Prospective Relationships of Pain and Mental Health to Sleep in Firefighters Working 24-hour Shifts in a 21-Day Cycle

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INTRODUCTION

- Firefighters (FF) often report sleep deprivation[1] & poor sleep quality[2,3]
- Mental health issues may be related to poor sleep in FF incl. anxiety,[4] depression,[1,5] Post-Traumatic Stress Disorder (PTSD)[6,7]
- Pain in at least one site has been reported in over half of FF[8]
- Possible relationships of pain & sleep health in FF not previously examined
- Irregular & unique work schedule –
  - 7 24hr shifts in 21-day cycle
  - Differs from 24/48 or 48/96[9]
- Present study measured FF actigraphy longer than previous studies (3-18 days)[1,10-14]

Sample 21 Day Work Schedule

S	M	T	W	T	F	S
		1 Work	2 Off	3 Work	4 Off	5 Work
6 Off	7 Work	8 Off	9 Off	10 Off	11 Work	12 Off
13 Work	14 Off	15 Off	16 Work	17 Off	18 Off	19 Off
20 Off	21 Off					

Objective: Assess prospective relationships between mental health symptomatology (i.e., anxiety, PTSD, depression) & pain with actigraphically-assessed sleep measures among FF

METHODS

- 32 firefighters followed for 21 days (1 work cycle: ~7 days on & ~14 off)
- Measures: Follow-up questionnaire, daily diaries, actigraphy
- PREDICTORS (from follow-up questionnaire):
  - Anxiety Severity (Generalized Anxiety-7 [GAD-7] categorized as mild [5-9], moderate [10-14], severe [≥15])
  - Depression Severity (Patient Health Questionnaire-9 [PHQ-9] categorized as mild [5-9], moderate [10-14], severe [≥15])
  - PTSD (Post-Traumatic Stress Disorder-5 [PTSD-5] categorized as presence [≥4] vs none [0-3])
  - Pain (presence vs absence)
- OUTCOMES:
  - Actigraphy (Philips Spectrum Plus) measures of objective sleep:
    - Total Sleep Time (TST)
    - Sleep Onset Latency (SOL)
    - Wake After Sleep Onset (WASO)
    - Sleep Efficiency (SE)
  - Actigraphically Assessed Sleep Measures: TST, SOL, WASO, SE
    - Assessed continuously & categorically using 25th/75th percentiles
    - Analyzed for longest sleep per 24hr period
- Unadjusted & adjusted robust Poisson regressions for categorical outcomes based on actigraphic continuous measures
- Adjustment variables:
  - Age, poor sleep quality (Pittsburgh Sleep Quality Index [PSQI]), comorbidity, sleep apnea, chronotype, work/occupational measures (job title, rank, work stress score, job roles number, call volume and severity, reported overtime)

RESULTS

- Based on 654 person-days from Feb.-May 2025
- Average Actigraphy Measures for longest sleep per day (n=654):
  - TST: 6.03 hrs (mean=361.7, sd=102.3)
  - SOL: 33.7 mins (mean=33.7, sd=44.7)
  - WASO: 49.9 mins (mean=49.9 sd=46.1)
  - SE: 78.2% (mean=78.2, sd=13.8)
- Mental Health & Pain Prevalence (95% C.I.) (n=32 participants):
- Anxiety
  - Mild: 38.3% (34.5% – 42.0%)
  - Moderate: 37.8% (34.1% - 41.5%)
  - Severe: 23.9% (20.7% - 27.2%)
- Depression
  - Mild: 12.8% (10.2% - 15.4%)
  - Moderate: 40.9% (37.1% - 44.6%)
  - Severe: 46.3% (42.5% - 50.2%)
- PTSD: 78.1% (74.9% - 81.2%)
- Pain: 50.6% (46.8% - 54.4%)

Table 1. Adjusted Risk Ratios Estimated from Poisson Regression Models of Objective Sleep Measures (Percentiles) with Anxiety, Depression, PTSD, & Pain (n=654)

	Sleep Outcomes		
	Adjusted† Risk Ratios (95% C.I.)		
	Poor TST (≤302.5mins)	Poor WASO (>58.5mins)	Poor SE (≤88.42%)
Anxiety			
Moderate	1.07 (0.80-1.43)	1.52 (0.94-2.45)	1.07 (0.88-1.31)
Severe	3.74* (2.15-6.52)	2.10* (1.10-4.01)	1.06 (0.81-1.39)
Mild	1.00 (Ref)	1.00 (Ref)	1.00 (Ref)
Depression			
Moderate	0.59* (0.38-0.90)	0.44* (0.24-0.80)	0.91 (0.73-1.15)
Severe	0.26* (0.11-0.64)	0.26* (0.08-0.79)	0.93 (0.63-1.38)
Mild	1.00 (Ref)	1.00 (Ref)	1.00 (Ref)
PTSD			
Yes	0.27* (0.23-0.32)	0.96 (0.57-1.63)	0.70* (0.52-0.93)
No	1.00 (Ref)	1.00 (Ref)	1.00 (Ref)
Pain			
Yes	0.87 (0.59-1.29)	1.73* (1.08-2.76)	0.75* (0.65-0.88)
No	1.00 (Ref)	1.00 (Ref)	1.00 (Ref)

*P-values ≤.05 for risk ratios (shaded blue).
CI, confidence intervals.
†Adjusted by age, job, rank, work stress score, number of FF roles, call volume, call severity, chronotype, poor PSQI, sleep apnea, any comorbidity history, worked overtime

RESULTS CONTINUED

Table 2. Adjusted Odds Ratios Estimated from Multinomial Regression Model of Objective Sleep Onset Latency with Anxiety, Depression, PTSD, & Pain (n=654)

	Sleep Onset Latency		
	Adjusted† Risk Ratios (95% C.I.)		
	Normal (10-20mins)	Short (<10mins)	Long (>20mins)
Anxiety			
Moderate (vs. Mild)	1.00 (Ref.)	0.42 (0.17-1.04)	0.45 (0.20-1.04)
Severe (vs. Mild)	1.00 (Ref.)	0.71 (0.18-2.84)	0.29 (0.08-1.05)
Depression			
Moderate (vs. Mild)	1.00 (Ref.)	4.01 (0.79-20.42)	7.15* (1.62-31.49)
Severe (vs. Mild)	1.00 (Ref.)	3.59 (0.31-41.82)	19.83* (2.10-187.24)
PTSD			
Yes (vs. No)	1.00 (Ref.)	1.34 (0.50-3.57)	1.24 (0.51-3.06)
Pain			
Yes (vs. No)	1.00 (Ref.)	4.97* (1.83-13.51)	0.90 (0.39-2.06)

*P-values ≤.05 for risk ratios (shaded blue).
CI, confidence intervals.
†Adjusted by age, job, rank, work stress score, number of FF roles, call volume, call severity, chronotype, poor PSQI, sleep apnea, any comorbidity history, worked overtime

DISCUSSION

In a cohort of 32 firefighters prospectively followed for a 21-day work cycle (n=654):

- Actigraphy means varied:
  - TST mean was 1hr less than recommended guidance of 7-9hrs/night
  - SOL & WASO longer than normal recommended values (10-20mins & 0mins)
  - SE over 78%, close to recommended 80%
- After adjustments & modeling quartile values:
  - Severe Anxiety (vs. Mild) ↑ risk for poor TST (RR=3.7) & poor WASO (RR=2.1)
  - Moderate & Severe Depression (vs. Mild) ↓ risk of poor TST by 41% & 76% & poor WASO by 46% & 74%
  - PTSD ↓ risk of poor TST by 73% & poor SE 30%
  - Pain ↑ risk of poor WASO (RR=1.7) but was protective against poor SE (RR=.75)
- Sleep Onset Latency:
  - Moderate & Severe Depression (vs. Mild) ↑ long SOL odds 7.2 & 19.8-fold
  - Pain increased odds of short SOL by nearly 5-fold

DISCUSSION CONTINUED

- Strengths
  - Longitudinal study that participants utilized daily diaries alongside actigraphy for objective sleep measures
  - 21-days of data per participant provides a large sample size for daily data
  - Utilized quartiles to compare participants to the specific population rather than the standard population
- Limitations:
  - 21-day summary measures for mental health (follow-up) vs. daily actigraphy data
  - Did not include sleep or other medication use (from the daily diary) in analysis as potential adjustments
- Potential future analyses should consider:
  - Sleep and other medication use as potential confounders

CONCLUSIONS

- Severe Anxiety was associated w/ 2.1-fold increased risk of poor WASO (>58.5mins) & 3.7-fold increased risk of Poor TST
- Directions & relationships of associations of several mental health outcomes & pain w/ sleep were unexpected:
  - Moderate-severe depression reduced TST & poor WASO risks, increased odds of long SOL
  - Pain associated w/ increased poor WASO & short SOL, protective against poor SE
  - PTSD was protective against poor TST & poor SE

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