Responsiveness of the Portable Warrior Test of Tactical Agility (POWAR-TOTAL) in Service Members with mTBI

Karen L. McCulloch, PT, PhD, MS, FAPTA

Coauthors: Amy S. Cecchini, PT, DPT, Wanqing Zhang, PhD, Courtney Harrison, MS, Oleg Favorov, PhD

mTBI RADAR
Rehabilitation and Assessment Research

UNC SCHOOL OF MEDICINE

HMSC
UNIVERSITY of NORTH CAROLINA at CHAPEL HILL
HUMAN MOVEMENT SCIENCE CURRICULUM

Disclosures and Funding

UNC SCHOOL OF MEDICINE

- No disclosures
- The views expressed herein are those of the author(s) and do not reflect the official policy or position of the U.S. Army Medical Department, Department of the Army, Department of Defense, or the U.S. Government.

- Funding was provided by CDMRP Psychological Health/Traumatic Brain Injury Research Program, W81XWH-17-2-0046 and supported by National Center for Advancing Translational Sciences (NCATS), National Institutes of Health, UL1TR002489.

Portable Warrior Test of Tactical Agility – POWAR TOTAL

Dual-task measure derived from components of the Assessment of Military Multitasking Performance

- Motor: Run-Roll task
- Cognitive: Working memory task

- Smaller “footprint”
- Faster/simpler administration
- Retain face validity
- Task provocative for balance/vestibular impairment
- Retain discriminative elements

POWAR TOTAL Motor task

Service member carries a simulated weapon (bluegun) during task

- Rapid movements (fwd/bkwd runs) and transitions (prone to stand, combat rolls)

Time to complete the course – via stopwatch

- Trials: Typically 15 s or less
  - 1 “walk through”
  - 1 practice
  - 1 single task
  - 3 dual-task

Inertial sensors (head and lumbar area to capture movement characteristics)

Used phone based sensors for POWAR study – have converted to inexpensive IMUs

POWAR TOTAL Cognitive task

Examiner provides an 8 character grid coordinate with 2 Alpha and 6 numeric characters verbally

- After a delay (or motor task) repeat grid coordinate exactly as remembered
- Single task trial (with 15 s delay), then 3 dual-task trials with motor
- New grid coordinate with each trial

Grid provided before motor task:

“Echo-Zulu-7-4-9-2-5-3”

POWAR TOTAL Cognitive task

Examiner provides an 8 character grid coordinate with 2 Alpha and 6 numeric characters verbally

- After a delay (or motor task) repeat grid coordinate exactly as remembered
- Single task trial (with 15 s delay), then 3 dual-task trials with motor
- New grid coordinate with each trial

Grid provided before motor task:

"Echo-Zulu-7-4-9-2-5-3"

SM recalls coordinate:

"Echo-Zulu-7-4-2-9-5-3"

Score = 6/8

POWAR-TOTAL Validation Approach

UNC SCHOOL OF MEDICINE

Cross-sectional study of ADSMs with mTBI and ADSM healthy controls

- Known group validity
  - Group differences
  - Effect sizes
- Construct validity - correlations with High Level Mobility Assessment Test (HiMAT) & other clinical measures

Pre-post physical therapy testing mTBI only

- Effect sizes
- Responsiveness: MDC, MCID
- Anchor based change (PGIC)

Test re-test reliability

- Small sample healthy controls

Inclusion and Exclusion

All participants

- ADSM, aged 18-45
- Free of medical, psychiatric, or other conditions that prevent exercise
- No activity restrictions that prevent testing
- Mild-mod behavioral health and chronic pain included

Healthy Control Group

- Can have concussion history if > 2 years and no ongoing issues

mTBI Group

- Documented mTBI >2 weeks ago, but < 2 years
- Recruited from those initiating a course of PT at Intrepid Spirit Centers
- Initial test during 1st week of therapy

Known-group validity findings – observational measures

UNC SCHOOL OF MEDICINE

The Portable Warrior Test of Tactical Agility: A Novel Functional Assessment That Discriminates Service Members Diagnosed With Concussion From Controls

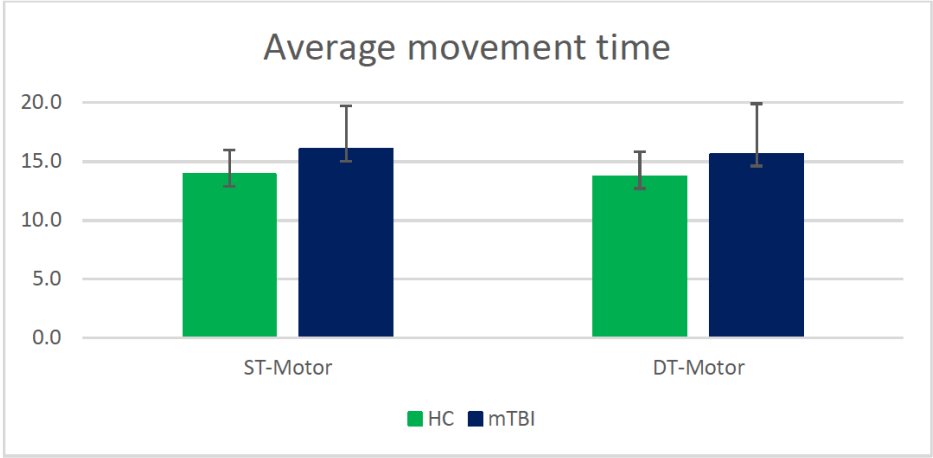
Amy Seal Cecchini, DPT, Julianna Prim, PhD, Wanqing Zhang, PhD, Courtney H Harrison, MS, Karen L McCulloch, PT, PhD, FAPTA

Military Medicine, usab346, https://doi.org/10.1093/milmed/usab346
Published: 19 August 2021 **Article history** ▾

Based on 59 ADSM HC, 64 ADSM with mTBI

Significant group differences:

- Single AND dual task cognitive
- Single AND dual task motor
- Large effect sizes for POWAR cognitive and motor components



Known-group validity – inertial sensors

UNC SCHOOL OF MEDICINE

Wearable Sensors Detect Movement Differences in the Portable Warrior Test of Tactical Agility After mTBI in Service Members

Oleg Favorov, PhD, Olcay Kursun, PhD, Timothy Challener, PhD, Amy Cecchini, PT, DPT, Karen L McCulloch, PT, PhD, FAPTA

Military Medicine, usab361, https://doi.org/10.1093/milmed/usab361
Published: 03 September 2021 **Article history** ▾

Inertial sensor comparison of movement phases

- Large effect sizes for transitions stand to prone, combat roll
- Predictive value of transitional movement speed

3143 Portable Warrior Test of Tactical Agility (POWAR-TOTAL) Predicts PT Improvement in Military mTBI

Courtney H Harrison, *Oleg Favorov and Karen Leigh McCulloch, PT, BSPT, MS, FAPTA*
Henry B. Gonzalez Convention Center - Exhibit Hall 2

Saturday Poster Session – 3-5pm

UNC
SCHOOL OF MEDICINE

Validity and Responsiveness

POWAR-TOTAL Validation Approach

UNC SCHOOL OF MEDICINE

Cross-sectional study of ADSMs with mTBI and ADSM healthy controls

- Known group validity
  - Group differences
  - Effect sizes
- Construct validity – correlations to High Level Mobility Assessment Test (HiMAT) & other clinical measures

Pre-post physical therapy testing

mTBI only

Effect sizes

Anchor based change (PGIC)

Responsiveness: MDC, MCID

Test re-test reliability

Small sample healthy controls

Pre-post mTBI Cohort

UNC SCHOOL OF MEDICINE

- ADSM with mTBI at two Intrepid Spirit Centers
  - 74 initial test (at start of PT course)
  - 49 post-tested using same test battery (at end of PT course)
  - Lost to follow-up did not differ significantly on primary outcome measures
- No attempt to control physical therapy intervention or duration

mTBI – post-test group (n=49)

UNC SCHOOL OF MEDICINE

	Mean (SD)
Age	29.2 (6.4)
mTBI history	
Time since recent mTBI (mos)	7.6 (6.5)
Prior number of mTBIs	6.0 (7.5) Range (1-40)
mTBI history prior to this injury	n=40 (81.6%)

Demographics	n (%)
Sex	
Male	46 (93.9)
Female	3 (6.1)
Ethnicity	
Caucasian	39 (79.6)
African American	2 (4.1)
Hispanic / Latino	5 (10.2)
Other	3 (6.1)
Education	
High School	14 (28.6)
Some College/Associates Degree	28 (57.1)
Bachelor's Degree or higher	7 (14.3)

Military history	
Time in service	8.1 yrs (5.9)
Number of Deployments	3.9 (2.9) Range (1-12)
No duty restrictions	n=21 (42.9%)
Physically ready to deploy in 72 hours	n=13 (26.5%)

Concurrent measures

Dynamic Visual Acuity (chart)
Sensory Organization Test (chart or project staff)
HiMAT without stairs (project staff)

Self-Report Measures

NSI – Neurocognitive Symptom Inventory
PCL-5 – Post traumatic Stress Checklist
DVPRS – Defense and Veterans Pain Rating Scale
DHI - Dizziness Handicap Inventory **
HIT-6 – Headache Impact Test **
PSQI – Pittsburgh Sleep Quality Inventory **
CDRS – Connor-Davidson Resilience Scale **
PGIC – Patient Global Index of Change **
Readiness to physically deploy in 72 hours?

Improvements after physical therapy

UNC SCHOOL OF MEDICINE

Self-report and performance measures	Initial Mean (SD) n=49	Final Mean (SD) n=49	p	Between subjects Effect Size
NSI (0-88)	37.6 (15.1)	28.2 (16.9)	<.001	-0.58
PCL-C (0-80)	28.8 (20.1)	21.1 (18.9)	<.001	-0.39
DVPRS (0-10)	4.4 (2.0)	3.1 (2.2)	<.001	-0.62
DHI (0-100)	33.5 (20.0)	24.4 (19.7)	<.001	-0.46
HIT-6 (36-78)	62.3 (8.1)	57.4 (8.9)	<.001	-0.58
PSQI (>5 referral threshold)	13.5 (4.5)	11.1 (5.0)	<.001	-0.50
DVAT (lines lost)	2.6 (1.5)	1.8 (1.0)	<.001	-0.71
SOT Composite (of 100)	68.6 (15.3)	75.7 (13.9)	<.001	0.72
HiMAT (of 32)	22.3 (8.1)	24.3 (7.6)	<.001	0.32

Moderate effect size

Significant improvements, but symptom burden remains

Improvements in POWAR metrics

UNC SCHOOL OF MEDICINE

Measure	Initial Mean (SD) n=49	Final Mean (SD) n=49	p	Between subjects Effect Size
NSI (0-88)	37.6 (15.1)	28.2 (16.9)	<.001	-0.58
PCL-C (0-80)	28.8 (20.1)	21.1 (18.9)	<.001	-0.39
DVPRS (0-10)	4.4 (2.0)	3.1 (2.2)	<.001	-0.62
DHI (0-100)	33.5 (20.0)	24.4 (19.7)	<.001	-0.46
HIT-6 (36-78)	62.3 (8.1)	57.4 (8.9)	<.001	-0.58
PSQI (>5 referral threshold)	13.5 (4.5)	11.1 (5.0)	<.001	-0.50
DVAT (lines lost)	2.6 (1.5)	1.8 (1.0)	<.001	-0.71
SOT Composite (of 100)	68.6 (15.3)	75.7 (13.9)	<.001	0.72
HiMAT (of 32)	22.3 (8.1)	24.3 (7.6)	<.001	0.32
POWAR-TOTAL metrics				
ST-Cognitive (of 8)	5.4 (1.9)	6.6 (1.5)	<.001	0.67
DT-Cognitive (avg of 3 trials, of 8)	5.2 (1.8)	5.9 (1.7)	0.003	0.42
ST-Motor (seconds)	16.1 (4.0)	14.3 (3.0)	0.002	-0.51
DT-Motor (avg of 3 trials, seconds)	15.9 (4.6)	14.0 (2.8)	0.006	-0.50

Moderate effect size

Moderate effect sizes for POWAR variables, higher effect size than HiMAT

Correlation of change in measures

UNC SCHOOL OF MEDICINE

	POWAR ST Motor (95% CI)	p value	POWAR DT Motor (95% CI)	p value
Performance based measures				
High-level Mobility Assessment Test	0.52 (.26, .71)	<.001	0.55 (.29, .73)	<.001
Sensory Organization Test	0.46 (.16, .67)	.004	0.42 (.11, .65)	.009
Self-report measures				
Dizziness Handicap Inventory	0.44 (.17, .64)	.002	0.30 (.01, .54)	.04
Neurobehavioral Symptom Inventory	0.35 (.07, .58)	.01	0.29 (-.004, .53)	.05

Test retest reliability

UNC SCHOOL OF MEDICINE

- 11 healthy control ADSM were tested twice (one month apart)
- ICCs for motor and cognitive components from .81-.88
- Average improvement on motor task ST .82s, DT 1.06s
- NO change on cognitive task performance with retest – innate prioritization on motor on average

Anchor for responsiveness analysis

UNC SCHOOL OF MEDICINE

Patient Global Impression of Change*

Since beginning treatment at this facility, how would you describe the change (if any) in ACTIVITY LIMITATIONS, SYMPTOMS, EMOTIONS and OVERALL QUALITY OF LIFE, related to your painful condition? Choose ONE.

___No change (or condition has gotten worse) (1)
___Almost the same, hardly any change at all (2)
___A little better, but no noticeable change (3)
___Somewhat better, but the change has not made any real difference (4)
___Moderately better, and a slight but noticeable change (5)

Little or no global change

___Better and a definite improvement that has made a real and worthwhile difference (6)
___A great deal better and a considerable improvement that has made all the difference (7)

Significant global change

*Recommended for use in military mTBI studies by the TBI Center of Excellence

Interpretation of change – anchor based responsiveness

UNC SCHOOL OF MEDICINE

Improvement rating based on PGIC	Single task* motor task difference pre-post
Little or no global improvement (5 or less on PGIC) n=16	.12 s (sd 3.14)
Significant global improvement (6 or 7 on PGIC) n=31	-2.87s (sd 3.98) p=.008

* Dual task differences were comparable

Interpretation of change – anchor based responsiveness

UNC SCHOOL OF MEDICINE

Improvement rating based on PGIC	Single task motor task difference pre-post	Guidance for interpretation of change
Little or no global improvement (5 or less on PGIC) n=16	.12 s (sd 3.14)	Minimal Detectable Change (MDC) -1.96s ST -2.05 DT
Significant global improvement (6 or 7 on PGIC) n=31	-2.87s (sd 3.98) p=.008	Minimal Clinically Important Difference (MCID) -3.65 ST -3.84 DT

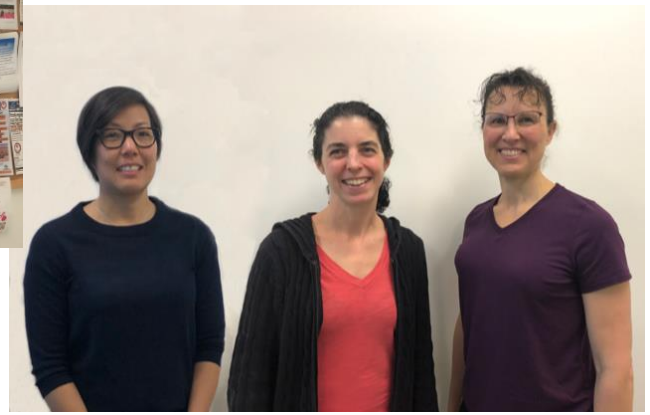
Test re-test differences from HC group
-.82s ST
-1.06s DT

POWAR-TOTAL

- Valid and clinically feasible
- Detects group differences – observational measures only
- Acceptable test re-test reliability
- Responsive to change
  - Moderate effect sizes
  - Preliminary guidance for re-test interpretation
- Additional analyses
  - Dual-task interference effects

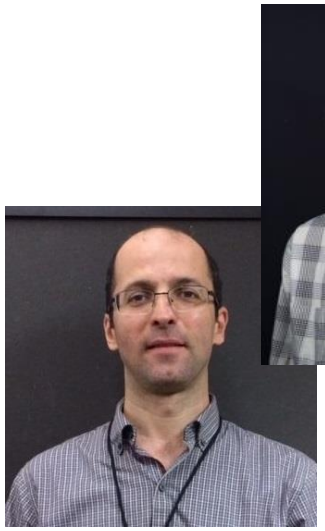
Additional study for reference/normative values, provision of feedback to therapist/service member

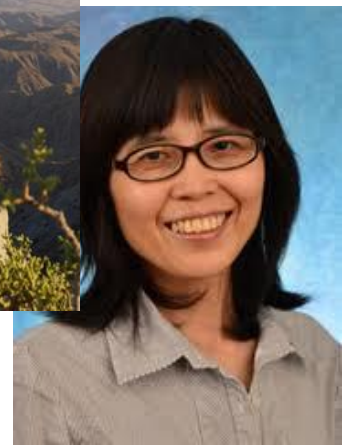
Womack Army Medical Center – Fort Bragg



Assessment of Military Multitasking Performance Team

https://tarheels.live/mtbiradar/





mTBI RADAR
Rehabilitation and Assessment Research


UNC
SCHOOL OF
MEDICINE

Demographics - Known group analysis sample

Characteristics Mean (s.d.) or %	HC (n=59)	CONCUSSION (n=64)	P-value
Age	29.5 (6.73)	29.7 (6.98)	.848#
Sex (Male)	54 (93%)	60 (94%)	.575^
Race, Caucasian	38 (66%)	44 (74%)	.404^
Education, Bachelor's or >	19 (33%)	9 (15%)	**.041^**
Service time	7.7 (6.84)	8.5 (6.34)	.532#*
Pay Grade(E1-E6)	40 (66.7%)	45 (70%)	.249^
Prior deployments, Y Number if yes	29 (49%) 3.73 (3.07)	35 (70%) 3.57 (2.65)	**.0017^** .820#
Prior concussions Number if yes	34 (58%) 6.43 (9.45)	64 (100%) 5.5 (6.99)	**<.001^** * .597#
Physically ready to deploy? (Yes)	56 (95%)	19 (30%)	**<.001^** *

^= chi-square, # = independent t-test

POWAR TOTAL variables	Mean (SD)	Mean (SD)	*t*-Test *P*-value (effect size)
ST-cognitive (items of 8 correct)	6.95 (1.41)	5.39 (1.97)	<0.001 (–0.91)
DT-cognitive (items of 8 correct)	6.35 (1.38)	5.08 (1.91)	<0.001 (–0.76)
ST-motor (seconds)	13.9 (2.04)	16.0 (3.74)	<0.001 (0.70)
DT-motor (seconds)	13.7 (2.12)	15.6 (4.30)	0.004 (0.56)
Pretest vision line (of 11, higher is better, 8 represents 20/20 vision)	8.26 (1.42)	7.63 (1.37)	0.014 (–0.45)
Pretest vision clarity self-report (0-10 rating, lower is better)	1.40 (1.68)	3.61 (1.98)	<0.001 (1.2)
Final vision line	8.28 (1.48)	7.12 (1.42)	<0.001 (–0.80)
Final vision clarity	1.84 (1.90)	4.86 (2.32)	<0.001 (1.4)

Known-group validity findings – observational measures

TABLE I. Statistics of Comparisons of the Healthy Control (HC) and Mild Traumatic Brain Injury (mTBI) Samples

Statistical test	Group or trial #	Trial phase		
		Rising and running	Lowering	Rolling
(A) paired *t*-test of the in-subject difference of the phase durations between trials 2 and 5 (*P* value)	HC group	0.0033	0.0004	0.0080
	mTBI group	0.68	0.82	0.20
(B) *t*-test of the difference of the means of phase durations between HC and mTBI samples (*P* value)	trial 2	0.1032	0.0002	0.0007
	trial 3	0.0899	<0.0001	0.0038
	trial 4	0.0167	0.0001	0.0009
	trial 5	0.0133	<0.0001	0.0006
(C) effect size Cohen's *d* for HC and mTBI samples	trial 2	0.27	0.79	0.68
	trial 3	0.28	1.01	0.59
	trial 4	0.47	0.84	0.70
	trial 5	0.49	1.05	0.72
(D) correlation of phase durations with subject's age (r^2/p)	HC group	0.0008/0.84	0.0024/0.73	0.0092/0.49
	mTBI group	0.0024/0.77	0.0753/0.09	0.0154/0.45

For Cohen's *d*: blue—small effects; green—medium effects; red—large effects.

Known group validity findings – inertial sensor measures

mTBI characteristics

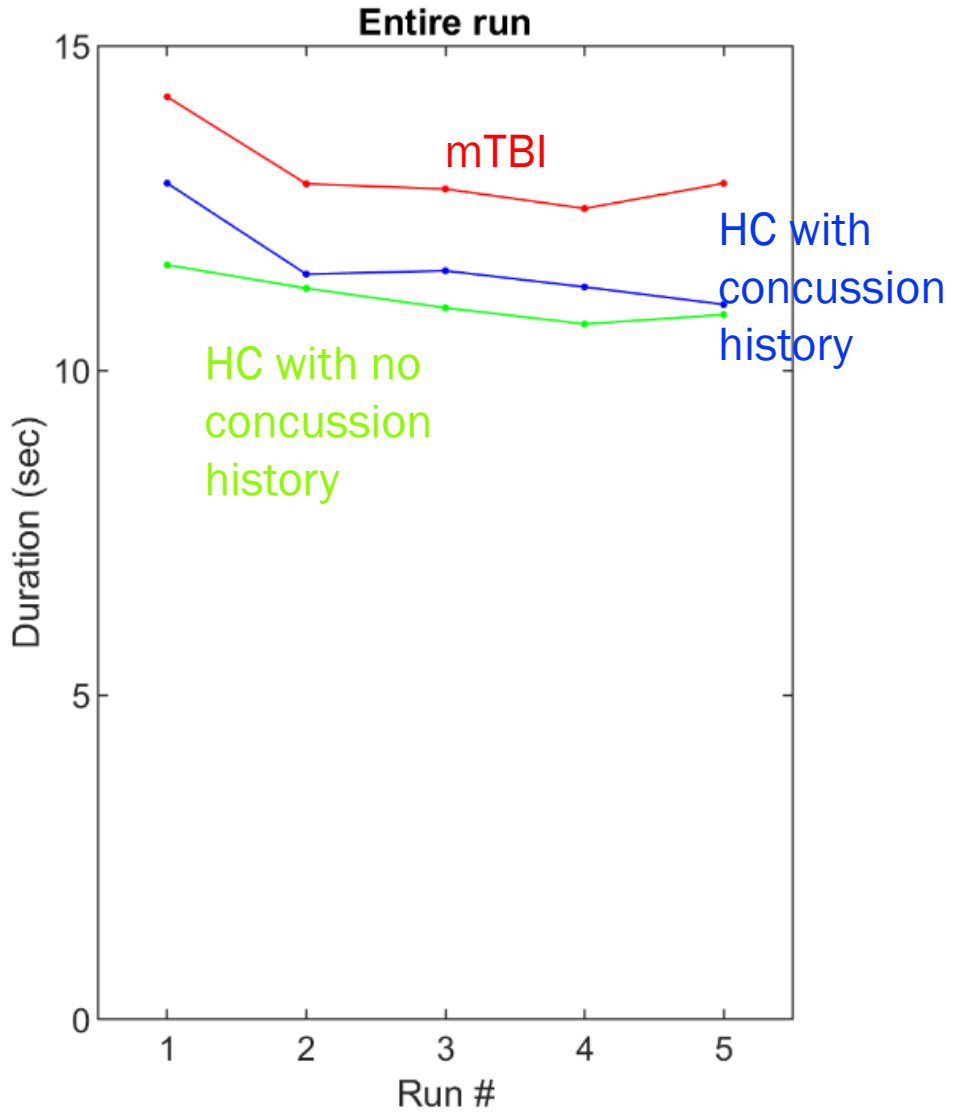
Variables	Total Sample Mean (SD) n=74	Returned for post-testing Mean (SD) n=49
Age	29.6 (6.8)	29.2 (6.4)
Time in service	8.6 (6.2)	8.1 (5.9)
Number of Deployments	3.6 (2.7) Range (1-12)	3.9 (2.9) Range (1-12)
Time since recent concussion (mos)	7.8 (6.6)	7.6 (6.5)
Prior number of Concussions	5.5 (6.4) Range (1-40)	6.0 (7.5) Range (1-40)
Connor Davidson Resilience Scale*	74.5 (15.7)	73.8 (15.9)

Categorical variables	n (%)	n (%)
Sex		
Male	68 (91.9)	46 (93.9)
Female	6 (8.1)	3 (6.1)
Ethnicity		
Caucasian	55 (74.3)	39 (79.6)
African American	4 (5.4)	2 (4.1)
Hispanic / Latino	8 (10.8)	5 (10.2)
Other	7 (9.5)	3 (6.1)
Education		
High School	21 (28.4)	14 (28.6)
Some College/Associates Degree	44 (59.5)	28 (57.1)
Bachelor's Degree or higher	9 (12.2)	7 (14.3)
Concussion history prior to this injury	58 (78.4)	40 (81.6)
No duty restrictions	33 (44.6)	21 (42.9)
Physically ready to deploy in 72 hours	22 (29.7)	13 (26.5)

Test retest reliability – practice effects

Learning/practice effects associated with this novel motor task – improvement over initial trials – investigating 5th trial difference with mTBI group (fatigue?)

Controls with and without concussion history plotted separately – similar performance by 5th trial, but some differences initially



Floor effects

From mTBI sample of 74, 7 were unable to complete all trials on first test session (9.5% floor effect)

- 4 SMs stopped the test because of increased symptoms, 3 subjects were stopped by project staff – concerns about symptoms/safety
- On post-testing 4 did not return for testing, those that did return completed all the trials

Testing in first week of PT could have been mistimed for these subjects & influenced continuance in the study

If used in practice, clinician could initiate test at a point when symptom burden is lower and return to duty is considere


UNC
SCHOOL OF
MEDICINE