Factor Structure of Baseline and Acute mTBI Assessments in US Service Academy Cadets: Implications for Diagnostic Optimization

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RAMHS Research in Athlete & Military Health Sciences

FASTER
FAir, interpretable, and time-Sensitive Tool for Efficient mTBI Recognition

VCU School of Medicine

Disclosure and Disclaimer

Disclosure:

Landon Lempke, PhD: No relevant, real, or apparent personal/professional financial relationships with proprietary entities that produce healthcare goods/services.

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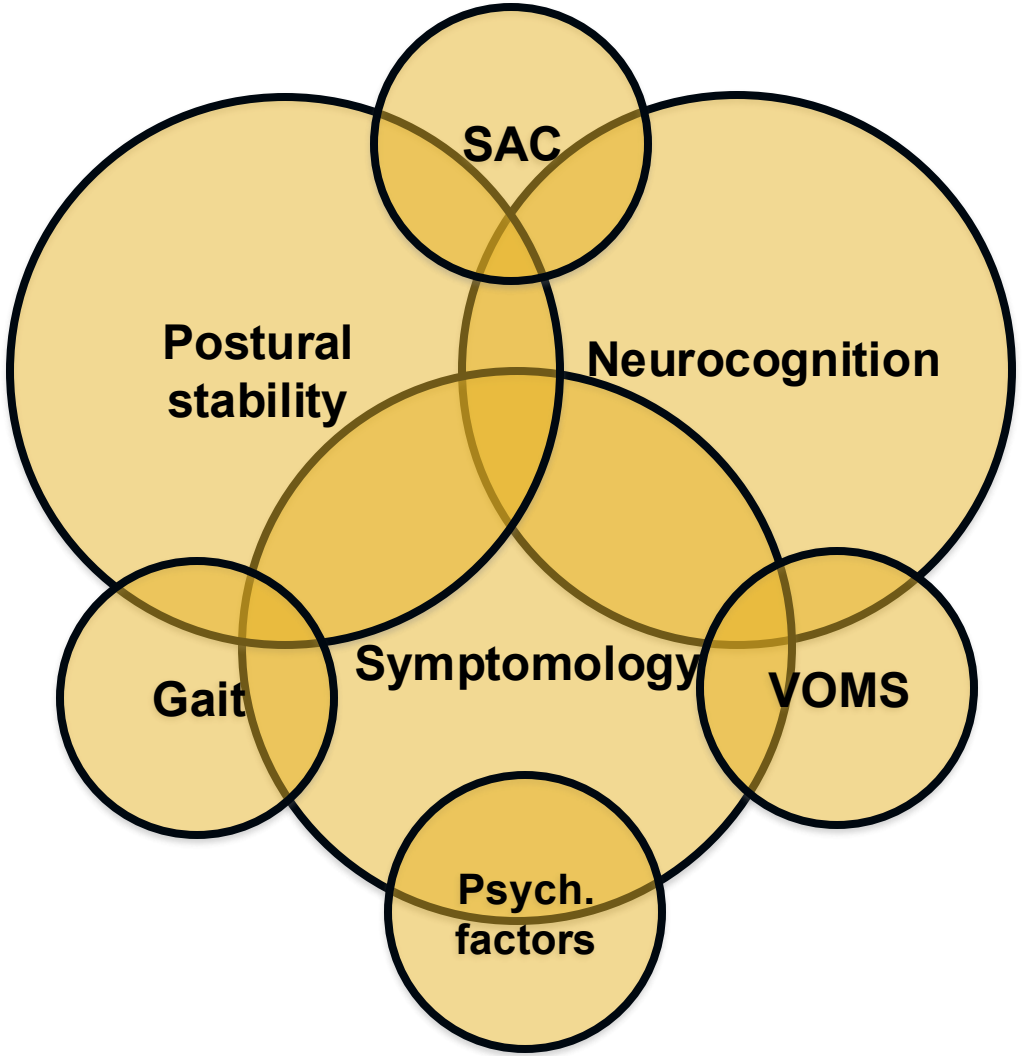
Introduction

- Multimodal mTBI evaluations consensus recommended[1-2]
  - Outcome theorized to provide unique patient insights
- Redundancy may exist between & within assessments
- Relationships & empirical optimization between & within assessments can be quantified
  - Limited to adolescent & collegiate athletes cohorts[3,4]
- **The Problem:** Unknown multi-assessment factor structure for military populations
  - More assessments = ↑ patient, clinician, and resource (time, cost) demand; "less is more" potential



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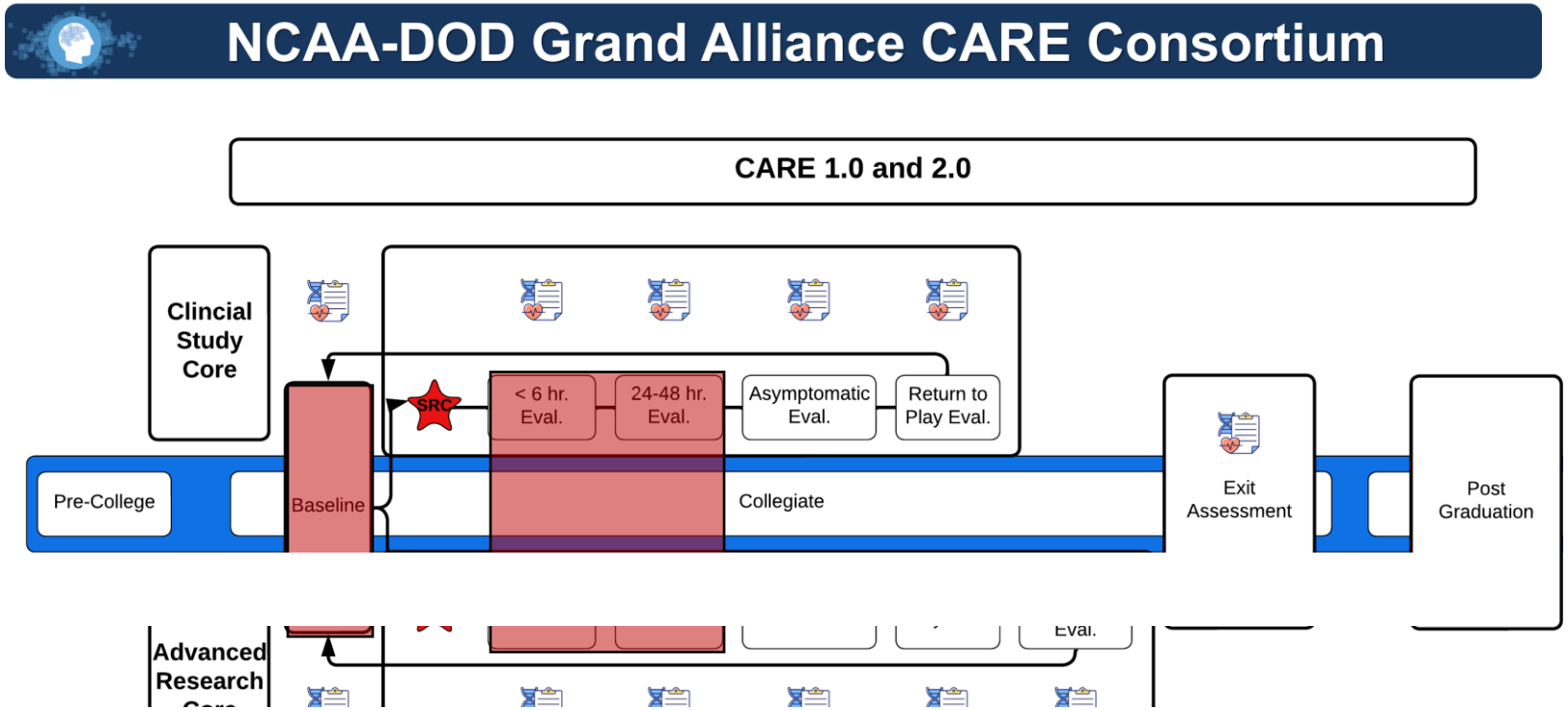
Objective

To examine & confirm the factor structure of a common mTBI assessment battery at pre-injury (baseline) <48-hour post-mTBI among United States service academy cadets.

Methods – Study Design

- NCAA-DoD CARE Consortium
  - longitudinal, multi-phasic cohort[1]
- Specific to this report:
  - 2014-2018 (CARE 1.0)
  - Baseline & Acute (<48-hour) timepoints
  - 30 sites total; 4 US Service Academies:
    - Army (USMA)
    - Navy (USNA)
    - Air Force (USAFA)
    - Coast Guard (USCGA)



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Methods –Participant Inclusion/Exclusion

Pre-Injury Baseline

Initial cases[a]

n = 66,363

All baselines from
Fall 2014 – Spring 2018

Participant Demographics

- Predominately:
  - 18-20 years old
  - Male (62 & 75%)
  - White (71 & 74%) & non-Hispanic (83 & 84%)
  - From Air Force (48 & 77%) and Army (43 & 18%)
  - Prior mTBI for 18 & 26%

Table. Baseline and Post-Injury Demographics.

	Baseline N = 17,780[1]	Post-Injury N = 1,431[1]
Age; Mean (SD)	18.90 (1.36)	18.65 (1.20)
Sex (Male)	13,343 (75.04%)	882 (61.64%)
Race (White)	13,108 (73.72%)	1,010 (70.58%)
Black	1,361 (7.65%)	128 (8.94%)
Multiracial	1,607 (9.04%)	152 (10.62%)
Asian	1,178 (6.63%)	91 (6.36%)
Hawaiian/Pacific Islander, Indigenous	453 (2.55%)	44 (3.08%)
Ethnicity (Non-Hispanic)	14,760 (83.01%)	1,200 (83.86%)
Academy Site		
Air Force	8,458 (47.57%)	1,108 (77.43%)
Coast Guard	1,601 (9.00%)	66 (4.61%)
Army	7,721 (43.43%)	257 (17.96%)
mTBI History (Yes)	3,248 (18.27%)	369 (25.79%)

Methods – Dependent Variables

- Sport Concussion Assessment Tool (SCAT) Symptom Checklist
  - 22 individual symptom items (0-6 Likert scale)
- Brief Symptom Inventory-18 (BSI-18)
  - 18 individual items of global psych distress (0-4 Likert scale)
- Standardized Assessment of Concussion (SAC)
  - 4 Subscores of Orientation, Immediate Memory, Concentration, Delayed Recall
- Balance Error Scoring System (BESS)
  - 6 Subscores (double limb, single-limb, tandem x firm and foam surface)
- Immediate Post-Concussion Assessment and Cognitive Test (ImPACT)*

  Navy did not complete ImPACT; data-driven exclusion from analyses
  - Verbal memory composite score
  - Visual memory composite score
  - Visual motor speed composite score
  - Reaction time composite score

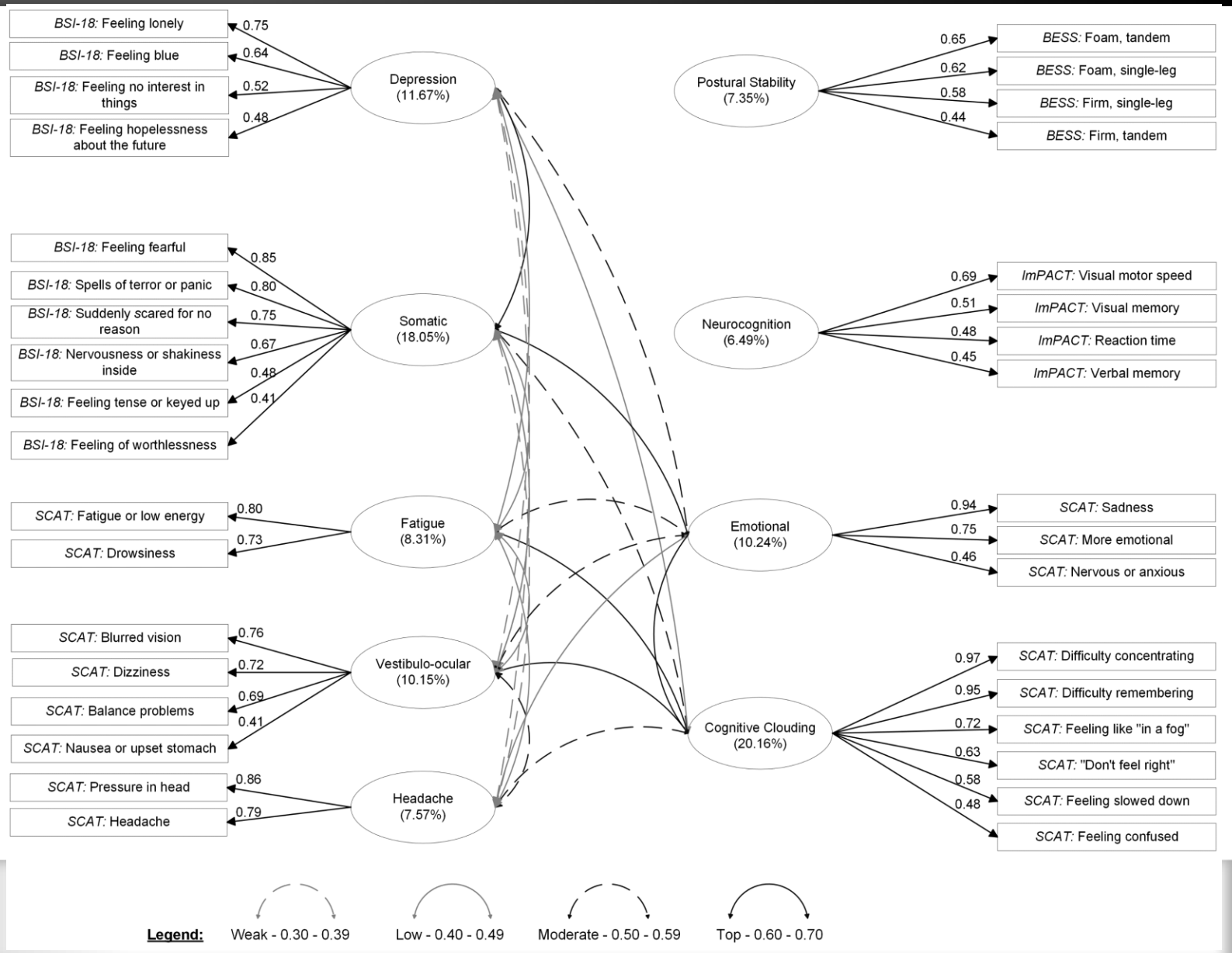
Methods – Statistical Analysis

- **Exploratory factor analysis models**
  - 50% random data split (training set)
    - Scree plots with parallel analyses determined factor quantity
    - ProMax rotations with maximum likelihood estimation
      - Factor loading ≥0.40, but not ≥0.40 on 2+ factors
  - Model outcomes:
    - Variance explained (σ^2) overall and at factor level
    - Factor loading: Correlation equivalent between variable and factor
    - Inter-factor correlation: correlation between factors

- **Confirmatory factor analysis**
  - Baseline 50% remaining random split (testing set); Acute mTBI timepoint separately
  - Model outcomes:
    - Root mean square error of approximation (RMSEA ≤0.06)
    - Comparative fit index (CFI ≥0.90)
    - Change: ΔCFI ≤ 0.01 or ΔRMSEA ≤ 0.01

Results – Exploratory Baseline

- 9-factor model
  - (σ^2=52.2)% explained; cognitive clouding & somatic greatest
  - All SAC and select BSI-18 & BESS items did *not* meaningfully load/contribute to model
  - Postural stability and neurocognition (objective) uncorrelated with symptom-based factors (subjective)
    - Weak-high correlations between symptom-based factors



Results – Confirmatory Factor Analysis

Table. Confirmatory Factor Analysis - Overall Model Fit Indices					
Data	**RMSEA**	**(90% CI)**	**ΔRMSEA**	**CFI**	**ΔCFI**
Training - Baseline (n=8,890)	0.046	(0.045, 0.047)	Referent	-	-
Testing - Baseline (n=8,890)	0.051	(0.050, 0.052)	0.005	0.915	Referent
Post-Injury (n=1,431)	0.056	(0.054, 0.058)	0.005	0.911	-0.004

- Strong factor structure fit from baseline training → testing data
- Strong fit (though subtly lower) at acute (<48-hr) post-injury

Suitable (confirmed) factor structure regardless of pre- or post-mTBI

Conclusions

- Confirmed factor structure pre-and post-mTBI
  - Same domains and similar weighting present – measuring correct factors
- Notable factor loadings and inter-factor correlations were present
  - Reducing assessment items likely possible
- Null SAC, select BSI-18 & BESS factor loading
  - Cumulatively may indicate limited benefit & redundant[1,2]
- **Future work and implications:**
  - Determine minimal battery & time composition for maximal diagnostics
  - Calibrate/tailor to patient-level factors for greater diagnostic suitability
  - Understand diagnostic and cumulative financial trade-off nationwide for DoW Service Members

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FASTER Team & Acknowledgements

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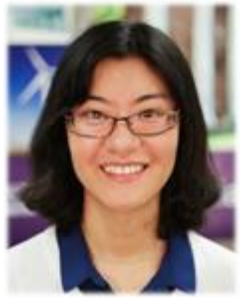

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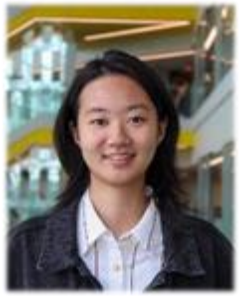

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Thank you – Questions?

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