Understanding Risk Factors of Fatigue and Sleep in Wildland Firefighters

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Defining Fatigue

- A physiological state of diminished mental and physical performance capacity caused by acute or chronic sleep deprivation or incomplete recovery from prior work.

- Level of Environmental Stimulation
- Workload
- Circadian Phase (Biological Time of Day)
- Age and Medical Conditions
- Prior Sleep-Wake History
- Time on Task
- Length of Prior Wakefulness
Defining Fatigue

- A physiological state of diminished mental and physical performance capacity caused by acute or chronic sleep deprivation or incomplete recovery from prior work

- Disproportionately high amount of workplace accidents
  - ~2x the provincial injury rate\(^1\)
  - Overexertion and strain 45% of FF injuries\(^1\)
  - Fatigue 7-10% globally and $35B in lost productivity\(^3\)
Study Objectives

1. Understand fatigue and sleep in firefighters

2. Investigate impact of current schedule

3. Build on current fatigue risk management plan
Project Design

- Recruited 40 Participants (30 WF, 10 MT)

- Testing occurred prior to and immediately after each shift for full work cycle

- Measured objective and subjective levels of:
  1. Fatigue
  2. Sleep
  3. Alertness
  4. Performance
Measurements

1) Fatigue:
   - Objective reaction time tests of performance
     - 5 min Psychomotor vigilance test (PVT) (ms)
     - Median RT (ms)
     - Lapses (>355 ms)
   - Daily subjective questionnaires
     - Visual Analogue Scales (0-10)

2) Sleep:
   - Actigraph and sleep logs
     - Total Sleep Time (TST)
     - Efficiency (%)
   - Subjective sleepiness and quality questionnaires
Results: Objective Cognitive Performance

PVT Median Across a 14 Day Rotation

PVT Reaction Time (ms) vs. Work Day
Results: Objective Cognitive Performance

PVT Median Across a 14 Day Rotation

M = 271.64ms ± 38.4ms
Results: Objective Cognitive Performance

PVT Median Across a 14 Day Rotation

M = 271.64ms ± 38.4ms
Results: Objective Cognitive Performance

PVT Lapses Across a 14-Day Rotation

- # of PVT Lapses
- Work Day
- # of PVT Lapses
  - Work Day 1: 5
  - Work Day 2: 4
  - Work Day 3: 5
  - Work Day 4: 6
  - Work Day 5: 5
  - Work Day 6: 4
  - Work Day 7: 3
  - Work Day 8: 2
  - Work Day 9: 3
  - Work Day 10: 4
  - Work Day 11: 5
  - Work Day 12: 6
  - Work Day 13: 7
  - Work Day 14: 8
Results: Subjective Fatigue

M=4.92  M=5.49

Visual Analogue Scale (0-10)

Work Day
Results: Objective Sleep

- Total Sleep Time
- Efficiency

Hours of Sleep (hrs.)

Work Day

Sleep Efficiency %
Results: Objective Sleep

Total Sleep Time - Efficiency

M = 6.98 hrs. ± 1.51
Results: Objective Sleep

- Sleep Efficiency:
  - M = 6.6 hrs. ± 0.81
  - M = 6.98 hrs. ± 1.51

- Total Sleep Time
  - M = 6.6 hrs. ± 0.81
Results: Subjective Sleepiness & Quality

Visual Analogue Scale (0-10)

M=5.00  M=3.29
1) **Circadian Alertness Simulator- CAS**
   - CAS converts schedule and sleep data into three fatigue levels:
     1. Green Zone- Low Fatigue Risk 0-30
     2. Yellow Zone- Average Fatigue Risk 31-60
     3. Red Zone- High Fatigue Risk 61-100

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Homoeostatic Factors

- Sleep Inertia
- Circadian Factors
Fatigue Score = 40.28

1) Total Work Hours

2) Sleepiness Risk on Duty
CAS Modelling - Identifying Schedule Features

Distribution Of Duty Duration

Frequency

Duration in Hours

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
CAS Modelling- Identifying Schedule Features

Distribution Of Time Off Between Successive Duty Periods

- Absolute Minimum
1) Strong safety management policies on schedule and shift practices
   - Time between shifts
   - Night shift crews
   - Driving and sleep environments

2) Bench mark fatigue
   - Identify high risk groups
   - Record schedule deviations

3) Conduct fatigue root cause investigation
   - Annual accident, near misses, injury reports

4) Training and Education
   - Techniques and strategies to improve sleep
   - Fatigue mitigation tips
   - Signs and tips to recognize and prevent fatigue
A Guide to Managing Fatigue and Sleep in Wildland Firefighting
Conclusions

1) Poor performance at beginning of shift

2) Gradual increase in fatigue and sleepiness
   - Appears rest period not utilized to fully recover

3) Total sleep time was 6.6 hours over 17 days
   - Consistent with studies

4) Schedule had low/moderate CAS fatigue risk
   - Upper limit of duty hours
   - Maintain comprehensive fatigue plan
Special Thanks

• WMB
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• UBC
• Firefighters
References


3) [www.circadian.com/advantage-disadvantages12hrshifts](http://www.circadian.com/advantage-disadvantages12hrshifts)