashes and Near-Miss Incidents after Extended Shifts

<table>
<thead>
<tr>
<th>Variable</th>
<th>Extended Work Shifts (≥24 hr)</th>
<th>Nonextended Work Shifts (&lt;24 hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crashes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. reported</td>
<td>58</td>
<td>73</td>
</tr>
<tr>
<td>No. of commutes</td>
<td>54,121</td>
<td>180,289</td>
</tr>
<tr>
<td>Rate (per 1000 commutes)</td>
<td>1.07</td>
<td>0.40</td>
</tr>
<tr>
<td>Odds ratio (95% CI)</td>
<td>2.3 (1.6–3.3)</td>
<td>1.0</td>
</tr>
<tr>
<td>Near-miss incidents</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. reported</td>
<td>1,971</td>
<td>1,156</td>
</tr>
<tr>
<td>No. of commutes</td>
<td>54,121</td>
<td>180,289</td>
</tr>
<tr>
<td>Rate (per 1000 commutes)</td>
<td>36.42</td>
<td>6.41</td>
</tr>
<tr>
<td>Odds ratio (95% CI)</td>
<td>5.9 (5.4–6.3)</td>
<td>1.0</td>
</tr>
</tbody>
</table>

Percutaneous Injuries-Interns

- Ayas NT, et al.
- *Extended Work Duration and the Risk of Self-Reported Percutaneous Injuries in Interns*
- *JAMA, 296, 1055-62, 2006*
- Prospective Web-based survey
- Monthly responses
- Case crossover analysis
# Percutaneous Injuries-Interns

<table>
<thead>
<tr>
<th></th>
<th>Nonextended Periods</th>
<th>Extended Periods</th>
<th>Injuries During Extended vs Nonextended Periods, OR (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No. of Intern-Months</td>
<td>No. of Opportunities</td>
<td>No. of Injuries</td>
</tr>
<tr>
<td>All percutaneous injuries</td>
<td>3660</td>
<td>60 763</td>
<td>46</td>
</tr>
<tr>
<td>Injuries reported to OH</td>
<td>3660</td>
<td>60 763</td>
<td>21</td>
</tr>
<tr>
<td>Injuries in the ICU</td>
<td>536</td>
<td>8 764</td>
<td>4</td>
</tr>
<tr>
<td>Injuries in the operating room or labor and delivery</td>
<td>748</td>
<td>12 211</td>
<td>25</td>
</tr>
<tr>
<td>Injuries in the ICU, non-ICU, or ED</td>
<td>3660</td>
<td>60 763</td>
<td>13</td>
</tr>
</tbody>
</table>

# Percutaneous Injuries-Interns

Table 4. Percutaneous Injuries Occurring During the Daytime (7:30 AM to 3:30 PM) vs Nighttime (11:30 PM to 7:30 AM)*

<table>
<thead>
<tr>
<th></th>
<th>Daytime</th>
<th></th>
<th>Nighttime</th>
<th></th>
<th>Events Occurring During Nighttime OR (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No. of</td>
<td>No. of</td>
<td>Rate (95% CI)</td>
<td>No. of</td>
<td>Rate (95% CI)</td>
</tr>
<tr>
<td></td>
<td>Interns</td>
<td>Opportunities</td>
<td>per 1000</td>
<td>Opportunities</td>
<td>per 1000</td>
</tr>
<tr>
<td>All percutaneous</td>
<td>14.290</td>
<td>318,515</td>
<td>223</td>
<td>0.700 (0.608-0.792)</td>
<td>63,009</td>
</tr>
<tr>
<td>Injuries reported</td>
<td>14.290</td>
<td>318,515</td>
<td>101</td>
<td>0.317 (0.255-0.379)</td>
<td>63,009</td>
</tr>
<tr>
<td>to OH</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Injuries in the ICU</td>
<td>1430</td>
<td>33,680</td>
<td>14</td>
<td>0.416 (0.196-0.633)</td>
<td>98,24</td>
</tr>
<tr>
<td>Injuries in the</td>
<td>2348</td>
<td>53,508</td>
<td>96</td>
<td>1.73 (1.39-2.09)</td>
<td>13,262</td>
</tr>
<tr>
<td>operating room</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Injuries in the</td>
<td>14.290</td>
<td>318,515</td>
<td>56</td>
<td>0.176 (0.130-0.222)</td>
<td>63,009</td>
</tr>
<tr>
<td>ICU, non-ICU, or</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ED (excludes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>pathology, labor,</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>surgery, procedure</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>room</td>
<td>812</td>
<td>18,091</td>
<td>12</td>
<td>0.663 (0.288-1.04)</td>
<td>39,34</td>
</tr>
</tbody>
</table>

Compliance With Work Hours

<table>
<thead>
<tr>
<th></th>
<th>Preimplementation (95% CI)</th>
<th>Postimplementation (95% CI)</th>
<th>Change, %</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean No. of weekly work hours*</td>
<td>70.7 (70.5-70.9)</td>
<td>66.6 (66.3-66.9)</td>
<td>-5.8</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Mean duration of extended work shifts, h</td>
<td>32.1 (32.0-32.2)</td>
<td>29.9 (29.8-30.0)</td>
<td>-6.9</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Mean longest period with no sleep, h</td>
<td>25.3 (25.1-25.4)</td>
<td>24.9 (24.7-25.0)</td>
<td>-1.6</td>
<td>.25</td>
</tr>
<tr>
<td>Mean nightly sleep duration, h</td>
<td>5.91 (5.88-5.94)</td>
<td>6.27 (6.23-6.31)</td>
<td>+6.1</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Mean nightly sleep during extended shifts, h</td>
<td>2.69 (2.66-2.73)</td>
<td>2.57 (2.52-2.62)</td>
<td>-4.5</td>
<td>&lt;.001</td>
</tr>
</tbody>
</table>

Abbreviations: ACGME, Accreditation Council for Graduate Medical Education; CI, confidence interval.
*Excludes vacation weeks and leaves of absence.

Landrigan CP, et al., Interns Compliance with Accreditation Council for GME Work-Hours Limits, JAMA, 296, 1063-70, 2006
Work Hour Limits for Physicians in Other Countries

- **European Working Time Directive** (law which applies to practicing physicians & residents in all EU countries)
  - Maximum of **48-56 hours per week** and **13 consecutive hours**

- **New Zealand Employer - Resident Contract**
  - Maximum **72 hours weekly** and **16 consecutive hours**
Work Hour Limits for Other Occupations in the U.S.

- Truckers: maximum 11h continuous driving
- Pilots: maximum 8h per 24 flying domestic routes
- Nuclear Power plant workers: maximum 12h shift
- Train engineers: maximum 12h shift
Countermeasures

- Enough sleep
- Naps
- Caffeine
- Modafinil
- Multiple human control layers
- Multiple non-human control layers
  - Error tracking and warning systems
    - Allergy, drug interactions
Conclusions

- Sleep-Wake regulation is complex
- 4 components contribute to impaired daytime function
  - Homeostatic Sleep Drive
  - Circadian Phase
  - Total Amount of Sleep Over Time
  - Sleep Inertia
- Literature supports significant impact
- Work hours, even if adhered to, unlikely to be complete answer