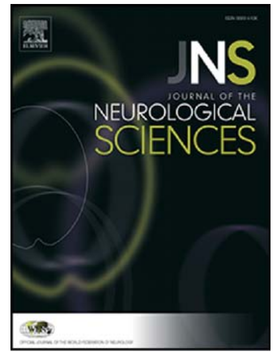
Accepted Manuscript



Assessment of the King-Devick® (KD) test for screening acute mTBI/concussion in warfighters

David V. Walsh OD, PhD, José E. Capó-Aponte OD, PhD, Thomas Beltran BS, Wesley R. Cole PhD, Ashley Ballard OD, Joseph Y. Dumayas MS

PII: S0022-510X(16)30569-X
DOI: doi: 10.1016/j.jns.2016.09.014
Reference: JNS 14808

To appear in: *Journal of the Neurological Sciences*

Received date: 30 May 2016
Revised date: 8 September 2016
Accepted date: 8 September 2016

Please cite this article as: David V. Walsh, José E. Capó-Aponte, Thomas Beltran, Wesley R. Cole, Ashley Ballard, Joseph Y. Dumayas, Assessment of the King-Devick® (KD) test for screening acute mTBI/concussion in warfighters, *Journal of the Neurological Sciences* (2016), doi: 10.1016/j.jns.2016.09.014

Pages: 13
Words: 2,156
Tables: 3
Figures: 3
References: 25

Contact: LTC David V. Walsh
Email: david.v.walsh.mil@mail.mil
Phone number: 334-255-6991
Guarantor: LTC Walsh

Assessment of the King-Devick® (KD) test for screening acute mTBI/concussion in Warfighters

David V. Walsh, OD, PhD[1]
José E. Capó-Aponte, OD, PhD[2]
Thomas Beltran, BS[3]
Wesley R. Cole, PhD[4]
Ashley Ballard, OD[2]
Joseph Y. Dumayas, MS[2]

[1]Vision Protection and Performance Division, U.S. Army Aeromedical Research Laboratory, 6901 Farrel Rd, Fort Rucker, AL 36362

[2]Department of Optometry, Womack Army Medical Center, 2817 Reilly Rd; Stop A, Fort Bragg, NC 28310

[3]Department of Clinical Investigation, Womack Army Medical Center, 2817 Reilly Rd; Stop A, Fort Bragg, NC 28310

[4]Department of Brain Injury Medicine/Defense and Veterans Brain Injury Center, Womack Army Medical Center, 2817 Reilly Rd; Stop A, Fort Bragg, NC 28310

Keywords: *King-Devick (KD) test, saccades, mild Traumatic Brain Injury (mTBI), military*

Abstract

OBJECTIVES: The Department of Defense reported that 344,030 cases of traumatic brain injury (TBI) were clinically confirmed from 2000 to 2015, with mild TBI (mTBI) accounting for 82.3 percent of all cases. Unfortunately, warfighters with TBI are often identified only when moderate or severe head injuries have occurred, leaving more subtle mTBI cases undiagnosed. This study aims to identify and validate an eye-movement visual test for screening acute mTBI.

METHODS: Two-hundred active duty military personnel were recruited to perform the King-Devick® (KD) test. Subjects were equally divided into two groups: those with diagnosed acute mTBI (≤72 hours) and age-matched controls. The KD test was administered twice for test-retest reliability, and the outcome measure was total cumulative time to complete each test.

RESULTS: The mTBI group had approximately 36 percent mean slower performance time with significant differences between the groups ($p < 0.001$) in both tests. There were significant differences between the two KD test administrations in each group, however, a strong correlation was observed between each test administration.

CONCLUSIONS: Significant differences in KD test performance were seen between the acute mTBI and control groups. The results suggest the KD test can be utilized for screening acute mTBI. A validated and rapidly administered mTBI screening test with results that are easily interpreted by providers is essential in making return-to-duty decisions in the injured warfighter.

1. Introduction

The Department of Defense reported that 344,030 cases of traumatic brain injury (TBI) were clinically confirmed from 2000 to 2015, with mild TBI (mTBI) accounting for 82.3 percent of all cases (1). Warfighters who experienced mild head impacts producing subtler injuries are harder to diagnose versus those warfighters who have suffered moderate to severe head injuries. Some of the confounders in identifying post-concussive problems include the overlap of symptoms in co-morbid disorders such as post-traumatic stress disorder (PTSD)(8, 20), and the difficulty in diagnosing self-reported symptoms to the health provider (19).

A recently convened military mTBI diagnostics workshop emphasized the lack of biomarkers or diagnostic tests for mTBI (15, 19). Consequently, there is a quest for objective markers (e.g., protein, imaging, cognitive, neurosensory) to diagnose warfighters with mTBI/concussion (15). In combat or training scenarios, warfighters having cognitive and neurosensory difficulties triggered by an mTBI event can put lives and safety in danger when operating in environments that depend on optimal situational awareness and perception of the surrounding environment. Having a rapid and accurate diagnostic tool in the management and treatment of mTBI generally improves an individual's prognosis for neurological recovery (10, 17, 18) and safe return-to-duty (RTD) (9, 11, 25). Valid diagnostic tests are particularly important in theater to assist deployed clinicians in making accurate determination of RTD or evacuation from theater. Returning a warfighter with a possible head injury back to duty prior to recovery puts the warfighter at a greater risk of disability if they suffer further brain trauma (22).

Seven of the twelve cranial nerves, along with approximately 30 percent of the brain (23, 24) , are involved in visual processing; therefore, it should be no surprise that oculomotor/saccadic eye movements are commonly affected in individuals with mTBI/concussion (2-4, 7). Saccades are rapid movements of the eyes as they shift fixation from one point to another. The King-Devick® (KD) test is a rapid, easy-to-administer eye movement test developed in 1976, and used to assess dyslexia and other learning disabilities (5). In recent studies, the KD test has been examined as a potential screening tool for assessment of concussions in sports such as boxing, football, hockey, soccer, and rugby (5, 6, 12, 13). All of these studies have demonstrated promising results in assessing pre- and post-concussive differences which suggests the KD test could potentially be used to identify warfighters who have suffered mTBI/concussion. Finally, test–retest reliability for the KD test has been examined in previous studies and shown to be high, with intraclass correlations of 0.97 (95% confidence interval [CI] 0.90, 1.0) between measurements in the absence of concussion (5, 6).

The purpose of this study was to assess an "off-the-shelf" eye movement test, the King-Devick®, in those who have experienced an acute mTBI/concussion. The results of this study may validate the use of an easy-to-administer and interpret eye movement test as a post-mTBI screening tool which can be added to a range of concussion assessment tools in assisting health-care providers with RTD decisions in warfighters.

2. Methods

2.1. Subjects

Two-hundred active duty military personnel were recruited for the study. The subjects were divided into two groups: those with diagnosed acute mTBI (≤72 hours; n = 100) and age-matched controls (n = 100). The diagnosis of mTBI was made by primary care providers at a military Concussion Care Clinic based on a Glasgow Coma Scale score from 13 to 15, normal structural brain imaging, if available, and meeting at least one of the following criteria: any alteration of mental state; loss of consciousness though not exceeding 30 min; posttraumatic amnesia of no more than 24 hours. Inclusion criteria for the control group were any active-duty service member with no history of mTBI/concussion. The study was approved by the Womack Army Medical Center Institutional Review Board and the US Army Medical Research and Materiel Command (USAMRMC), Human Research Protection Office. Each subject was provided written informed consent before participating in the study.

2.2. Equipment & Procedures

The KD test used to evaluate saccadic eye-movement performance is shown in **Fig. 1**. The KD test is based on the measurement of the speed of rapid number naming and involves reading aloud a series of single-digit numbers from left to right on three progressively more difficult test cards. Standardized instructions provided with the instrument were used. The KD test was administered in a well-lit room at a normal reading distance (i.e., 40 cm) with the subject's best near-visual correction, if needed (e.g., glasses, contact lenses). To begin, a demonstration card was shown to the subject with explicit instructions on how to perform the test. The subject was instructed to read the numbers as fast as possible without making errors. If error(s) were made, and the subject returned to correct the error(s), then the error(s) were not counted. The subjects were instructed not to use their hands or fingers on the card to assist during the testing. Speed and accuracy were emphasized throughout the test and the cumulative times were recorded by the tester. The cumulative time was measured with a stopwatch, and the test was administered twice with an approximately 5-minute gap between each test administration.

2.3. Statistical Analyses

Means and standard deviations were calculated for each group with cumulative time to complete each KD test being the outcome measure. A Shapiro-Wilk test for normality was performed on all data, and indicated the presence of non-normal distributions. Thus, in each group, a Wilcoxon Matched-Pairs Signed-Rank Test was used to confirm test-retest reliability by comparing the KD test results from time 1 to time 2. A Mann-Whitney U was performed to compare control vs. mTBI group performance. Since non-parametric statistical analyses were performed on the groups' data, medians (Mdn) and Interquartile Ranges (IQR) were also reported. Statistical significance was set at $p < 0.05$, and statistical analyses were performed with the Statistical Package for Social Sciences (SPSS) 20.0 software and GraphPad Prism 6 (GraphPad Software, San Diego, CA).

3. Results

3.1. Demographics & Mechanisms of Injury

Demographics information of both groups is shown in **Table I.** The mean age of both groups was 26.31 ± 5.83. In both groups, subjects were predominantly male (87% mTBI vs. 79% controls), Caucasian, and most were junior enlisted (E1-E4) Army soldiers. The Mechanisms of Injury (MOI) of the acute mTBI group are shown in **Table II**. Out of the 100 mTBI subjects, a little more than two-thirds were injured due to parachute jump. Each of the remaining MOI reported (Blunt Force, Combatives, Fall, Motor Vehicle Accident, Sports/Recreational Activities, Other) accounted for less than 10% of the injuries in this sample population. None of the subjects suffered from a blast-induced mTBI.

3.2. King-Devick test

Descriptive statistics are shown in **Table III**. In test 1, the mean cumulative test times for the mTBI and control groups were 62.01 ± 19.91 sec (95 % CI [58.06, 65.96]) and 45.65 ± 8.31 sec (95 % CI [44.00, 47.30]), respectively. In test 2, the mean cumulative test time for the mTBI and control groups were 58.57 ± 19.71 sec (95 % CI [54.64, 62.47]) and 43.40 ± 8.10.sec (95 % CI [41.80,45.01]), respectively. The Wilcoxon Matched-Pairs Signed-Rank Test revealed a significance difference between the two test administrations (time 1 versus time 2) in both groups (controls: $z = -5.90$, $p < 0.001$; mTBI: $z = -5.32$, $p < 0.001$). Due to the significant differences between the two tests administered to both study groups, a correlation analysis was performed. Spearman's ρ's were 0.918 ($p < 0.001$) and 0.949 ($p < 0.001$) for repeated tests for the control and mTBI groups, respectively **(Fig 2)**.

For test time 1, a Mann-Whitney U Test revealed significant differences between the mTBI (Mdn = 58.29, IQR = 49.41 - 72.97 sec) and control (Mdn = 44.93, IQR = 39.21 - 50.49 sec) groups, $U = 2168$, $p = < 0.001$ **(Fig 3a)**. Similarly, in time 2, a significant difference was found between the mTBI (Mdn = 53.49, IQR = 45.70 – 70.94 sec) and control (Mdn = 42.80, IQR = 37.13 - 47.97) groups, $U = 2380$, $p = < 0.001$ **(Fig 3b)**. Finally, the mTBI mean cumulative reading times were approximately 36% slower in both administration times 1 and 2.

4. Discussion

The primary aim of the present study was to investigate the potential use of the KD test, an eye-movement screening test, as a diagnostic tool for warfighters who may have suffered an mTBI/concussion event. Results from the study demonstrated significant differences in KD test performance between the acute mTBI and age-matched control groups. The KD test showed a little more than one-third slower reading time in the mTBI group. For both groups, there was a statistically significant difference between the two test administration times, though the test-retest correlations were strong, indicating solid test-retest reliability in both the mTBI and control groups.

Numerous previous studies have validated the KD test on athletes, though with study subjects receiving baseline assessments and serving as their own controls (5, 6, 12, 13). Prior KD test studies utilizing separate control groups have shown significant differences between the controls and experimental groups; however, their experimental groups consisted of patients with Parkinson's disease (14) and multiple sclerosis (16), not acute mTBI as seen in the present study. But a recent KD test study on subjects recruited from an emergency department did include acute (within 72 hours) mTBI patients and controls (21). Their study did not find significant differences in KD test performance between the mTBI and control groups. This finding was contrary to previous sports-related concussions studies, and Silverberg et al. primary argument concerning the different results was their patients' mean assessment time was 31 hours post-injury, whereas, the data collected in the other sports-related injury studies referenced here was within 60 minutes post-injury. Silverberg et al. theorized "sensitivity of the K-D may dissipate rapidly over the hours to days following an mTBI." In the present study, the subjects' mean assessment time was 2.02 days post-injury; therefore, the average post-injury was more comparable to the Silverberg et al. study. The differences in results between the studies could be due to the approximately 3.4 times greater sample size in the present study (200 vs. 59).

A limitation of the present study was no baseline KD testing was performed on the two groups of subjects. The KD test decision matrix in screening head injuries is based upon differences in baseline and post-injury KD times of the injured individuals. However, the study's significant result between the groups does strongly suggest that baseline testing should be performed on warfighters prior to exposure to combat or training environments.

Finally, there are two drawbacks to the KD card test. First, a confounding variable with test results is the reading speed is controlled by the subject. This confounder may produce false positive or false negative results in soldiers. To reduce this issue, the KD test should not be used at as a stand-alone screening test for mTBI events. Other screening tests, preferably objective, should be used in combination with the KD test when determining RTD. Second, the KD card test is that it does not provide information on what the eyes or visual system are doing while performing the test. To address this limitation, KD test technology has advanced with automated testing, and an automated KD test with eye tracking integrated is currently undergoing test-retest validity at US Army Aeromedical Research Laboratory in a separate study. However, a disadvantage of such an automated test is that it has a larger physical "footprint" (compared to KD test card), and thus may have difficulties being used as a screening device in deployment settings. The ideal screening device would be developed into smaller device such as a smartphone or tablet. With ever-advancing technology at the fingertips of front-line providers, having a quick mTBI assessment tool can not only help make rapid screening decisions, but also give eye-movement/attention information to higher echelons of care that may be helpful for any potential rehabilitation treatments on the brain-injured warfighter.

5. Conclusion

Traumatic brain injury, and especially mTBI, is an ongoing concern among the military medical community and operational commanders. Premature RTD places warfighters at greater risk of short-and long-term disability if they suffer additional concussive brain trauma. Results of the present study indicate the KD test shows promise as an additional screening tool for mTBI. However, due to intrasubject performance variability that can impact subjective test results, we recommend the KD test be utilized as a supplementary screening tool in those who have suffered an mTBI event. In addition, having pre-injury KD data will allow a more precise determination; therefore, we recommend the KD test be included as a baseline test for all warfighters prior to exposure to risk of mTBI/concussion. Having a validated, rapid, easy-to-assess mTBI brain screening test can assist frontline providers in making the RTD decision to send the warfighter back to the "fight", or to a higher echelon of care for more comprehensive tests.

Acknowledgement

This research was funded by the Military Operational Medicine Research Program of the US Army Medical Research and Materiel Command (USAMRMC), and FY13 Department of Defense Army Rapid Innovation Fund Research Program of the Office of the Congressionally Directed Medical Research Programs (CDMRP) under contract No. W81XWH-14-C-0048. This research was conducted with support from the Geneva Foundation as well as the Defense and Veterans Brain Injury Center (DVBIC) and staffing support from General Dynamics Information Technology.

Disclaimer

The views, opinions, and/or findings contained in this report are those of the author(s) and should not be construed as an official Department of the Army position, policy or decision unless so designated by other documentation. I, or any of the co-authors, have no conflict of interest to report.

References

1. Defense and Veterans Brain Injury Center (DVBIC), DoD Worldwide Numbers for TBI. 2015. http://www.dvbic.org/dod-worldwide-numbers-tbi.
2. Brahm KD, Wilgenburg HM, Kirby J, Ingalla S, Chang CY, Goodrich GL. Visual impairment and dysfunction in combat-injured servicemembers with traumatic brain injury. Optometry and vision science : official publication of the American Academy of Optometry. 2009;86(7):817-25. doi: 10.1097/OPX.0b013e3181adff2d. PubMed PMID: 19521270.
3. Capo-Aponte JE, Tarbett AK, Urosevich TG, Temme LA, Sanghera NK, Kalich ME. Effectiveness of computerized oculomotor vision screening in a military population: pilot study. Journal of rehabilitation research and development. 2012;49(9):1377-98. PubMed PMID: 23408219.
4. Capo-Aponte JE, Urosevich TG, Temme LA, Tarbett AK, Sanghera NK. Visual dysfunctions and symptoms during the subacute stage of blast-induced mild traumatic brain injury. Military medicine. 2012;177(7):804-13. PubMed PMID: 22808887.
5. Galetta KM, Barrett J, Allen M, Madda F, Delicata D, Tennant AT, et al. The King-Devick test as a determinant of head trauma and concussion in boxers and MMA fighters. Neurology. 2011;76(17):1456-62. doi: 10.1212/WNL.0b013e31821184c9. PubMed PMID: 21288984; PubMed Central PMCID: PMC3087467.
6. Galetta KM, Brandes LE, Maki K, Dziemianowicz MS, Laudano E, Allen M, et al. The King-Devick test and sports-related concussion: study of a rapid visual screening tool in a collegiate cohort. Journal of the neurological sciences. 2011;309(1-2):34-9. doi: 10.1016/j.jns.2011.07.039. PubMed PMID: 21849171.
7. Goodrich GL, Kirby J, Cockerham G, Ingalla SP, Lew HL. Visual function in patients of a polytrauma rehabilitation center: A descriptive study. Journal of rehabilitation research and development. 2007;44(7):929-36. PubMed PMID: 18075950.
8. Hoge CW, McGurk D, Thomas JL, Cox AL, Engel CC, Castro CA. Mild traumatic brain injury in U.S. Soldiers returning from Iraq. The New England journal of medicine. 2008;358(5):453-63. doi: 10.1056/NEJMoa072972. PubMed PMID: 18234750.
9. Iaccarino MA, Bhatnagar S, Zafonte R. Rehabilitation after traumatic brain injury. Handbook of clinical neurology. 2015;127:411-22. doi: 10.1016/B978-0-444-52892-6.00026-X. PubMed PMID: 25702231.
10. Katz DI, Alexander MP. Traumatic brain injury. Predicting course of recovery and outcome for patients admitted to rehabilitation. Archives of neurology. 1994;51(7):661-70. PubMed PMID: 8018038.
11. Khan F, Baguley IJ, Cameron ID. 4: Rehabilitation after traumatic brain injury. The Medical journal of Australia. 2003;178(6):290-5. PubMed PMID: 12633489.
12. King D, Gissane C, Hume PA, Flaws M. The King-Devick test was useful in management of concussion in amateur rugby union and rugby league in New Zealand. Journal of the neurological sciences. 2015;351(1-2):58-64. doi: 10.1016/j.jns.2015.02.035. PubMed PMID: 25748294.
13. King D, Hume P, Gissane C, Clark T. Use of the King-Devick test for sideline concussion screening in junior rugby league. Journal of the neurological sciences. 2015;357(1-2):75-9. doi: 10.1016/j.jns.2015.06.069. PubMed PMID: 26152829.
14. Lin TP, Adler CH, Hentz JG, Balcer LJ, Galetta SL, Devick S. Slowing of number naming speed by King-Devick test in Parkinson's disease. Parkinsonism & related disorders. 2014;20(2):226-9. doi: 10.1016/j.parkreldis.2013.10.009. PubMed PMID: 24269283; PubMed Central PMCID: PMC3946616.
15. Marion DW, Curley KC, Schwab K, Hicks RR, m TBIDW. Proceedings of the military mTBI Diagnostics Workshop, St. Pete Beach, August 2010. Journal of neurotrauma. 2011;28(4):517-26. doi: 10.1089/neu.2010.1638. PubMed PMID: 21265587.
16. Moster S, Wilson JA, Galetta SL, Balcer LJ. The King-Devick (K-D) test of rapid eye movements: a bedside correlate of disability and quality of life in MS. Journal of the neurological sciences. 2014;343(1-2):105-9. doi: 10.1016/j.jns.2014.05.047. PubMed PMID: 24954088.

17. Novack TA, Bush BA, Meythaler JM, Canupp K. Outcome after traumatic brain injury: pathway analysis of contributions from premorbid, injury severity, and recovery variables. Archives of physical medicine and rehabilitation. 2001;82(3):300-5. doi: 10.1053/apmr.2001.18222. PubMed PMID: 11245749.
18. Povlishock JT, Katz DI. Update of neuropathology and neurological recovery after traumatic brain injury. The Journal of head trauma rehabilitation. 2005;20(1):76-94. PubMed PMID: 15668572.
19. Schmid KE, Tortella FC. The diagnosis of traumatic brain injury on the battlefield. Frontiers in neurology. 2012;3:90. doi: 10.3389/fneur.2012.00090. PubMed PMID: 22701447; PubMed Central PMCID: PMC3373009.
20. Schneiderman AI, Braver ER, Kang HK. Understanding sequelae of injury mechanisms and mild traumatic brain injury incurred during the conflicts in Iraq and Afghanistan: persistent postconcussive symptoms and posttraumatic stress disorder. American journal of epidemiology. 2008;167(12):1446-52. doi: 10.1093/aje/kwn068. PubMed PMID: 18424429.
21. Silverberg ND, Luoto TM, Ohman J, Iverson GL. Assessment of mild traumatic brain injury with the King-Devick Test in an emergency department sample. Brain injury. 2014;28(12):1590-3. doi: 10.3109/02699052.2014.943287. PubMed PMID: 25093537.
22. Slobounov S, Slobounov E, Sebastianelli W, Cao C, Newell K. Differential rate of recovery in athletes after first and second concussion episodes. Neurosurgery. 2007;61(2):338-44; discussion 44. doi: 10.1227/01.NEU.0000280001.03578.FF. PubMed PMID: 17762746.
23. Van Essen DC. Organization of visual areas in macaque and human cerebral cortex. In: Chalupa LM, Werner JS, editors. The visual neurosciences. 1. Cambridge, MA: MIT Press; 2004. p. 507-21.
24. Van Essen DC, Drury HA. Structural and functional analyses of human cerebral cortex using a surface-based atlas. The Journal of neuroscience : the official journal of the Society for Neuroscience. 1997;17(18):7079-102. PubMed PMID: 9278543.
25. Vandiver VL, Johnson J, Christofero-Snider C. Supporting employment for adults with acquired brain injury: a conceptual model. The Journal of head trauma rehabilitation. 2003;18(5):457-63. PubMed PMID: 12973275.

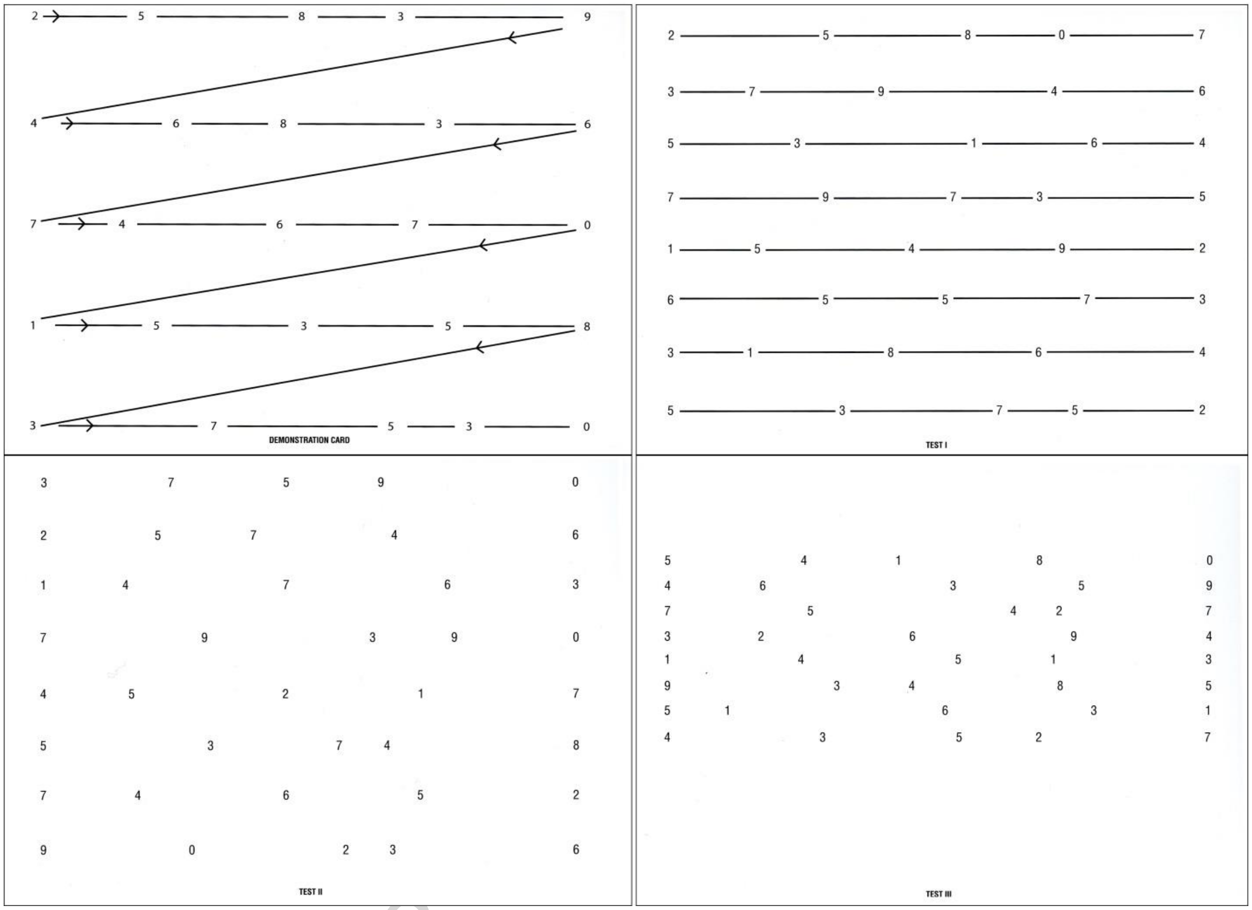


Fig 1. King-Devick cards. The first card (top left) is the demonstration card, and subsequent cards are tests I, II, and III.

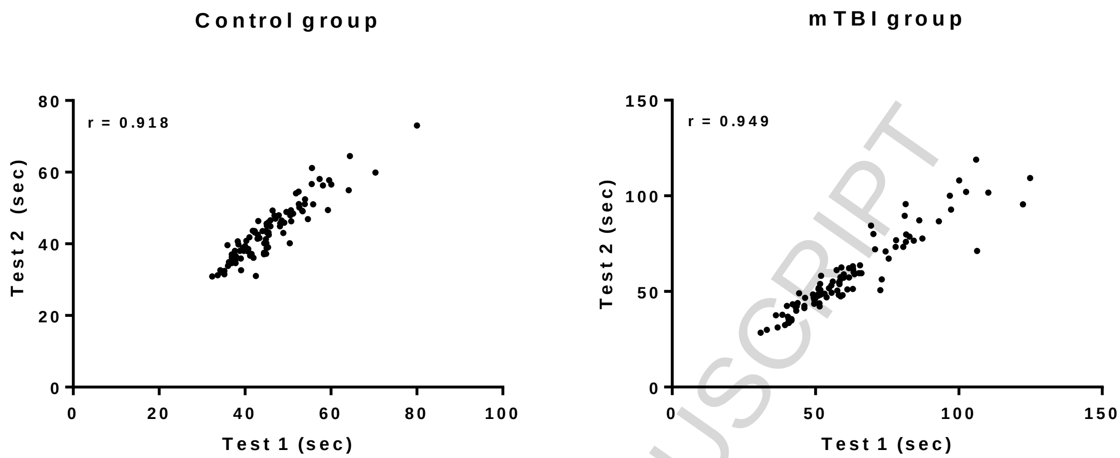


Fig 2. Correlation graphs of KD test-retest reliability in Control (left) and mTBI (right) groups**.** Spearman's ρ's were 0.918 ($p < 0.001$) and 0.949 ($p < 0.001$) for repeated tests for the control and mTBI groups, respectively

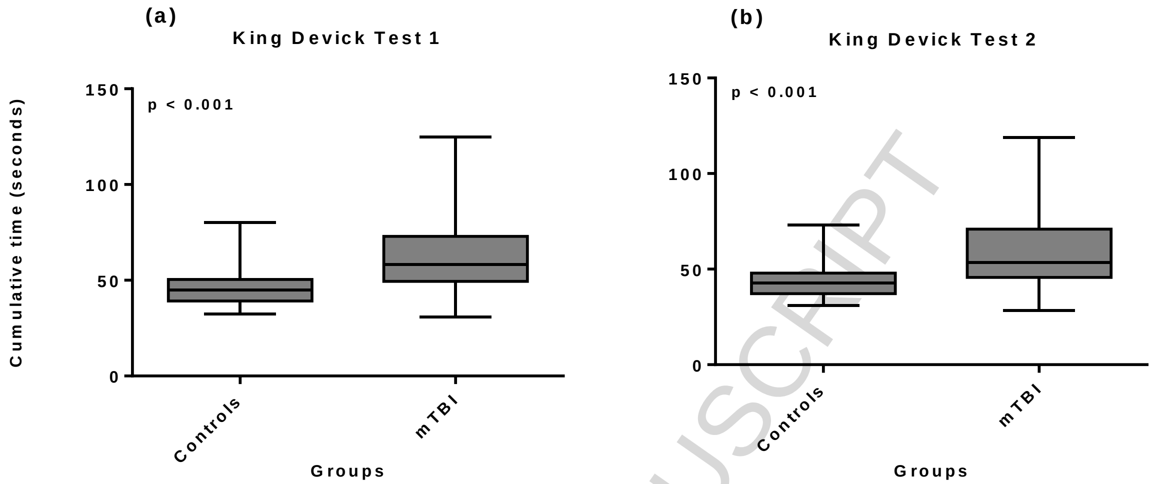


Fig 3. Box-and-Whisker Plots of (a) King-Devick Test 1 controls and acute mTBI data and (b) King-Devick Test 2 controls and acute mTBI data. The length of the box is the Interquartile Range (25-75%) with the middle line the median value of the data. The "whiskers" extending from the box represents the maximum and minimum range of the data. Significant differences between the controls and mTBI groups were seen in both test 1 and test 2 ($p < 0.001$)

Table I. Demographics

	mTBI (n=100)	Controls (n=100)
Age (years ± SD)	26.31 ± 5.83	26.31 ± 5.83
Sex (%)		
Males	87	79
Females	13	21
Branch		
Army	99	97
Marines	1	0
Navy	0	1
Air Force	0	2
Military Rank (%)		
E1-E4	62	54
E5-E6	25	17
E-7-E9	3	2
CW2-CW3	2	2
O1-O5	8	25
Ethnicity (%)		
Caucasian	60	58
African- American	14	18
American-Indian	3	1
Hispanic	14	13
Asian	3	6
Other	6	4

SD = Standard Deviation

Table II. Mechanisms of Injury

	Percent (%)
Blunt Force	5
Combative Training	2
Fall	7
Parachute Jump	69
Motor Vehicle Accident	6
Sports/Recreational Activities	5
Other	6

Table III. Descriptive Statistics

	mTBI		Controls	
	Mean ± SD	Median (IQR)	Mean ± SD	Median (IQR)
Test 1 (sec)	62.01 ± 19.91	58.29 (49.41 - 72.97)	45.65 ± 8.31	44.93 (39.21 - 50.49)
Test 2 (sec)	58.57 ± 19.71	53.49 (45.70 – 70.94)	43.40± 8.10	42.80 (37.13 - 47.97)

sec = seconds; SD = standard deviation; IQR = Interquartile Range

Highlights

- King-Devick® (KD) test on Army warfighters studied as screening tool
- Significant KD cumulative time differences between acute mTBI and control groups.
- Strong test-retest reliability in KD tests in both groups.
- Results suggest acquiring KD baseline tests prior to deployment/training.