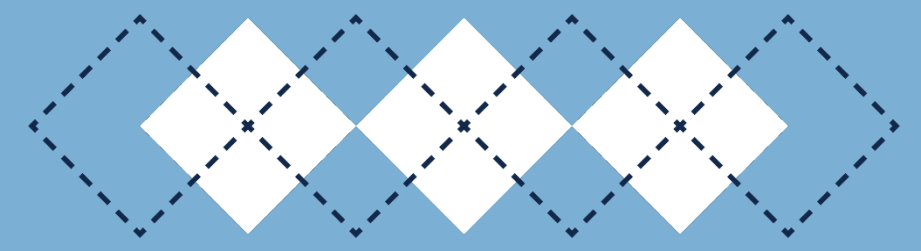




Heart Rate Variability Recovery Impairment After Exercise In Active-Duty Service Members With Mild Traumatic Brain Injury

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Background

The Complex Assessment of Military Performance (CAMP) test battery assesses physical capacities of active-duty military service members (SM) after mTBI. ¹ After mTBI, symptoms such as headache, dizziness, and cognitive impairment are common. Autonomic nervous system (ANS) dysfunction at rest has been shown acutely after mTBI², but has not been studied in more chronic injury during exercise. Heart rate variability (HRV) provides an objective measure of ANS function that may prove useful in return to duty decision making.¹ Consent and self-report measures were completed. HRV was measured at baseline before testing for 3 minutes. Each SM completed three agility and exertional tasks interspersed with 3 minute rests to measure HRV.

Objective

To examine cross-sectional SM HRV, comparing SMs recovering from mTBI and healthy control (HC) SM peers at baseline and during recovery after the CAMP test battery. We hypothesized HRV differences after mTBI, particularly during exercise recovery.

Demographics

Participants were recruited from Fort Bragg, Camp Lejeune, and Joint Base Lewis-McChord. Those with mTBI were recruited via Intrepid Spirit Center outpatient programs for mTBI.

- 45 SM with mTBI undergoing intervention for persisting symptoms (> 2 wks and < 2yrs), with median time post injury of 29 weeks
- 28 HC SM without a diagnosis of mTBI in the past 2 years, no symptoms associated with a prior injury

The mTBI group was older (31.97 ± 7.37 vs. 27.35 ± 6.43 years, $p = 0.0001$), with more years of military service (11.16 ± 7.64 vs. 6.22 ± 5.54 , $p < 0.0001$), and Neurobehavioral Symptom Inventory scores were substantially higher in the mTBI group compared with HC group (38.00 ± 17.23 vs. 0.29 ± 0.55 , $p < 0.0001$). Both groups were predominantly male (89.6% mTBI vs. 86.4% HC, $p = 0.28$).

Methods

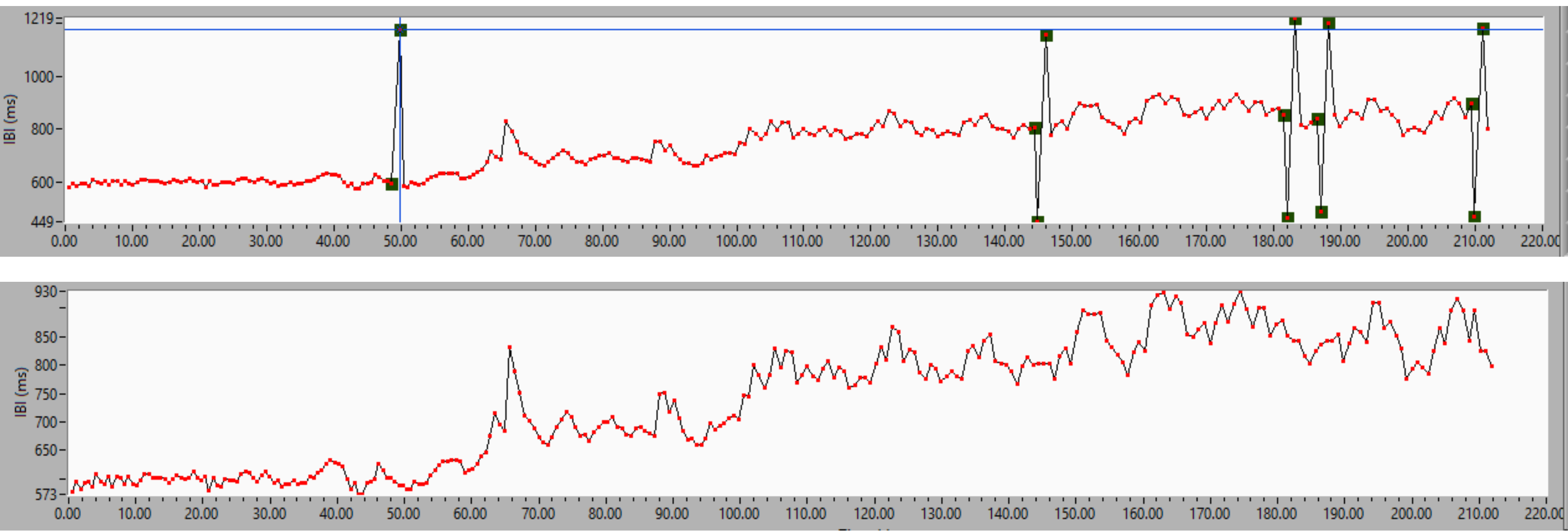
HRV measures: average Respiratory Sinus Arrhythmia (RSA), and Heart Period (HP) using a POLAR10 chest heart rate monitor.



CAMP Test Sequence	
Baseline	Seated 3 min
Run Roll Task	Aerobic 4 x 15 sec ~5 min
Break 1	Seated 3 min
Dual-task Agility	Cognitive & Aerobic Grid coordinate memory & Shuttle run ~10 min
Break 2	Seated 3 min
Patrol Exertion	Aerobic 10 min repeated stepping & patrol scene with reaction time
Recovery	Seated 3 min Rest

Data Analyses

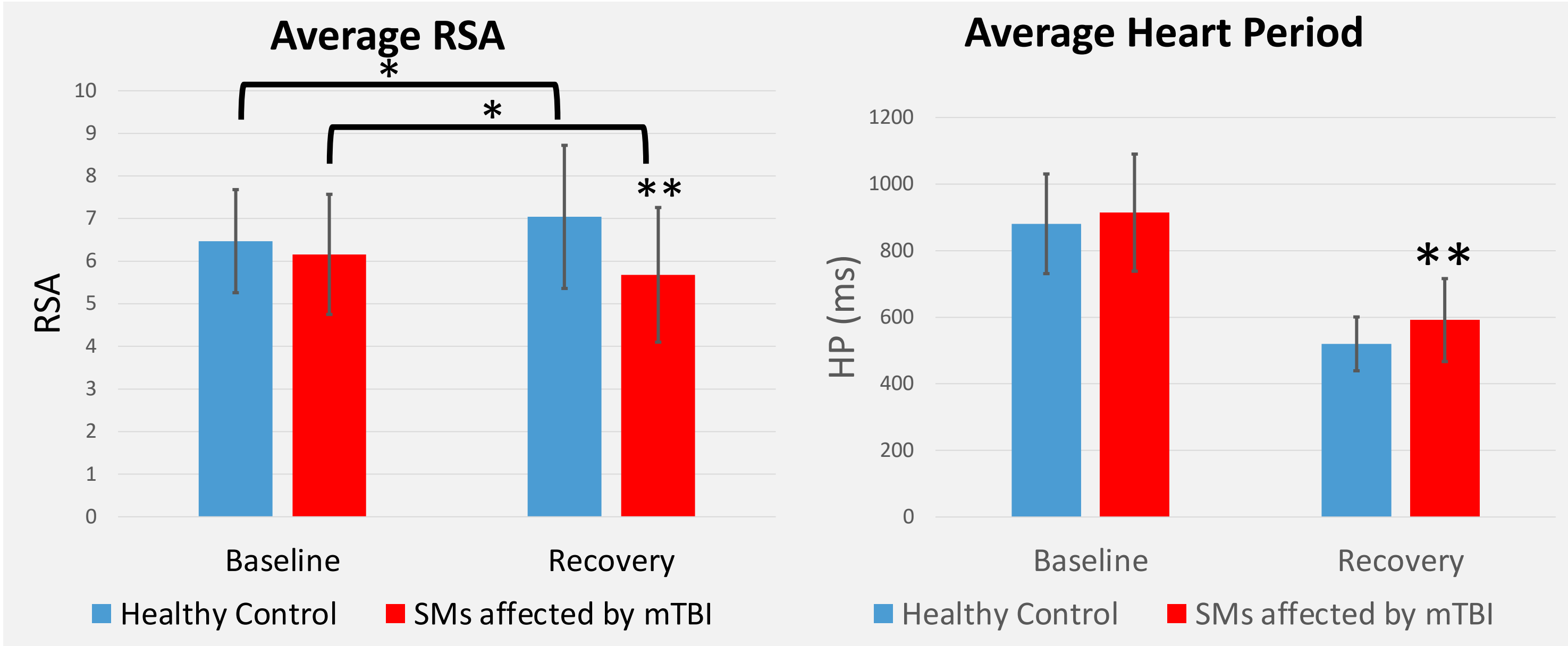
Inter-beat-interval files for rest and recovery periods (4) for each participant were inspected for completeness and edited using a standardized approach with Cardio Edit software. Retained files were edited less than 5%, using integer arithmetic (e.g. division of IBI when detection of R wave from sensor was missed, averaging intervals when spurious invalid detections occurred) See example below.



Edited files analyzed using CardioBatch to compute average RSA and HP.

Results

At baseline mean RSA and HP did not differ significantly between groups. Showing comparable BSL1 between groups prior to task engagement.



* $p < 0.05$, ** $p < 0.005$

RSA change differed significantly between groups. Participants with mTBI exhibited a mean reduction in RSA from baseline to recovery, whereas HC showed a mean increase in RSA. Change-score analyses confirmed a significantly greater reduction in mean RSA in mTBI relative to HC. Mean HP decreased from baseline to recovery in both groups, and the magnitude of HP change did not differ significantly between groups.

During recovery, mean RSA differed significantly between groups. RSA was significantly lower in the mTBI group compared with HC $p = 0.001$ and large effect size ($d = -0.83$).

- HC: 7.04 ± 1.68 SD
- mTBI: 5.68 ± 1.58 SD

During recovery mean HP was significantly higher in the mTBI group with $p = 0.004$ and moderate-to-large effect size ($d = 0.65$).

- HC: 520.03 ± 80.88 ms SD
- mTBI: 591.48 ± 124.64 ms SD

Perceived exertion was **not significantly associated** with autonomic change in either group.

Conclusions

ADSMs with more chronic mTBI and HCs had comparable baseline HRV data at rest but showed differences in recovery after short bouts of exercise, with lower mean RSA demonstrating slower recovery to baseline. This HRV recovery delay could have functional implications for returning to active duty. Thus, more research is necessary on HRV data to confirm if it is a useful tool in judging recovery from mTBI for clinicians.

References

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2. Prim JH, Hernandez MID, Cole W, Cecchini AS, Ranapurwala SI, McCulloch KL. Utility of Heart Rate Variability and Exertional Task Completion During Recovery of Mild Traumatic Brain Injury in Active Duty Service Members. *Mil Med*. Published online September 24, 2025:usaf454. doi:10.1093/milmed/usaf454