Relative Value of Dual-Task Screening Tests for College Football Injury Risk Assessment

Madalene A. Greene, MS, ATC; Kelly E. Ormond, MS, ATC; Gary B. Wilkerson, EdD, ATC; Shellie N. Acocello, PhD, ATC

THE UNIVERSITY of TENNESSEE UT CHATTANOOGA

BACKGROUND AND PURPOSE

- College football presents high risk for recurrent musculoskeletal injuries, progressive dysfunction, and disability[1]
  - Unrecognized persisting effects of previous injuries may increase susceptibility to re-injury and chronic symptoms[2]
- Emerging evidence suggests neurocognitive factors play a key role in maintenance of dynamic segmental stability[3]
  - Dual-task screening tests may be necessary for identification of subtle deficiencies that elevate injury risk[4]
- Modifiable factors such as postural balance, peripheral vision, and reaction time (RT) may be important to assess[5]
  - High exposure to game conditions is a well-known risk factor that may magnify effects of suboptimal capabilities[6]
- The purpose of this study was to assess the potential value of simultaneous imposition of cognitive and motor challenges for estimation of injury risk among college football players

PARTICIPANTS AND PROCEDURES

- 66 NCAA Division I-FCS football players available during summer conditioning assed prior to first pre-season practice
  - 20.1 ±1.3 years, 187.65 ±5.59 cm, 105.54 ±20.77 kg
- Single-leg balance assessed for 30 s, with and without verbal responses to flanker displays on a laptop screen (Figure 1)
  - Postural sway quantified by HUMAC Balance System (CSMI Solutions, Inc., Stoughton, MA) for both extremities
  - 4 possible flanker 5-arrow displays presented for 750-ms (5 of each possible set); <<<<<, >>>>>, <<><<, >><>>
    - Center of pressure (COP) values for right and left extremities averaged for data analysis
- Visuomotor performance assessed with and without verbal responses to 20 1-s flanker displays on LCD screen
  - Responses quantified by Dynavision D2™ system (Dynavision International, West Chester, OH); 60-s tests (Figure 2)
    - Proactive mode – target buttons illuminated until hit (Average RT represented in ms)
    - Proactive mode + Flanker – simultaneous verbal responses to 5-arrow flanker displays on LCD screen
    - Reactive mode – target buttons must be hit within 1 s, while simultaneously reading scrolling text on LCD screen
- Electronic documentation system used for injury surveillance throughout pre-season practices and 13-game season
  - Injury defined as any core or lower extremity (Core/LE) sprain or strain that required evaluation and treatment
- Receiver operating characteristic analysis used to establish cut-point for binary classification of cases
  - Cross-tabulation analysis performed to assess association between binary classification and injury occurrence
  - Logistic regression analysis used to derive multivariable model linking screening test results to injury occurrence
    - 95% Credible Low Estimate (CLE_{95}) for each OR value derived from lower limit of 90% confidence interval
  - Prediction model derived from logistic regression analysis evaluated by time-to-event Cox regression analysis

RESULTS

- Univariable analysis results for binary categorizations of performance values and player attributes presented in Table 1
  - Variables that failed to demonstrate discernable cut-points marked with asterisks
  - Single-leg balance center of pressure (COP) values slightly improved or unchanged with concurrent flanker test
    - Missing COP Average Velocity (single task) values imputed for 7 cases to permit inclusion in multivariable analysis
  - Visuomotor performance values demonstrated good discriminatory power both with and without concurrent flanker test
    - Proactive mode Outer/Inner RT calculated as Ring 4-5 Average RT / Ring1-3 Average RT
    - Proactive+Flanker Outer Efficiency Index (OEI) calculated as Ring 4-5 Average RT / Response Accuracy
      - OEI represents speed / accuracy trade-off (Ring 4-5 Average RT adjusted by adding penalty for errors)
- Logistic regression model included Starter Status (OR_{Adj}=7.74; CLE_{95}=2.33) and OEI ≥ 1013 ms (OR_{Adj}=3.57; CLE_{95}=1.03)
  - Proactive+Flanker OEI (dual-task) retained; Proactive Outer/Inner RT (single-task) excluded from final model
    - Model χ^2 (2) = 12.13; p=.002; Hosmer & Lemeshow χ^2 (2) = 0.62; p=.734; Nagelkerke R^2 =.255
      - Cascaded decision tree for 2-Factor model presented in Figure 3
- Time-to-event Cox regression analysis included Starter Status and OEI; effect of OEI adjusted for Starter Status (Figure 4)
  - Model χ^2 (2) = 10.54; p=.005; Starter Status (HR_{Adj}=5.29; CLE_{95}=1.83); OEI ≥ 1013 ms (HR_{Adj}=2.80; CLE_{95}=0.97)

Table 1.

Variable	Cut-Point	Odds Ratio	CLE_{95}	Sensitivity	Specificity
Starter Status versus Non-Starter Status	Starter	6.74	2.10	80	63
Concussion History	Yes	3.18	1.15	47	78
Dynavision Proactive - Outer/Inner RT	≥ 1.44	4.39	1.59	60	75
Dynavision Proactive+Flanker - Outer/Inner RT	*	*	*	*	*
Dynavision Proactive+Flanker - Response Accuracy	≤ 0.98	2.75	1.02	60	65
Dynavision Proactive+Flanker - Outer Efficiency Index	≥ 1013	2.80	0.88	80	41
Dynavision Reactive+Text - Outer/Inner Hits	*	*	*	*	*
Center of Pressure Med-Lat Movement Std Dev	*	*	*	*	*
Center of Pressure Med-Lat Movement Std Dev+Flanker	≥ .271	3.33	1.14	43	82
Center of Pressure Average Velocity	≥ 1.48	3.18	1.15	47	78
Center of Pressure Average Velocity+Flanker	≥ 1.41	2.06	0.75	50	67
Center of Pressure Max Deviation	*	*	*	*	*
Center of Pressure Max Deviation+Flanker	*	*	*	*	*
Center of Pressure Path Length	≥ 40.87	1.77	0.67	53	61
Center of Pressure Path Length+Flanker	≥ 39.57	1.98	0.74	60	57

Figure 1

Figure 2

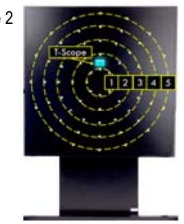


Figure 3

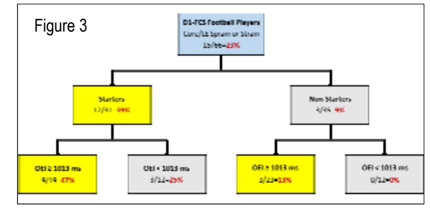
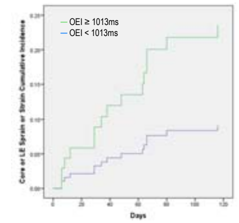


Figure 4



CLINICAL RELEVANCE

- High exposure to game conditions (Starter Status) demonstrated strongest association with Core/LE injury
  - With adjustment for Starter Status, dual-task OEI demonstrated strongest predictive power among measures
  - Starters with OEI ≥ 1013 ms had greater injury incidence than Non-Starters, and players with OEI < 1013 ms
    - Logistic regression model validated by time-to-event for players with OEI ≥ 1013 ms, adjusted for Starter Status
- Research is needed to assess the potential benefit of dual-task training for injury risk reduction among college football players who demonstrate suboptimal postural balance, visuomotor RT, and/or neurocognition test results

REFERENCES

1. Westermann RW, et al. Increasing lower extremity injury rates across the 2009-2010 to 2014-2015 seasons of National Collegiate Athletic Association football. *Am J Sports Med.* 2016;44(12):3230-3236.
2. Williams JZ, et al. Epidemiological patterns of initial and subsequent injuries in collegiate football athletes. *Am J Sports Med.* 2017; DOI: 10.1177/0363546516685317.
3. Herman DC, Barth JT. Drop-jump landing varies with baseline neurocognition: implications for anterior cruciate ligament injury risk and prevention. *Am J Sports Med.* 2016;44(9):2347-2353.
4. Negahban H, et al. Attentional demands of postural control during single-leg stance in patients with anterior cruciate ligament reconstruction. *Neurosci Lett.* 2013;556:118-123.
5. Clark JF, et al. Analysis of central and peripheral vision reaction times in patients with postconcussion visual dysfunction. *Clin J Sport Med.* 2017; DOI: 10.1097/JSM.0000000000000381.
6. Shankar PR, et al. Epidemiology of high school and collegiate football injuries in the United States, 2005-2006. *Am J Sports Med.* 2007;35(8):1295-1303.