SUBJECTIVE AND OBJECTIVE SLEEP AND MOOD OUTCOMES IN RPA AND SPACE SHIFT WORKERS RELATED TO SHIFT SCHEDULE

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1. Introduction: Duties of United States (US) service members often require continuous operations covered by shift work where schedules and associated disruptions to sleep may contribute to physical and mental health outcomes in continuous operations communities, such as Space Force (USSF) and USAF Remotely Piloted Aircraft (RPA) Operators. This study used surveys, Oura ring-derived sleep measures, and vocal biomarkers to examine changes in mood and sleep behavior over six months between these two military cohorts operating on different shift work schedules.

2. Methods:

Participants: USSF cohort (n=39) worked on a hybrid "Panama" schedule: 3-days on, 2 off, 2 on, 3 off; rotating between 8/12-hour shifts every 10/12-days and forward rotating between working days, afternoons or nights every 90-days.

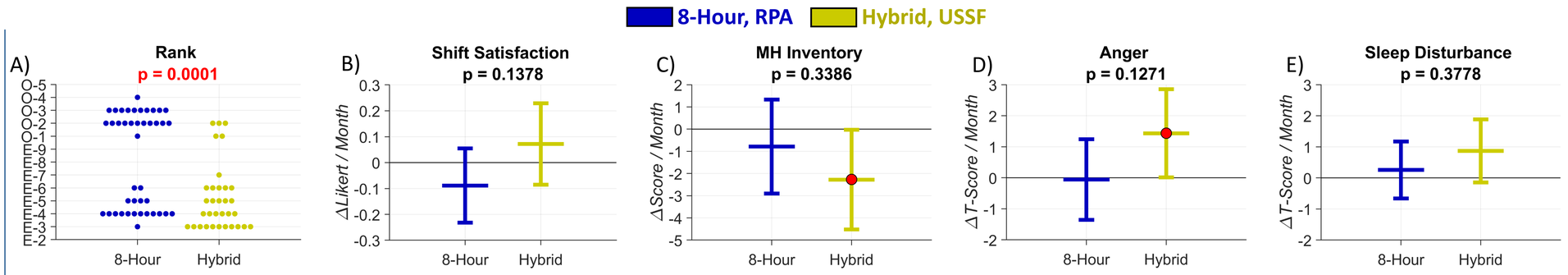
RPA cohort (n=50) worked a Panama schedule with a forward-rotating 90-day rotation index with standard 8-hour shifts.

Subjective Measures: Upon recruitment, participants submitted demographic information including gender, age, rank, schedule, and unit type. They also completed the PROMIS Positive Affect 15a, Anger Short Form 5a, and Sleep Disturbance Short Form 8b surveys[1], as well as the Mental Health Inventory 5-item measure[2]. Participants ranked satisfaction in their new shift schedules (five-point Likert scale) and reported the number of non-schedule factors affecting their sleep such as childcare or personal schedule conflicts. Three and six months after recruitment, participants repeated PROMIS, MHI-5, and shift surveys to assess subjective changes in their disposition, mood, and sleep.

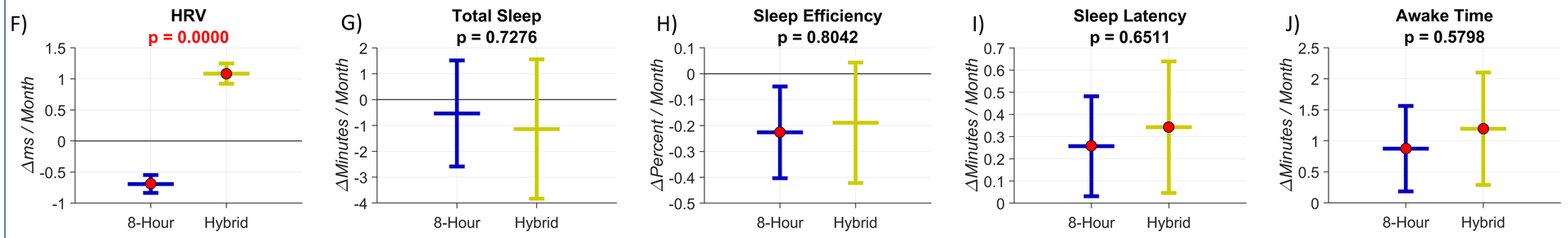
Objective Sleep Measures: Participants were given a gen3 Oura ring to wear during sleep. This ring model uses photoplethysmography sensors to measure heart and breathing rates, a negative temperature coefficient sensor to measure external body temperature, and an accelerometer to measure activity and movement. Oura rings have been validated in measuring total sleep time relative to a single dry electrode EEG reference.[3]

Objective Mood Measures: Participants completed a daily 30-second vocal journal using the Sonde Health LLC Mental Fitness App™. The app's Mental Fitness score ranges from 0-100 with scores below 70 identified at-risk using the terminology of "Pay Attention." Sub-score data for specific vocal features were viewable by the researchers but not participants. Participants were not instructed on a specific time to provide their vocal sample, given the rotation of shift work.

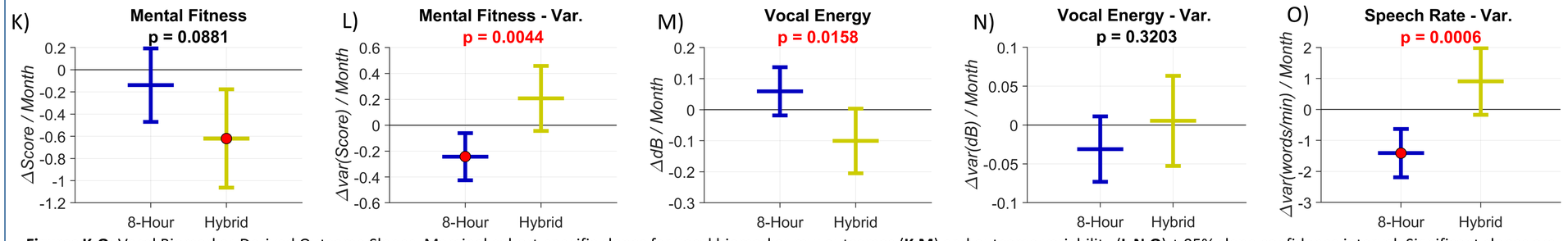
Analysis and Statistics: A significance level of 0.05 was used for all statistical tests and resulting p-values were not corrected for multiple comparisons due to the exploratory nature of this study. Difference in mean rank between cohorts was assessed using a two-sided two sample t-test. Change in each outcome over time was evaluated using separate linear mixed effects models with time (days since study start) modeled as a continuous fixed-effect, cohort modeled as a categorical fixed-effect, a cohort-time interaction term to estimate cohort-specific rates of change, and a random intercept for each participant to account for repeated measurements. Cohort-specific marginal slopes were estimated as the sum of the time and interaction fixed-effect coefficients. Within-cohort change was evaluated using one-sample contrasts of the cohort marginal slopes against zero, and difference in outcome changes between cohorts was evaluated using covariance-based two-sample contrasts of cohort marginal slopes. Change in outcome variability over time was evaluated using a hierarchical modeling scheme with variability estimated as the absolute value of residuals from the initial models, then change in variability estimated using the same linear mixed effects model structure described above with the magnitudes of outcome residuals used as response variables.



Figures A-E: Survey Results. (**A**) Participant counts per rank; dots represent individual participants. (**B-E**) Marginal cohort-specific slopes for survey outcomes ± 95% slope confidence interval. Significant slopes are marked by a red dot. (**A-E**) Red p-values in the plot title indicate a significant difference between cohorts. (**C**) MH = mental health.



Figures F-J: Oura Sleep Outcome Slopes. Marginal cohort-specific slopes for Oura sleep outcomes ± 95% slope confidence interval. Significant slopes are marked by a red dot. Red p-values in the plot title indicate a significant difference in marginal slopes between cohorts. (**F**) HRV = heart rate variability.



Figures K-O: Vocal Biomarker-Derived Outcome Slopes. Marginal cohort-specific slopes for vocal biomarker raw outcomes (**K,M**) and outcome variability (**L,N,O**) ± 95% slope confidence interval. Significant slopes are marked by a red dot. Red p-values in the plot title indicate a significant difference in marginal slopes between cohorts. (**L,N,O**) Var. = variability.

3. Results: The 8-hour shift RPA cohort had a significantly higher mean rank than the hybrid shift USSF cohort (**A**). USSF participants also self-reported significantly greater degraded mental health (**C**) and greater anger as the study progressed. From the Oura ring data (**F-J**), the RPA cohort exhibited significantly decreasing HRV and USSF cohort showed significantly increasing HRV (**F**). Despite USSF's increased capacity to adapt to stress, both cohorts exhibited increased restlessness over time as measured by increased sleep latency (**I**) and nightly awake time (**J**). From Sonde Health's vocal biomarker app (**K-O**), USSF voice-derived mental fitness diminished over time (**K**) and RPA's variability in mental fitness diminished over time (**L**). Finally, RPA's speech rate diminished over time (**O**).

4. Conclusions: The results of this preliminary study generally suggest that the hybrid shift assignment might reduce mood (**C,D**), diminish sleep quality (**I-J**), and dull mental fitness (**K,L,O**) as measured by the voice. It may be the case that shorter or more consistent shifts lead to better mood and sleep behaviors, though further studies will need to evaluate the effect of covariates to produce more confident conclusions on the effect of different shift assignments. The researchers will continue to follow both cohorts for a total of 12 months.

5. References:

1. Cella, D., Riley, W., Stone, A. A., et al. (2010). The Patient Reported Outcomes Measurement Information System (PROMIS) developed and tested its first wave of adult self-reported health outcome item banks: 2005-2008. *Journal of Clinical Epidemiology,* 63, 1179-1194.
2. Ten Have, M., Van Bon-Martens, M.J.H., Schouten, F., et al. (2024). Validity of the five-item mental health inventory for screening current mood and anxiety disorders in the general population. *International Journal of Methods in Psychiatric Research*, 33(3), doi: 10.1002/mpr.2030
3. AFRL-OSU Gold Standard Validation Projects Vol.3. Oct 2023. Dayton, OH