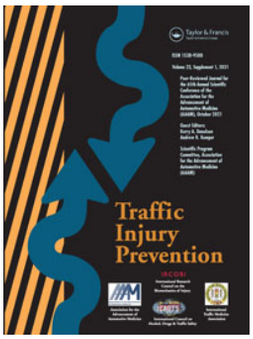

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The effect of prior night sleep on simulated driving performance in medical residents

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ABSTRACT

Objective: Indications of driving performance negatively affected by poor sleep often occur early in simulated driving experiments and are measured to progress over relatively large epochs of time. How driving performance changes over smaller increments of time as a function of not only sleep quantity but also sleep quality is largely unknown. The overall objective of this work in progress is to examine the trajectory of driving performance in medical residents as a function of the prior night's sleep quality using a high-fidelity driving simulator.

Method: Thirty-two medical residents were enrolled and wore sleep tracking devices for up to 2 weeks. The residents drove a 16-min scenario in a high-fidelity driving simulator. A mixed effects model was used to estimate baseline intercept and slope of simulated driving performance over the course of the drive. The slope of driving performance over the drive and actigraphy-estimated sleep variables from the prior 24 h served as predictors.

Results: Preliminary descriptive findings indicate a wide range of sleep quality metrics in the sample.

Conclusions: This study is among the first to focus on the trajectory of driving performance over small continuous epochs of time when simulated driving performance may first begin to degrade. Further, objective estimates of sleep using actigraphy as predictors of the next day's driving will enhance our understanding of the potential "dose–response" between low sleep quality and crash risk in the following 24 hours.

KEYWORDS

Sleep; drowsy driving; actigraphy; driving simulator

Introduction

The odds of at-fault crash risk increase with less than 7 h of sleep in the preceding 24 h (Tefft 2018). Sleep deprivation negatively affects lane maintenance in both driving simulation and on-road experiments (Philip et al. 2005). When sleep prior to driving has been restricted, lane positioning is more varied, and subjective sleepiness may be predictive of lane maintenance (Horne and Baulk 2004). The majority of driving simulator studies impose experimental sleep deprivation conditions focusing on quantity of sleep prior to the simulated drive and feature experimental sessions 30 min or much longer (Soares et al. 2020) with time on task effects measured between epochs of time (e.g., every 10 min). However, both subjective sleepiness and variation in lane positioning increase soon after beginning a drive in a driving simulator (Ingre et al. 2006), and thus the trajectories of driving performance metrics over smaller increments (e.g., every 30 s, every minute) are largely unknown. Further, driving performance metrics in a driving simulator as a function of specific sleep quality measurements require attention, in addition to sleep quantity. For instance, when demonstrating no significant differences in sleep quantity, drivers with untreated and undiagnosed sleep apnea displayed greater lane variability over the course of a driving simulator task compared to healthy controls (May et al. 2016). Medical residents provide an ideal population to examine the impact of sleep quality among other relevant fatigue factors on driving performance due to their wide variety of schedules (Lockley et al. 2007) and decrease in sleep quality (Zebrowski et al. 2018), which does not appear to improve across residency (McManus et al. 2020). The overall objective of this work in progress is to examine the trajectory of driving performance in medical residents as a function of the prior night's sleep quality using a high-fidelity driving simulator.

Method

Thirty-two medical residents (M_{age} = 28.56 years, SD = 2.18) wore actigraphy watches continuously over several days (M = 8.47 days, SD = 3.04), which provided objective estimates of sleep duration and sleep quality. The actigraphy watches were calibrated to each participant's age, sex, height,

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Table 1. Simulated driving performance and sleep quality prior to simulated driving task.

Variable	Mean (SD)	Range
Driving		
Average speed (mph)	51.38 (4.38)	41.61–58.23
Speed variability (mph)	23.21 (2.55)	18.77–31.03
SD lane position (feet)	1.21 (0.19)	0.90–1.87
Subjective sleep, fatigue, and stress		
Sleep propensity	9.28 (5.43)	0.00–19.00
Chronic fatigue	42.50 (17.42)	16.67–80.00
Acute fatigue	65.73 (19.79)	26.67–96.67
Persistent fatigue	36.04 (19.17)	10.00–83.33
Salivary cortisol	0.38 (0.23)	0.07–1.17
Actigraphy-measured sleep		
Duration (h)	7.30 (2.79)	2.57–13.20
Efficiency (%)	92.33 (3.80)	79.38–98.39
Wake after sleep onset (min)	34.13 (17.66)	9.00–91.00
Sleep fragmentation index (%)	20.50 (11.92)	2.73–52.70

and weight and contained a 3-axis accelerometer to estimate movement and sleep continuously. The medical residents completed a driving simulator appointment before beginning their shift to mimic driving after a typical 24-h period of sleep that was not experimentally manipulated. At the appointment, medical residents provided self-reported assessments of fatigue and subjective sleep propensity and a salivary cortisol sample as a biomarker of stress measurement and drove in a state-of-the-art driving simulator. The simulated driving scenario was a 16-min nighttime drive with a scenario resembling the local region. The primary analysis utilized a mixed effects model to estimate baseline intercept and slope of driving performance over the course of the drive. The slope of driving performance over the drive and actigraphy-estimated sleep variables from the prior 24 h served as predictors.

Results

Data collection is complete for the sample. Descriptive statistics for the driving simulator variables, subjective fatigue and sleep variables, salivary cortisol, and actigraphy-estimated sleep variables for the 24 h prior to the appointment are displayed in Table 1. Preliminary analyses indicated the odds of obtaining fewer than the recommended 7 to 9 hours of sleep was 325% higher in the night preceding the simulated drive of interested compared to an off-duty day, $\chi^2(1) = 4.73$, $P = 0.03$ (odds ratio = 4.25; 95% confidence interval, 1.15–15.65). Preliminary analyses also indicated an association between braking reaction time and sleep quality averaged over the multiple days of actigraphy wear. Ranges indicated a wide variety of sleep quality metrics in the sample.

Discussion

The final data analysis will be complete in summer 2021. This study will be among the first to focus on the trajectory of driving performance over small epochs of time when simulated driving performance may first begin to degrade. Further, objective estimates of sleep using actigraphy as predictors of the next day's driving will enhance our understanding of the potential "dose–response" between low sleep quality and crash risk in the following 24 h. Further, medical residents display high levels of stress and poor sleep outcomes throughout medical residency and may often be at high risk for drowsy driving as a result. Although these data do not include a control group or control period of sleep for comparison purposes, future studies should consider including such comparisons. These findings may further develop policies, recognition, and recommendations of when crash risk may be high as a result of poor sleep outcomes.

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