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Affective and Cognitive Conditions are Stronger Predictors of Success with Community Reintegration than Gait and Balance Performance in Veterans with Mild Traumatic Brain Injury

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ABSTRACT

Introduction: Optimal community reintegration is an integral part of the clinical management of patients with mild traumatic brain injury. **Background/Objective:** We sought the contribution and inter-relation of such variables as balance, executive function, and affective regulation to the community reintegration of veterans with mTBI. **Methods:** We examined the statistical relationship among the above variables by conducting a series of objective evaluations to assess the balance, gait, executive function, affective regulation, and scores representing the patients' issues with community reintegration. The data were statistically analyzed for correlation and regression. **Results:** High correlation was found among scores for balance and gait, executive function and affective regulation. The first and second best predictors of success with patient's community reintegration were data representing affective regulation and cognitive impairments, respectively. However, the data for dynamic balance correlated weakly and insignificantly with scores for the three subsets of community reintegration. **Conclusions:** We revealed varying degrees of correlation among balance, executive function and affective regulation, and as they related to the community reintegration success of patients with mTBI. The strongest, intermediate and weakest predictors for these patients' success with community reintegration represented those for affective regulation, executive function, and dynamic balance and gait performance, respectively.

Keywords: Balance and gait, executive function, affective regulation, community reintegration.

1. INTRODUCTION

In the past decade, more than 220,000 American veterans have sustained traumatic brain injury (TBI) in various military operations, including those involved in Iraq and Afghanistan wars (1, 2, 3). Often these veterans present with altered executive function, affective regulation and balance, which pose major challenges to their community reintegration. Executive functions are cognitive processes that regulate our abilities such as working memory, alternating and selective attention, self-monitoring inhibition, cognitive flexibility, problem solving, organizational skills, and abstract reasoning (4). Also, affective regulation allows us to respond to ongoing demands of physical and social environment, using emotions in a manner that is individually effective and socially tolerable (5, 6, 7, 8). Functional balance is defined as a measure of sway and components of sensorimotor system that allow the brain to interpret and integrate the sensory information from our physical and social environment (9, 10). Pathological conditions affecting these functions pose challenges to the successful community re-intergeneration, including the return to work of service members with mild TBI (mTBI) (11, 12, 13).

The U.S. Department of Veterans Affairs (VA) recognizes traumatic brain injury as an important diagnosis to be addressed in returning service members. Therefore, treating veterans with mTBI and developing strategies, enabling them to successfully return to work and their community, is a high priority for Veterans Health Administration (14). Although the majority of these patients show improvement in their symptoms over time, 7.5 % of them continue to experience symptoms such as vertigo, dizziness and disturbed balance up to five years post initial injury (15, 16, 17). In addition, they may experience difficulty with performing their daily activities as a result of executive dysfunction, affective dysregulation and impaired balance secondary to diagnosed or undiagnosed neurological impairments arising from the initial mTBI (1, 5, 6, 7, 8, 11, 15, 16, 17).

The primary goal of this study was to identify the relationship among the altered balance, executive function and affective regulation in a population of American veterans, and the extent to which these variables may serve as predictors of successful community reintegration. This goal originated from our prior clinical observations, leading us to the notion that there might be an association among these variables in veterans with mTBI, and the difficulties they faced with their return to work and community integration. The study specific hypotheses were twofold:

1) There may be an association among imbalance, cognitive dysfunction and affective dysregulation in veterans with mTBI, and the person's problems with community reintegration; and, *2)* The extent of impairment of balance, cognitive and affective status in veterans with mTBI may be a good predictor of their success with community reintegration.

2. METHODS

Study Design: This is an observational, case-control study aimed at examining the relationship among balance performance, cognitive dysfunction, and affective dysregulation as they interact with each other, and as they relate to community reintegration in Veterans with mTBI. Each patient served as his/her own control, with the patients' subjective and objective information prior to participation and at baseline, respectively, being the controls. The assessment data and the statistical analyses served as the experimental findings.

Sample: We initially recruited 26 veterans (20 male [76%]; 6 female [24%]) at ages 19 to 65 years old, all of whom diagnosed with mTBI and referred to the study by physicians between September 2014 to October 2015 by the Polytrauma/TBI Clinic of Physical Medicine and Rehabilitation Service at the District of Columbia Veterans Affairs (DC VA) Medical Center, Washington, DC. The sample size was arrived at by the study statistician (D. Maron). These patients presented residual deficits in balance and apparent cognitive and affective disturbance, and were medically diagnosed with mTBI to participate voluntarily in this study. The consent and HIPPA forms were obtained from each of the participants according to VHA policy. The comprehensive evaluation electronic template with medical data for each participant was reviewed following the IRB-approved and HIPAA compliant data collection procedures. The diagnosis of mTBI was established for each patient from his/her chart review, which had also been confirmed by the referring physician.

Inclusion Criteria: Veterans with impaired balance, cognitive dysfunction and affective dysregulation were included in this study. These features were important since they are barriers to community reintegration across all ages. Consequently, the study findings were beneficial not only to the young but also the middle-aged Veterans. Every effort was made to include only medically stable patients, as confirmed by the study physician, to minimize future adverse conditions and the risk of drop outs. No patient was enrolled if he/she did not meet the inclusion and exclusion criteria or had not been recommended by the referring physicians.

Exclusion Criteria: To minimize the effect of confounders and improve sample homogeneity, we excluded the participants with these past medical histories*:* peripheral neuropathy, Parkinsonian syndromes, multiple sclerosis; bipolar, schizophrenic, seizure or psychiatric illnesses. Also, patients with missing data, i.e., those who did not complete all of the assessment tests were excluded from the study.

Subject Recruitment: The recruitment, screening, enrollment, and assessment occurred in a concurrent fashion over a one-year period (September, 2014 - October, 2015) after IRB approval of the study protocol. Patient recruitment and selection were not restricted due to race, gender, or national origin. We also attended interdisciplinary meetings regularly and communicated with the social workers and case managers to recruit potential subjects for the study. **Screening:** We employed MACE (Military Acute Concussion Evaluation) scores of 15/30 or above to ensure the participants have the cognitive ability to understand our study protocol, and therefore, participate voluntarily in the study (17). Specifically, the following tests were used for screening:

Functional gait assessment (FGA) was used as part of screening measures. FGA is a 10 item assessment test that measures balance, vestibular status and gait, and has a reliability of 80% for community dwelling outcome measure for gait and balance (18, 19). Initially, we performed standard PT evaluation of the range of motion, manual muscle testing, vestibular screening, balance, and gait assessment. We also measured the patients' sway around their center of mass by the data from sensory organization test (SOT) and static balance outcome measures, using NeuroCom (20) pressure plate and BioSensics™ system, respectively (21, 22).

BioSensics™ system was used to measure the components of gait and dynamic balance, such as double stance stride length, cadence swing and stance, and the percentage of the dynamic gait outcome measures. Finally, we tested the dynamic balance to determine the overall independent sensory motor function.

Balance and Vestibular Measures: For static balance outcome measures, we used sway data derived from SOT test on a NeuroCom™ unit and wearable sensors of a BioSensics™ system. For this purpose, the following six standing positions were used: Single, double or tandem stance with eyes either open or closed. The BioSenics™ system was also used to assess the dynamic components of gait and balance.

Executive Function: We used Frontal Systems Behavior (FrSBe) scale as the outcome measures to determine the participants' level of impaired executive function, including cognition (23, 24). This 46-item, self-reported set of scales quantify issues arising from impaired cognition, disinhibition and apathy caused by damage to the brain's frontal lobe. The operational definition of executive dysfunction is based on the clinical diagnosis made by a physician and the patient's responses to a series of standardized FrSBe questions. A total score or any of the 3 subscale scores below one standard deviation compared to the normative scale would qualify the participants' impaired executive function for inclusion in this study.

Affective Regulation: We used PCL-5 checklist to assess the presence of post-traumatic stress disorder (PTSD) symptoms. PCL-5 is a self-screening checklist to assess 20 standard symptoms of PTSD, also known as DSM-5. It is applicable to a variety of clinical purposes, including monitoring changes in patients' PTSD symptoms during and after treatment (25, 26).

Community Reintegration: We assessed the participants community reintegration status (CRIS), using data derived from injured service members method (27) as the outcome measure.

Self-perception: The self-reported Activity Based Confidence (ABC) and Dizziness Handicap Index (DHI) outcome measures were also used to determine the patients' own perception of their disability (28, 29).

Statistical Analysis: Descriptive measures of disbursement and variance were analyzed for all variables (Table 1). All data were examined for normality, and non-parametric statistics as appropriate, and alpha was set at 0.05 for all analyses (30, 31). The strength of correlation between independent and dependent variables was also examined based on a 2-tailed Pearson correlation coefficient test, using the data representing balance, executive function and affective regulation. To examine the relationship of balance performance, as measured via functional gait, and the participants' executive function and affective regulation, we also used Pearson correlation coefficient test to identify positive or negative trend among the following:

1) balance and executive function, *2)* balance and affective regulation, and *3)* executive function and affective regulation.

Further, we conducted stepwise linear regression analysis to examine the association between the indicators of static and dynamic balance, and the extent to which they influenced the community reintegration. Also, to determine whether the balance performance, executive function or affective regulation was the strongest predictor of the participants' success with community reintegration, we used multiple regression analyses to explore the continuous primary and secondary outcomes. We felt that multiple co-linearity might have existed among the independent variables. Therefore, we considered the strongest bivariate relationship analysis, where needed.

3. RESULTS

Twenty two participants, 16 male and 6 female at ages19 to 65 years old (average 44), completed all of the assessment tests. The participants had completed at least 12 years of education prior to entering the study. Overall, the correlation and regression analyses of the results demonstrated association between the indepen-

Variables	Min	Max	Mean	Std. Dev.	Variance
Gait–Mediolateral:					
DS-EO	0.22	3.43	1.01	0.73	0.53
SS-EO	0.39	6.78	2.29	1.83	3.37
BESS-TS-EO-R—>L	0.38	4.08	1.46	1.03	1.07
BESS-DS-EC	0.25	3.66	1.55	0.96	0.92
BESS-SS-EC-R-L	0.30	10.33	3.73	2.07	4.29
BESS-TS-EC-R-L	0.49	9.60	3.18	2.09	4.37
Gait–Antroposterior:					
DS –EO	0.57	7.84	1.76	1.48	2.18
SS-EO	0.87	16.01	4.00	3.17	10.04
BESS-TS-EO-R—>L	0.46	7.53	2.71	1.76	3.10
BESS-DS-EC	0.47	5.51	2.58	1.23	1.52
BESS-SS-EC-R-L	0.34	7.61	4.10	2.13	4.52
BESS-TS-EC-R-L	0.40	20.39	5.34	4.56	20.80
Gait–Sway:					
DS -EO	0.17	26.18	2.60	5.46	29.85
SS-EO	0.35	61.62	11.18	14.77	218.19
BESS-TS-EO-R—>L	0.15	24.25	4.51	5.96	35.57
BESS-DS-EC	0.12	15.90	4.48	4.14	17.10
BESS-SS-EC-R-L	0.10	78.59	16.72	16.87	284.66
BESS-TS-EC-R-L	0.20	195.71	22.18	41.05	1685.00
Cognition: FrSBe: Apathy	47.00	107.00	77.82	17.90	320.25
FrSBe: Disinhibition	41.00	109.00	72.23	18.37	337.61
FrSBe: Executive Function	55.00	111.00	80.45	13.56	183.78
Emotion: PCL-5 Total	16.00	78.00	50.00	15.19	230.70
Community Integration: CRIS: Extent of Participation	27.80	79.00	42.90	10.11	102.30
CRIS: Perceived Limitations	26.11	53.25	41.93	7.62	57.99
CRIS: Satisfaction	25.83	52.61	41.90	6.92	47.92
Other Tests: ABC Scale	35.63	91.60	63.43	12.95	167.82
DHI	18.00	88.00	58.11	19.13	365.99

Table 1. Descriptive Variables Analyses. DS = double stand; SS = single stand; TS = tandem stand; EO = eyes open; EC = eyes closed, R = right; L = left; BESS = Balance error scoring system; FrSBe = Frontal Systems Behavior test, PCL-5 = Post-traumatic stress disorder checklist (aka, DSM-5); CRIS = Community reintegration status, ABC = Activity Based Confidence; DHI = Dizziness Handicap Index

Correlation	Executive Function	Affective Regulation	Double Stance		Single Stance		Tandem Stance	
			Eyes open	Eyes closed	Eyes open	Eyes closed	Eyes open	Eyes closed
Executive Function		0.62** (0.003)	- 0.14 (0.55)	0.16 (0.48)	- 0.05 (0.81)	0.03 (0.89)	- 0.11 (0.62)	- 0.48* (0.02)
Affective Regulation	0.62** (0.003)		- 0.31 (0.17)	- 0.22 (0.34)	- 0.12 (0.61)	0.32 (0.16)	- 0.18 (0.42)	- 0.66** (0.001)

Table 2. Correlation of executive function and affective regulation with static balance. Numbers represent 2-tailed Pearson correlation coefficients. Numbers in brackets denote p-values. * = Moderate correlation; ** = Strong correlation

Correlation	Executive Function Before**			Executive Function After**		
	Apathy	Disinhibition	Cognition	Apathy	Disinhibition	Cognition
Dynamic* Balance	0.11 (0.64)	0.25 (0.25)	0.24 (0.29)	- 0.02 (0.93)	- 0.07 (0.75)	0.91 (0.03)

Table 3. Correlation between dynamic balance and executive function. * Based on FGA data; ** Executive function scores were based on FrSBe responses. Numbers represent Pearson correlation coefficients. Numbers in brackets denote "p" values.

Community Reintegration*	Executive Function**		
	Apathy	Disinhibition	Cognition
Extent of Participation CC (p-value)	- 0.345 (0.116)	- 0.217 (0.331)	- 0.470 (0.028)
Perceived Limitations CC (p-value)	- 0.298 (0.177)	- 0.222 (0.320)	- 0.580 (0.005)
Satisfaction CC (p-value)	- 0.334 (0.129)	- 0.334 (0.128)	- 0.495 (0.019)

Table 4. Correlation of community reintegration with executive function. * Based on CRIS scores; ** Based on FrSBe scores. Numbers represent Pearson correlation coefficients (CC). Numbers in brackets denote p-values.

Community Reintegration*	Affective Regulation**	
	Correlation Coef.	p-value
Extent of Participation	- 0.240	0.294
Perceived Limitations	- 0.499	0.021
Satisfaction	- 0.554	0.009

Table 5. Correlation of community reintegration with affective regulation. * Based on CRIS scores; ** Based on PCL-5 scores. Correlation Coef. = 2-tailed Pearson correlation coefficient.

dent variables: balance and gait, executive function and affective regulation versus the dependent variable, community reintegration.

Executive Function and Affective Regulation vs Static Balance: As highlighted in Table 2, there was a strong correlation between scores for executive function and affective regulation. Data for tandem stance with eyes closed correlated moderately but strongly with those for executive function and affective regulation, respectively. Data for the remaining five standing positions did not correlate significantly with scores for either executive function or affective regulation. Regardless of the statistical significance, the correlation of data for all standing positions with scores for executive function or affective regulation was consistently negative.

Executive Function vs Dynamic Balance: As shown in Table 3, the data for dynamic balance i.e., functional gait assessment (FGA), correlated weakly with those for the components of executive function before mTBI, as recalled by patients, using FrSBe tests. The data for post-mTBI demonstrated a similar trend, except for *cognition*, which correlated strongly with those for dynamic balance tests, i.e., FGA.

Community Reintegration*	Dynamic Balance**	
	Correlation Coef.	p-value
Extent of Participation	- 0.102	0.650
Perceived Limitations	- 0.025	0.9106
Satisfaction	0.058	0.798

Table 6. Correlation of community reintegration with dynamic balance. * Based on CRIS scores; ** Based on FGA data. Correlation Coef. = 2-tailed Pearson correlation coefficient.

Community Reintegration vs Executive Function: The scores for the three categories under community reintegration correlated moderately but significantly with the cognition component of executive function post-mTBI. However, the "apathy" and "disinhibition" scores did not correlate significantly with those for community reintegration (Table 4). The correlations of the components of executive function with the three subsets of community reintegration were consistently negative, regardless of the statistical significance.

Community Reintegration vs Affective Regulation: As reflected in Table 5, the scores for the perceived limitation and satisfaction under community reintegration correlated moderately but significantly with those reflecting affective regulation. The scores for the extent of participation did not correlate significantly with those for affective regulation.

Community Reintegration vs Dynamic Balance: The scores for the subsets under community reintegra-

Variable	Parameter Estimate	Standard Error	t-value	p-value	95% confidence interval Lower bound	Upper Bound
Intercept	54.499	4.343	12.55	<0.0001		
PCL-5*	-0.241	0.083	-2.90	0.0092	-0.413	0.747

Table 7. Regression analysis of the Predictors of Community Reintegration Satisfaction. *PCL-5 = Post-traumatic stress disorder checklist. Other predictors used for the regression analysis are: FrSBe total score (after); FrSBe Apathy; FrSBe: Disinhibition; FrSBe: Executive Function; FrSBe Apathy (before); Functional gait assessment (FGA) scores.

tion correlated weakly and insignificantly with data for dynamic balance in patients with mTBI (Table 6).

Predictors of Community Reintegration Satisfaction: Stepwise linear regression analysis was performed to identify the best predictors of the patients' satisfaction with their community reintegration activities, as represented by CRIS scores. This regression model, which includes PCL-5 as the only predictive variable, was statistically significant at the $p < 0.009$, accounting for 27% of the variance in the CRIS scores. The PCL-5 parameters indicated that for every unit increase in the scores there was a -0.24 unit decrease in the CRIS scores. None of the other regression models and the respective variables significantly increased variance and were, therefore, not considered. Assumption of model fit, error normality, error equality of variance, and error independence were assessed and no violations were detected. When one outliner was detected, it reflected less than 5% of the sample, which was not the result of data entry and was, therefore, included in the analysis.

Using the above regression model, we examined the three CRIS outcomes and the ABC data versus the data for affective regulation (PCL-5), executive function (FrS-Be) and dynamic balance (FGA). The analysis indicated that the best predictor of satisfaction with community reintegration in mTBI patients was the level of affective regulation. The second and third predictors were the scores for executive function and dynamic balance, respectively (Table 7).

4. DISCUSSION

An evidence-based plan for the rehabilitation of patients with TBI should be based on reliable and objective assessment data derived from various sensory input, such as functional balance and gait, executive function and affective regulation. Further, an ideal rehabilitation plan should lead the patient to a successful community reintegration. Aimed at improving upon the commonly used clinical assessment protocols, this study was conducted to examine the relationship of static and dynamic balance with other clinically relevant, sensory inputs such as executive function and affective regulation in patients with mTBI. The study findings and recommendations may improve upon the clinical assessment significantly and provide an objective basis for designing evaluation protocols for monitoring the patients as they progress through the rehabilitation program.

Executive Function and Affective Regulation vs Balance: The strong correlations between the scores for executive function and affective regulation (Table 2), and the negative correlation with static and dynamic balance (Tables 2 & 3) suggest that these variables are inter-dependent. We believe the examination of these variables should receive priority in the clinical assessment of patients with mTBI. Also, the strong negative correlation between affective regulation and tandem stance with eyes closed (Table 2) suggests that this position is the most sensitive as it relates to static balance, and that the other five positions are not as conclusive. As evident by data in Tables 2 and 3, a similar argument may be made for examining executive function, especially the *cognition* component, when assessing static or dynamic balance in these patients. Further, the inter-relationship among the above three variables may help predict the status of any one of them when the status of the other two is known.

Notably, the statistical relationships among the above variables, as reflected in Tables 2 and 3, are being reported by this study for the first time, since such information has not been reported previously by others, especially in veterans with mTBI. Uncovering of the above findings may also necessitate seeking the consultation of a clinical psychologist to review the status of the patient's affective regulation and make recommendation toward the management.

Community Reintegration vs Executive Function, Affective Regulation & Balance:

Support for the significance of examining the *cognition* component of the executive function in the clinical assessment of patients with mTBI came from the negative correlation of this variable with those for the three subsets of community reintegration (Table 4). Conversely, the *apathy* and *disinhibition* components did not provide conclusive information as they relate to community reintegration. Also, the observation that the scores for affective regulation correlated significantly with two out of three subsets of community reintegration (Table 5) emphasizes the role of emotion and its contribution to the patients' success with community activities. These findings suggest that methodical examination of the status of both cognitive and affective aspects should be given a high priority when assessing the challenges that patients with mTBI are facing.

On the other hand, scores for none of the subsets of community reintegration correlated with those for dynamic balance and gait (Table 6). This is surprising, since clinicians traditionally would give much attention to the assessment and treatment of imbalance in patients with mTBI in order to overcome the difficulties and challenges they have routinely with their community activities. The results of this study emphasize the importance and inclusion of executive function and affective regulation in addition to the balance performance in the clinical assessment and reassessment of patients with mTBI and similar conditions.

Predictors of Success with Community Reintegration: Consistent with the correlation findings, results from our regression analysis (Table 7) demonstrated that the first and second best predictor of satisfaction with community reintegration in patients with mTBI were the integrity of affective regulation and executive function. The findings suggest that the clinical assessment of the patients' affective and cognitive state must be emphasized. The fact that dynamic balance was found to be the least predictor of success with community reintegration suggests that overly emphasizing balance performance while ignoring or under-estimating the affective and cognitive states is not a sound strategy for the assessment of patients with mTBI. Therefore, we encourage clinicians to consider applying our evidence-based methods to the assessment of patients with mTBI and similar conditions.

Study Limitations & Recommendation: This was an observational study; therefore, the results may not be generalizable to patients with other neurological conditions. The patients' age range used in this study might have influenced the results for static and dynamic balance and gait, since age is linked to gait kinematics and its cycle. Also, we used subjective self-report information, such as FrSBe, ABC, CRIS and PCL-5 scores, to uncover the levels of patients' various disabilities associated with mTBI. Obviously, there were no other objective substitutions to quantify these aspects of disability. In future studies, we recommend conducting large and randomized clinical trials to examine the role of executive function, affective regulation and balance performance in facilitating the integration of patients with mTBI in the community.

5. CONCLUSIONS

This study examined the relationship among static and dynamic balance, executive function and affective regulation, and provided a predictive outcome model for the assessment of the challenges facing mTBI patients with a focus on community reintegration. Specifically, this study achieved the following findings applicable to the assessment of veterans with mTBI:

Strong correlation existed between scores for executive function and affective regulation.

Tandem stance with eyes closed was the most sensitive position to test static balance and it correlated with scores for both executive function and affective regulation.

Data for dynamic balance correlated strongly with those for the *cognition* component of executive function.

Scores for community reintegration correlated moderately with those for the *cognition* component of executive function and affective regulation, but not with dynamic balance.

Scores for affective regulation, executive function, and dynamic balance and gait were the strong, intermediate and weak predictors, respectively, of patients' success with community reintegration.

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- **Authors' Contributions:** Dr. Leland and Dr. Libin conceived, designed the study and selected the tests. Dr. Scholten coordinated the patient recruitment and supervised the study. Dr. Leland conducted the study, performed the tests and wrote the first draft of the paper. Ms. Mathis compiled the data and test scores. Mr. Maron and Mr. Kaveh B. Kelarestaghi recommended the statistical models and performed the correlation and regression analyses. Dr. Bakhshi and Dr. Tavakol wrote the drafts of the manuscript, and revised the final version of the paper.

REFERENCES

1. Hoge CW, Castro CA, Messer SC et al. Combat duty in Iraq and Afghanistan, mental health problems, and barriers to care. N Engl J Med. 2004; 351(1): 13-22. doi:10.1056/NEJMoa040603.
2. Zeitzer MB, Brooks JM. In the line of fire: traumatic brain injury among Iraq War veterans. J Am Assoc Occup Health Nurses. 2008; 56(8): 347-53, quiz 354-355.
3. Scherer MR, Weightman MM, Radomski MV. et al. Returning service members to duty following mild traumatic brain injury: Exploring the use of dual-task and multitask assessment methods. Phys Ther. 2013; 93(9): 1254-67. doi:10.2522/ptj.20120143.
4. Coppin AK, Shumway-Cook A, Saczynski JS. et al. Association of executive function and performance of dual-task physical tests among older adults: analyses from the In Chianti study. Age Ageing. 2006; 35(6): 619-24. doi:10.1093/ageing/afl107.
5. Yardley L, Redfern MS. Psychological factors influencing recovery from balance disorders. J Anxiety Disord. 2001; 15(1-2): 107-19.
6. Yardley L, Papo D, Bronstein A. et al. Attentional demands of continuously monitoring orientation using vestibular information. Neuropsychologia. 2002; 40(4): 373-83.
7. Balaban CD. Projections from the parabrachial nucleus to the vestibular nuclei: potential substrates for autonomic and limbic influences on vestibular responses. Brain Res. 2004; 996(1): 126-37.
8. Smith PF, Darlington CL. Personality changes in patients with vestibular dysfunction. Front Hum Neurosci. 2013; 7: 678. doi:10.3389/fnhum.2013.00678.
9. Herdman S. In: Vestibular Rehabilitation. Philadelphia, FA Davis. 2013; 714. Available at: http://search.ebsiohost.com/login.aspx?direct=true&scope=site&db=nlebk&db=nlabk&AN=191 (Accessed June 4, 2014).
10. Shumway-Cook A, Woollacott MH. Motor Control: Translating Research into Clinical Practice. 3rd ed. Philadelphia, PA. Lippincot Williamns & Wilkins, 2007.
11. Lew HLM, Otis JD, Tun C, Kerns RD. et al. Prevalence of chronic pain, posttraumatic stress disorder, and persistent postconcussive symptoms in OIF/OEF veterans: polytrauma clinical triad. J Rehabil Res Dev. 2009; 46(6): 697-702.
12. Leland A, Tavakol K, Scholten J, Mathis D, Maron D, Bkhshi S. The Role of Dual Tasking in the Assessment of Dait, Cognition and Community Reintegration of Veterans with Mild Traumatic Brain Injury.. Mater Sociomed. 2017 Dec; 29(4): 248-53. doi: 10.5455/msm.2017.29.248-253.
13. Sayer NA, Rettmann NA, Carlson KF. et al. Veterans with history of mild traumatic brain injury and posttraumatic stress disorder: challenges from provider perspective. J Rehabil Res Dev. 2009b; 46(6): 703-16.
14. Veterans Affairs, Definition of TBI. http://veterans.vermont.gov/healthcare/tbi.
15. Sheridan PL, Solomont J, Kowall N. et al. Influence of executive function on locomotor function: Divided attention increases gait variability in Alzheimer's disease. J Am Geriatr Soc. 2003; 51(11): 1633-7.
16. Bagalman E. Congressional Research Service Health care

for Veterans, traumatic Brain Injury. 2015. Available online: https://www.fas.org/sgp/crs/misc/R40941.pdf (accessed March 9, 2015).
17. Stone ME, Safadjou S, Farber B. et al. Utility of the Military Acute Concussion Evaluation as a screening tool for mild traumatic brain injury in a civilian trauma population. J Trauma Acute Care Surg. 2015; 79(1): 147-51.
18. Wrisley DM, Kumar NA. Functional gait assessment: concurrent, discriminative and predictive validity in community-dwelling older adults. Phys Ther. 2010; 90(5): 761-73. doi:10.2522/ptj.20090069.
19. Leddy AL, Crowner BE, Earhart GM. Functional gait assessment and balance evaluation system test: reliability, validity, sensitivity, and specificity for identifying individuals with Parkinson disease who fall. Phys Ther. 2011; 91(1): 102-13. doi:10.2522/ptj.20100113.
20. Pickett TC, Radfar-Baublitz LS, McDonald SD. et al. Objectively assessing balance deficits after TBI: Role of computerized posturography. J Rehabil Res Dev. 2007; 44(7): 983-90.
21. O'Sullivan M, Blake C, Cunningham C. et al. Correlation of accelerometry with clinical balance tests in older fallers and non-fallers. Age Ageing. 2009; 38(3): 308-13. doi:10.1093/ageing/afp009.
22. Rine RM, Roberts D, Corbin BA. et al. New portable tool to screen vestibular and visual function–National Institutes of Health Toolbox initiative. J Rehabil Res Dev. 2012; 49(2): 209-220.
23. Lane-Brown AT, Tate RL. Measuring apathy after traumatic brain injury: Psychometric properties of the Apathy Evaluation Scale and the Frontal Systems Behavior Scale. Brain Inj. 2009; 23(13-14): 999-1007. doi:10.3109/02699050903379347.
24. Carvalho JO, Ready RE, Malloy P. et al. Confirmatory factor analysis of the Frontal Systems Behavior Scale (FrSBe). Assessment. 2013; 20(5): 632-41. doi:10.1177/1073191113492845.
25. Asmundson, GJ, Frombach I, McQuaid J. et al. Dimensionality of posttraumatic stress symptoms: a confirmatory factor analysis of DSM-IV symptom clusters and other symptom models. Behav Res Ther. 2000; 38(2): 203-14.
26. PTSTD: National Center for PTSTD. PTSD PCL-5. 2017. Also available online at: https://www.ptsd.va.gov/professional/assessment/adult-sr/ptsd-checklist.asp (Accessed March 12, 2017).
27. Resnik L, Plow M, Jette A. Development of CRIS: Measure of Community Re-integration of Injured Service Members. J Rehabil Res Dev. 2009; 46(4): 469-80.
28. Powell LE, Myers AM. The Activities-specific Balance Confidence (ABC) Scale. J Gerontol A Biol Sci Med Sci. 1995; 50A(1): M28-M34.
29. Tamber AL, Wilhelmesen KT, Stand LI. Measurement Properties of Dizziness Handicap Inventory by Cross section and Longitudinal Design. Health and Quality of Life Outcomes. 2009; 7: 101.
30. Gallin JI, Ognibene FP. ScienceDirect (Online service). Principles and Practice of Clinical Research. London: Elsevier/Academic Press. 2012. Available online at: http://www.sciencedirect.com/science/book/9780123821676. (Accessed July 22, 2014).
31. Domholdt, E. Rehabilitation Research: Principles and Applications. St. Louis, Mo. Elsevier Saunders. 2005: 17-28.