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

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ABSTRACT

Introduction:
Return-to-duty (RTD) readiness assessment for service members (SM) following concussion requires complex clinical considerations. The Portable Warrior Test of Tactical Agility (POWAR-TOTAL) is a functional assessment which improves on previous laboratory-based RTD assessments.

Methods:
Sixty-four SM diagnosed with concussion and 60 healthy control (HC) SM participated in this study. Group differences were analyzed to validate the POWAR-TOTAL. The High-level Mobility Assessment Test (HiMAT) was used to examine concurrent construct validity. An exploratory logistic regression analysis examined predictive validity.

Results:
The groups were demographically well-matched except for educational level. POWAR-TOTAL measures were statistically significantly different between the groups with moderate to large effect sizes. Concussed participants were less likely to be able to complete all trials of the POWAR-TOTAL. Motor scores correlated highly with HiMAT scores. POWAR-TOTAL motor task performance and membership in the control group was significantly associated with self-reported physical readiness to deploy.

Conclusion:
The POWAR-TOTAL is a clinically feasible, military relevant assessment that is sensitive to differences between concussed and HC SM. This analysis supports the discriminant and construct validity of the POWAR-TOTAL, and may be useful for medical providers evaluating RTD readiness for SM who have sustained a concussion.

INTRODUCTION

Since 2000, over 413,000 active-duty service members (ADSM) have sustained a traumatic brain injury (TBI), with 83% of these being categorized as mild (mTBI), or concussion. Concussion sustained by ADSM has the potential to significantly impact individual, unit and mission readiness. Symptoms and impairments associated with this type of injury typically resolve in 7-30 days[1,2]; however, anywhere from 10% to 30% of those who sustain concussion have symptoms and impairments that may last for months to years after injury. Causes of injury include blunt trauma, a mechanism common in contact sport athletes, as well as blast trauma, associated with improvised explosive devices or planned breaching operations, which are more uniquely associated with the military. The nature of military service increases the risk of multiple exposures to potentially concussive events over one's time in service. Military training intensity, mission variability and complex environments require dynamic abilities. These demands underscore the importance of ensuring recovery prior to full return to duty (RTD); physiological systems must be functional under real life conditions for mission success.

Return-to-duty (RTD) readiness assessment following concussion requires consideration of many impairments.[3–6] After a concussive event, service members (SMs) may present with deficits in balance, agility, memory, vision, and dual- or multi-tasking, among other complaints. Self-report measures for concussion assessment may be of limited value[7,8] in this population due to under- or over-reporting of symptoms. Self-report inaccuracy may occur because of operational demands, pressure from peers or command, or aspects of military culture that provide unique stressors.

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Information related to this manuscript was presented previously in poster format at American Congress of Rehabilitation Medicine Annual conference in 2019 and 2020 (virtual), poster format at AMSUS annual conference in 2020 (virtual) and was scheduled for a platform presentation at Military Health Services Research Symposium in 2020 (cancelled).

doi:https://doi.org/10.1093/milmed/usab346

While there are validated objective measures for evaluating a concussion injury, few include military specific motor skills.[9–14] An exception is the Military Functional Assessment of Performance, however, this test battery requires considerable space, equipment, and time, and has not been standardized or evaluated for scoring reliability.[5] Balance measures studied in an ADSM population include the Community Balance & Mobility Scale (CBMS)[9] and the NeuroCom™ Sensory Organization Test (SOT),[15] with normative reference values available for the SOT.[16] Other mobility assessments, such as the Dynamic Gait Index and the Functional Gait Assessment examine very basic mobility skills considerably below ADSM physical demands resulting in potential ceiling effects.[17–22] Neuropsychological tests have been validated for evaluating cognition in ADSM, but are typically administered as single task assessments.[11] Most concussion assessments focus on tasks that explore single functional domains (i.e., vision, memory, balance) and are administered in static positions.

Challenging concussion tests that use dual task, multi-task, or exertional conditions may expose undetected subtle impairments that are not evident if abilities are tested singly.[23–31] Impairment under complex conditions is particularly relevant to a military population, relating to core duty activities and participation roles.[28] Such functional assessments are recommended by practice guidance for many rehabilitation specialties[32] and are mandated by the Department of Defense's guidance for evaluation of a SM who has sustained greater than three concussions in a 12-month period, or who has sustained a concussion requiring specialty care due to the persistence of symptoms and impairments beyond the acute recovery phase.[32] Guidance from the Traumatic Brain Injury Center of Excellence (TBICoE) (i.e., "Progressive Return to Activity Following Acute Concussion/Mild TBI," "Recurrent Concussion Evaluation Card")[32] recommends standardized and validated military-specific functional assessments, but no tests have been published that are clinically feasible. Validation of such assessments would fill an existing gap in military concussion care.

The Portable Warrior Test of Tactical Agility (POWAR-TOTAL) is a performance-based exertional and dual-task assessment which requires less time, space, and technology than previous laboratory-based RTD assessments. The Assessment of Military Multitask Performance (AMMP), a test battery requiring laboratory equipment, extensive space and time, was validated by Weightman et al. and informed the development of the POWAR-TOTAL task.[33] A mobility task included in AMMP, the "Run-Roll-Aim" task (RRA)[34] and a simple working memory task, the "grid coordinate" cognitive task[33] were combined to challenge SMs in a smaller testing space with tasks that had discriminant validity in the AMMP study.[34] Visual testing was incorporated into the study as dizziness or gaze instability with rapid head or body movement are common post-concussion complaints. POWAR-TOTAL includes rapid position changes that may be provocative to the visual-vestibular system and retained externally valid components from RRA (i.e., carrying a simulated weapon, movements from training activities).[17] To examine the validity of the POWAR-TOTAL and its ability to differentiate those with concussion from their fit for duty HC peers, we conducted a cross-sectional case-control study.

METHODS

POWAR-TOTAL refined and improved upon the RRA task described previously,[33,34] removing task elements with unacceptable inter-rater reliability or that did not discriminate between those with and without concussion. Inertial sensors used in the RRA task, were retained, as hand timing using a stopwatch was not a sensitive discriminator.[34] The test sequence was simplified, so it was more quickly learned, took less space, and retained the movement components that were most challenging and discriminative based on the RRA data analysis.

The purpose of this study was to compare performance on the observational measures from the POWAR-TOTAL test between concussed ADSM (referred for physical therapy with the intent to RTD) with a peer group of fit for duty ADSM. This study was conducted at Ft. Bragg, North Carolina and at Joint Base Lewis McChord, Washington. The study received approval from the Regional Health Command-Atlantic Institutional Review Board (IRB) as well as the Madigan Army Medical Center IRB and all participants provided informed consent.

Participants

Participants included ADSM aged 18-42 who were screened to ensure that they had the medical clearance and the ability to perform the study activities. Patient participants were ADSM diagnosed with concussion ($\leq$2 years) who were initiating a course of treatment, including physical therapy, at an Intrepid Spirit Clinic (ISC). Patients had completed their physical therapy initial evaluation and were tested within the following week, prior to starting in-clinic treatment. A home exercise program may have been initiated. No effort was made to control for the physical therapy interventions, nor was timing of treatment controlled. We did not review records to determine care provided by other providers before this episode of care. We retested these individuals following this episode of care to examine responsiveness of the measures, those results will be reported in a future manuscript.

Fit for duty healthy controls (HC) were concussion free in the same time period, were on unrestricted active duty, and were eligible for deployment. To assure older ADSM in our control sample, a remote concussion history (>2 years) was allowed but only if the SM was without ongoing symptoms that required intervention for that prior concussion. Participants were recruited via large group briefings for ADSM of all ages, ranks, units, and military occupational specialties (MOS). Participants were excluded from either group if they had a medical condition that restricted moderate exertion, had

a history of major psychiatric disorder, had a history of moderate, severe, or penetrating brain injury, or had visual or hearing deficits that prevented participation in testing. Screening occurred after informed consent and prior to initiating study procedures.

Measures

In a 1-h test session intake, self-report and performance measures were completed. The intake recorded demographics (age, gender, ethnicity, education level, first language, history of ADD/ADHD, history of learning disability, and history of treatment for depression, anxiety, and combat stress), military history (service, pay grade, MOS, time in service, and deployment history), and concussion history (lifetime estimated number, most recent, prior symptoms, and for patient participants, current symptoms for which they were seeking care). A question about perceived physical readiness to be deployed to a combat zone in the next 72 h was also collected, a question of predictive value in a prior study.[34] All participants completed the Neurobehavioral Symptom Inventory (NSI) measuring symptoms associated with concussion, the Defense and Veterans Pain Rating Scale (DVPRS), and the Posttraumatic Stress Disorder Checklist DSM-5 (PCL-5). All participants also completed the POWAR test and the 8 item High-Level Mobility Assessment Test (HiMAT), a standardized assessment of mobility tasks that includes timed measures of forward and backward walking, toe walking, running, skipping, and hopping, and a distance measure of leaping.

The POWAR-TOTAL is a multiple trial high-level complex task integrating physical and cognitive components, and was preceded and followed by visual testing. Dynamic stability, working memory, dual task ability, visual stability, and tolerance to visual-vestibular provocative movements were all challenged. The motor task required running with rapid position changes while carrying a simulated weighted service weapon (Bluegun™ M4). *Visual testing:* Binocular *visual acuity* was tested using a Snellen Eye Chart. There were 11 lines on the chart ranging from 20/500 (line 1) to 20/10 (line 11) with line 8 representing 20/20 vision. Self rated *visual clarity* using an 11-point Likert Scale (0 = perfectly clear and stable, 10 = extremely blurry and/or unstable) was also recorded. Visual acuity and clarity were assessed in standing to record a baseline score and after all task trials were completed. *Cognitive testing:* Working memory was measured by asking the participant to retain an eight-character grid coordinate (e.g., Echo-Bravo 5-2-3-9-4-1), a method used by military personnel to identify operational locations. *Single task cognition:* The SM was instructed to remember the grid coordinate, provided verbally once at a rate of one character per second, in the exact sequence it was provided. After a 15-s delay (average time to complete the motor task), the SM recalled the grid coordinate. Verbatim responses were recorded and scored to allow credit for partial recall. Letters were counted as correct if recalled accurately in the correct order. Digits were counted as correct if stated in the correct first or last position or for any correct string of three digits together anywhere in the span. On the first trial, if recall was less than four characters, a second ST cognitive trial was conducted using a different letter/number sequence. The better of the two scores was recorded as the ST cognitive score (0-8). *Motor testing:* The motor component was administered as a ST beginning with the SM in prone (Fig. 1). Trials were timed by hand using a stopwatch. After a "go" signal the SM stood, ran forward and diagonally to the left, transitioned to prone, performed a combat roll to the right, transitioned back to standing, back pedaled to the starting position, side shuffled several feet to the left, ran forward and diagonally to the right, transitioned to prone, performed a combat roll left, transitioned to standing, and back pedaled to complete the trial. Timing stopped when the first foot crossed the finish line at the end of the course. The SM was instructed to perform the task as quickly and safely as possible while carrying the weapon as they normally would. Inertial sensors worn at the occiput and lumbar spine were used to record movement in a more sensitive way. Procedures and results of this analysis are described in a separate manuscript.[35] The SM performed a practice trial first, followed by a ST timed trial. A second ST trial was conducted only if some error in course navigation or task understanding occurred. *Dual task testing:* Three dual-task trials required the SM to perform the motor task while remembering a grid coordinate. No instructions were provided as to prioritization of the cognitive or motor task. For each trial a new grid coordinate was provided while in the prone start position. After the last number was provided, the examiner paused briefly before signaling "go" and the start of timing. Motor and cognitive scores were recorded. The task resulted in single task scores for cognition and motor and dual task cognitive and motor scores. Visual acuity and clarity scores were recorded prior to the POWAR test (baseline) and after its completion (final).

Statistical Analysis

Data were entered and verified using Research Electronic Data Capture 209 (REDCap), an online, password protected database. All statistical analyses were conducted using SPSS statistical software (version 22). Descriptive analyses were performed on demographic data. Data normality was checked by Kolmogorov–Smirnov test and coefficients of skewness and kurtosis. Independent t-tests were used to test for differences between groups for continuous data, categorical data were analyzed using Chi-square. Pearson correlations were used to assess the relationships of POWAR-TOTAL motor score to HiMAT scores. An exploratory logistic regression analysis was performed to determine the ability to predict self-reported readiness for physical deployment considering group status and single task motor trial time. Receiver operating characteristic curve analysis was performed to characterize

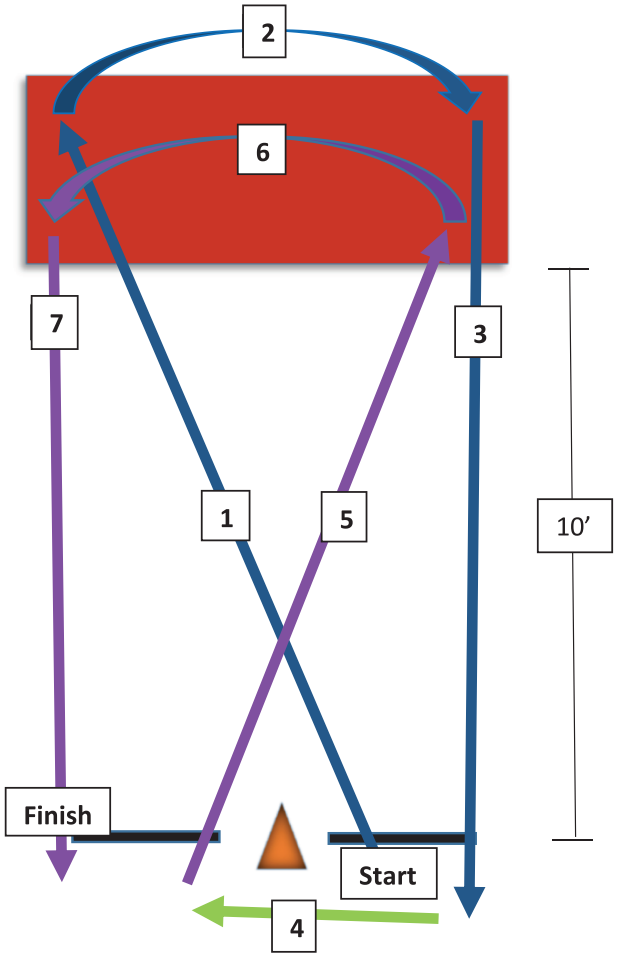

FIGURE 1. POWAR-TOTAL motor task schematic. The entire task is performed while carrying a simulated weapon, beginning in a prone position. Segments 1 and 5 require running forward to a mat and transition to prone, where a combat roll is performed (segment 2, roll to the right; segment 6, roll to the left), segments 3 and 7 require a transition to standing from the mat and backpedaling to the start/finish line.

POWAR motor performance with respect to the question of perceived readiness to be deployed as a binary dependent variable. A P value of less than 0.05 was considered statistically significant.

RESULTS

One hundred twenty four ADSM (60 HC, 64 concussed) were enrolled in the study; however, one control participant's data was excluded from the analysis due to high symptom burden, poor test performance, and extensive remote concussion history that resulted in him seeking a referral for evaluation at the ISC. The groups were well matched demographically with the exception of education level (Table I). The concussed group had significantly higher scores on the NSI, PCL-C, and DVPRS than their control peers ($P < 0.001$) demonstrating higher symptom complaints. The concussed group had significantly lower HiMAT scores than the control group ($P < 0.001$), reflecting slower performance on high level mobility tasks. The groups differed with respect to multiple variables (Table II). Those in the concussed group were more likely to have duty restrictions such as light duty, to be working outside their assigned occupational specialty, or to have physical training restrictions. They were also more likely to report that they were not physically ready to deploy in the next 72 h. The index injury for inclusion in this study was the first lifetime concussion for 22% of the concussed group, however the group had a mean 5.5 (SD 6.99) lifetime concussions. Median time from the index injury to testing was 5 months for the concussed group. In the HC group 57.6% had previously had a concussion, mean 6.43 (SD 9.45) lifetime concussions, and median time from most recent concussion to initial testing was 57 months.

While concussion may occur during a deployment, it has been reported that the majority of concussions in ADSM occur in garrison or while off duty.[1,22,36] In this sample, the concussed group was more likely to have been deployed, although the average number of prior deployments between ADSM with a history of deployment in each group did not differ significantly. The majority of our sample was recruited from Ft Bragg, where airborne operations provide additional exposures to potential injury.

TABLE I. Demographic and Self-report Variables

Measure	Fit for duty controls $n = 59$ Mean (SD)	ADSM seeking concussion care $n = 64$ Mean (SD)	P-value
Age	29.5 (6.73)	29.7 (6.98)	0.848
Time in service	7.7 (6.84)	8.5 (6.34)	0.532
Sex	n (%)	n (%)	0.575
Male	54 (93)	60 (94)	
Female	4 (7)	4 (6)	
Ethnicity			0.404
Caucasian	38 (66)	47 (74)	
African American	9 (15)	4 (6)	
Hispanic/Latino	5 (9)	7 (11)	
Other	6 (10)	6 (9)	
Education			0.041
High school	10 (17)	18 (28)	
Trade school	0 (0)	3 (6)	
Some college/ associates degree	30 (51)	34 (53)	
Bachelor's or advanced degree	19 (32)	9 (15)	
NSI (range 0-88)	7.88 (10.24)	37.97 (15.96)	<0.001
PCL-C (range 0-80)	6.63 (10.39)	28.25 (20.48)	<0.001
DVPRS (range 0-10)	1.36 (1.67)	4.36 (2.09)	<0.001
HiMAT (range 0-32)	30.63 (2.32)	22.23 (7.71)	<0.001

Abbreviations: NSI: Neurobehavioral Symptom Inventory; PCL: Posttraumatic Stress Disorder Checklist DSM-5; DVPRS: Defense and Veterans Pain Rating Scale; HiMAT: High Level Mobility Assessment Test.

TABLE II. Group Comparison: Categorical and POWAR-TOTAL Variables

Categorical variables		Fit for duty controls $n = 59$	ADSM seeking concussion care $n = 64$	X^2 *P*-value
		n (%)	*n* (%)	
History of concussion	N	25 (42.4)	0 (0)	<0.001
	Y	34 (57.6)	64 (100)	
History of deployment	N	30 (50.8)	19 (29.7)	=0.0017
	Y	29 (49.2)	45 (70.3)	
Duty restrictions	N	7 (11.9)	34 (53.1)	<0.001
	Y	52 (88.1)	30 (46.9)	
Ready to deploy	N	3 (5.1)	45 (70.3)	<0.001
	Y	56 (94.9)	19 (29.7)	
Completed all POWAR-TOTAL trials	N	0	5 (8)	0.0589
	Y	59 (100)	59 (92)	
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)

Abbreviations: ST: single task; DT: dual-task.

Known-Group Validity

Five concussed participants could not complete all POWAR-TOTAL trials due to symptom provocation that required stopping the test (2 dizziness, 2 pain, 1 headache). All control participants completed all trials, with the ability to complete the test approaching statistical significance ($P = 0.059$). The concussed participants were slower than fit for duty controls for single and dual task motor performance ($P < 0.001$, $P = 0.050$) with moderate effect sizes and were less accurate in recalling grid coordinates in both single and dual task conditions ($P < 0.001$) with moderate to large effect sizes (Table II, Figs. S1 and S2). Concussed participants reported lower visual acuity and clarity at both baseline and final timepoints compared to the control group ($P < 0.001$) with moderate to large effect sizes (Table II, Fig. S2).

Construct Validity

POWAR motor components were significantly correlated with total HiMAT scores (single task $r = 0.551$, $P < 0.01$; dual task $r = 0.409$, $P < 0.01$), supporting construct validity. Single task motor (ST-M) times were significantly correlated with each HiMAT subtask score, ranging from 0.453 to 0.661. The most significant correlation was between the HiMAT "run" subtask and S-TM ($r = 0.661$, $P < 0.01$).

Predictive Validity

The logistic regression model using ST-M performance indicated that participants in the control group were 34 times more likely to report "physical readiness to deploy" when compared to participants in the concussion group [95% CI (8.99, 128.35), $P < 0.001$]. The odds ratio for S-TM was 0.715 [95% CI (0.573, 0.893), $P = 0.003$]. With a cut-off point of 0.6, the area under the curve for this model is 0.903 [95% CI (0.850, 0.956)] making this an excellent model for prediction of self-reported physical readiness to deploy (Fig. S3).

Healthy Control Analysis

Separate analyses compared control group data for those with and without a history of concussion (Table III). Those with a history of concussion were older ($P = 0.01$), were more likely to have been deployed ($P < 0.001$), and reported higher scores on the self-report measures (NSI, DVPRS, PCL-C). There were no significant differences in HiMAT performance or on the observational POWAR-TOTAL measures, except for reports of poorer baseline and final visual clarity for those with a history of concussion.

DISCUSSION

POWAR-TOTAL motor and cognitive performance demonstrated significant differences between ADSM seeking concussion care and their HC peers, with moderate to large effect sizes. Simple hand timing, which was reliable in the AMMP version of this task but did not discriminate between groups in AMMP, **did** distinguish between groups for the POWAR task, increasing the clinical feasibility of this task. These findings are consistent with previous studies showing reduced dual-task cognitive and motor ability post-concussion

TABLE III. Fit for Duty Control Group Comparison

Measure	History of concussion $n = 35$ Mean (SD)	No history of concussion $n = 24$ Mean (SD)	p-Value
Age	31.3 (6.7)	26.8 (6.0)	0.010
Prior deployment	24 (68.65%)	5 (20.8%)	<0.001
NSI (0-88)	12.8 (11.4)	3.1 (3.7)	<0.001
DVPRS (0-10)	1.9 (1.9)	0.6 (0.9)	0.001
PCL-C (0-80)	9.8 (11.8)	2.0 (5.7)	0.001
HiMAT (0-32)	30.7 (2.1)	30.6 (2.8)	0.896
POWAR-TOTAL metrics			
ST-cognitive	6.9 (1.3)	7.0 (1.6)	0.972
DT-cognitive	6.5 (1.3)	6.1 (1.5)	0.289
ST-motor	14.1 (2.1)	13.7 (2.0)	0.566
DT-motor	13.8 (2.0)	13.7 (2.3)	0.900
1st vision line	8.3 (1.3)	8.3 (1.6)	0.993
1st vision clarity	1.8 (1.7)	0.8 (1.5)	0.019
Final vision line	8.3 (1.4)	8.3 (1.7)	0.911
Final vision clarity	2.3 (1.8)	1.1 (1.8)	0.013

with lower level skills such as standing and walking.[23–27,37] POWAR motor performance was significantly correlated with the HiMAT, supporting construct validity. Exploratory predictive validity for RTD readiness appears promising.

The POWAR-TOTAL was developed to provide rehabilitation clinicians with a more useful tool to assess RTD readiness for ADSM who sustain a concussion and receive physical therapy for their persistent symptoms and impairments, challenging known vulnerabilities that may affect higher level functional skills. The POWAR-TOTAL is proposed to supplement evaluation findings when medical providers are making RTD recommendations after a concussion, but is not a standalone assurance for soldiering skill and mastery. Symptom self-report and perception of readiness for deployment have many limitations indicating a need for valid measures to support or refute subjective reports. ADSM may exaggerate or minimize their symptoms and may over or under assess readiness for deployment. There is no psychometric measure of POWAR-TOTAL to validate effort. It is possible that an individual who does not have true impairment may under perform on the POWAR-TOTAL, but it is unlikely that an individual with true impairment will over perform. Performance based measures may have an advantage to identify SM who are truly not ready for RTD (e.g., unable to complete multiple trials of the test).

POWAR-TOTAL had a floor effect for some ADSM who were unable to complete the test, however, the test was administered during the week that a physical therapy course was initiated. Four of the five participants who could not complete the test were 4 or fewer months post injury with symptom complaints that prevented task completion. When a patient has a high symptom burden, therapy may focus on symptom management prior to initiating challenging physical activities.[38] POWAR-TOTAL provides an option for evaluation that can be accomplished in typical clinical space with minimal equipment and can be used to track performance changes over the course of treatment. A therapist may decide to use POWAR-TOTAL as a measure to gauge return to typical military training activities or for performance optimization,[38] and implement the evaluation at the appropriate time in an episode of care.

Within the fit for duty HC group, several important findings emerged. Those with a remote (>2 years) history of concussion, but reported no current concussion related difficulties and no duty or deployment limitations, had significantly higher report of symptoms associated with concussion, higher perception of post-traumatic stress, and higher overall pain levels (all $P < 0.001$), compared to those who had no history of concussion. HiMAT and POWAR-TOTAL performance did not differ between those with and without concussion history, with the exception of vision, which may have been related to age; the never-concussed group was significantly younger than the remotely concussed group. These findings suggest "functional recovery" of SMs who have sustained a concussion in the past (median 57 months post-injury) when compared to the patient group in this study. Despite reporting a modest level of concussion related symptoms, ADSMs with a remote concussion history exhibited recovery of high-level skills relevant to the military, as tested by this task. These findings support the importance of further study of ADSM who have sustained a concussion in the past but who have RTD, but may continue to demonstrate higher symptom burden than those without concussion history. Performance-based measures that are more sensitive than observational scores and timing may further clarify subtle differences undetected by observational measures.[35]

The patient participant group was limited to those who had sustained a concussion within the prior two years, which is a wide range, however, the median time post injury was 5 months. Providers at the Intrepid Spirit Centers regularly see ADSM whose most "recent" concussion was well outside the 2-year time frame, so we chose that cutoff in order to ensure sufficient recruitment to power our study. Although there are aggressive efforts by the military medical community to promote early identification of concussion and acute treatment, symptom burden and functional impairment for some ADSM with remote history of concussion continues to result in a need for military specialty care. The ability of POWAR to detect performance decrements in a post-acute group supports its potential value as a measure for ISC practice settings.

The POWAR-TOTAL task was designed to evaluate functions that are necessary for ADSM to perform no matter what their specific MOS. The main difference of POWAR-TOTAL from other previously validated concussion assessments is its ability to examine cognitive and motor abilities separately as well as in combination, more closely approximating tasks

used in typical military training scenarios and in more complex and potentially dangerous forward operations. Returning a SM to duty has unique implications and therefore must rise to a higher standard, using relevant challenges beyond those that might be applied to civilians for return to activity, school and work; or even for athletes for return to play and competition. SMs must perform at the highest level of skill due to the unique environments and conditions under which they may be required to operate, not only ensuring their own and their team's safety, as well as the safety and success of the overall mission.

Limitations

Study evaluators were not blinded to group status, this may have also introduced bias. Significantly higher education may have contributed to better control group cognitive task performance, although both groups prioritized motor performance over cognitive accuracy, as illustrated by faster run times and lower cognitive accuracy in the dual-task condition. Significantly higher levels of pain, other symptoms, or medication use in the concussed group may have degraded performance. POWAR-TOTAL does not differentiate factors that contribute to poorer performance. The impairments targeted in POWAR-TOTAL (visual-vestibular, dual task) may not have been an individual's primary complaints or focus of the physical therapy plan of care, therefore additional means of evaluation are likely to be necessary to comprehensively detect physical impairments post-concussion.

Finally, regarding the predictive validity analysis, the variable of perceived physical readiness to deploy was used as a proxy for RTD. As with all self-report information, candor of the response is subject to potential bias or inaccuracy. Given the exploratory nature of this analysis, seeking a RTD variable with higher external validity was beyond the scope of the study. Examination of the relationship of performance-based testing to actual RTD is an important area for future study.

CONCLUSION

The POWAR-TOTAL detected differences between concussed and HC ADSM based on simple observational scoring when used early in rehabilitation. The motor, cognitive, dual-task and visual components all demonstrated robust statistically significant differences between groups. Interestingly, even the single-task components of the POWAR-TOTAL discriminated between groups, perhaps due to the difficulty of the tasks, providing support for the continued development of performance-based assessments with challenging and military-specific skills.[28,33,34,39] The POWAR-TOTAL task appears to be a valid, clinically feasible method for evaluating functional skills that are highly relevant to a military population.

ACKNOWLEDGMENTS

The authors would like to thank CDR Scott Klimp, Dr. Lisa O'Block, LCDR Michael Krok, Mr. Robert Carlson, and Dr. Holly Roberts. We offer our deepest gratitude to the service members who volunteered to participate in this project, and to all those they serve with, for their courage, sacrifice, and commitment to the defense of freedom.

SUPPLEMENTARY MATERIAL

Supplementary material is available at *Military Medicine* online.

FUNDING

Support for the Portable Warrior Test of Tactical Agility study was provided by the Congressionally Directed Medical Research Program through the FY16 Joint Program Committee 8/Clinical and Rehabilitative Medicine Research Program, Psychological Health/Traumatic Brain Injury Research Program, Complex Traumatic Brain Injury Rehabilitation Research Award (award no: W81XWH-17-2-0046). The project described was supported by the National Center for Advancing Translational Sciences (NCATS), National Institutes of Health, through Grant Award Number UL1TR002489. The content is solely the responsibility of the authors and does not necessarily represent the official views of the NIH.

CONFLICT OF INTEREST STATEMENT

None declared.

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