# Validity and Reliability of Select Neurocognitive Tests of the C3 Logix Concussion Assessment Battery

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Context: Appropriate management of sport-related concussion relies on the clinical examination, while objective measurements are also recommended. The C3 Logix (C3) application offers a suite of concussion tests including neurocognitive tests that represent touch-screen adaptations of gold-standard paper-pencil tests. We were unable to identify published studies that established validity or reliability of the iPad versions of these neurocognitive tests. Objective: To assess the concurrent validity and one-week test-retest reliability of Trails A (TA), Trails B (TB), and Symbol Digit Modality Test (SDMT) available through C3. Design: Repeated-measures. Setting: Controlled laboratory. Participants: 38 healthy NCAA athletes (20 females, 18 males; age=20.08±1.44 years, height=166±18.5cm, mass=71.3±12.6kg). Interventions: Participants completed two test sessions (S1, S2), one week apart. Test sessions included administration of C3TA, C3TB, C3SDMT, and analogous paper-pencil tests. The order of test administration was randomized in two ways: whether C3 or paper-pencil tests would be taken first and whether Trails A/B or SDMT test would be taken first. Testing order was consistent between sessions with a five-minute break between C3 and paper-pencil tests. Main Outcome Measures: Independent variables included time to completion (seconds) for TA and TB and number of correctly matched pairs for SDMT. The dependent variable was the test session. Validity was assessed using Pearson correlations comparing the results of C3 and paper-pencil tests. One-week reliability was assessed using Intraclass Correlation Coefficients (ICC) comparing scores earned on C3 during week one and week two. Student T-tests were calculated to determine practice effects between sessions. Results: C3TA times (S1=17.51±3.92, S2=15.81±3.38) demonstrated weak correlation (r=.0.122 p=0.472) compared to paper-pencil times (S1=17.20±3.92, S2=15.57±3.61). C3TB times (S1=35.41±6.77, S2=29.90±6.30) showed a moderate correlation (r=.519, p=0.001) when compared to the paper-pencil test (S1=40.04±9.08, S2=33.96±7.15). C3SDMT matched pairs (session 1: 70.51±9.17, session 2: 74.11±10.65) demonstrated a very strong correlation (r=.715, p<0.01) with paper-pencil results (S1=68.41±8.09, S2=74.41±10.01). One-week test-retest reliability was moderate to strong for C3TA, ($ICC_{(2,1)}$=0.543, 95% CI [0.113-0.765] ,C3TB ($ICC_{(2,1)}$=0.862, 95% CI [0.732-0.929]), and C3SDMT tests ($ICC_{(2,1)}$=0.904, 95% CI [0.814-0.951]. Student t-tests showed a significant difference between test session one and two for all tests (p<0.05). Conclusions: Assessment of C3 Logix neurocognitive tests shows mixed support for their concurrent validity. Further testing will need to be conducted to construct validity. C3TB and SDMT tests demonstrated a strong correlation to their paper-pencil analogs, while C3TA provided poor concurrent validity. Reliability of the tests over the one-week period was moderate for C3TA and C3TB, and excellent for SDMT. Clinicians should be aware of the learning effect between session one and two, and mindful of the lack of memory tests within C3 Logix when making return to play decisions for concussed athletes. Word Count: 437