Interrelationships among Factors Associated with Injury Risk among College Football Players

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BACKGROUND AND PURPOSE

- Football players sustain an estimated 1.2 million injuries per year, ~ 50% being sprains and strains[1]
- Reaction time (RT) is an important component of neuromuscular responsiveness and injury susceptibility
  - Slow RT has been associated with core and lower extremity (Core/LE) sprains and strains[2]
- Visuomotor RT may represent a somewhat different performance capability from neurocognitive RT
  - Complex motor response to visual stimulus vs. simple motor response (e.g., mouse click) to cognitive challenge
- Other important factors may include postural stability, anthropometric characteristics, and previous injury[3]
- The purpose of this study was to identify pre-participation characteristics that correspond to elevated core and lower extremity injury risk among college football players

PARTICIPANT CHARACTERISTICS AND PROCEDURES

- 89 NCAA Division I-FCS football athletes: Mass101.11 ±18.82 kg, Height 1.85 ± .06 m
- Potential injury predictors quantified prior to first practice session (some athletes unavailable for every test)
  - Visuomotor RT (VMRT) quantified by LED display board (Dynavision International, West Chester, OH)
    - Proactive test mode; 60-s test, 3 trials
  - Composite neurocognitive RT (NCRT) values derived from computerized test (ImPACT, Pittsburgh, PA)
  - Unilateral postural stability quantified by electronic tablet application (Sway Balance, Sway Medical, Tulsa, OK)
    - 60-s test of ability to minimize postural sway with 45˚ knee flexion and 2.5 cm of heel elevation
      - Standard deviation of rate of change in body mass acceleration (m/s^3) within each plane of motion
      - Anterior-Posterior (A-P), Medial-Lateral (M-L), and Superior-Inferior (S-I)
- Estimated mass moment of inertia (MMOI) and body mass index (BMI) derived from height and weight values
- History (Hx) of previous Core/LE sprain or strain within the past 2 years derived from medical records
- Electronic injury documentation system used for injury surveillance throughout sport season
  - Injury defined as acute Core/LE sprain or strain requiring evaluation and treatment, within 2 categories:
    1) Any degree of activity modification (partial restriction or complete restriction of sport-related activity)
    2) Complete restriction of activity for ≥ 1 practice session or game (time-loss)
- Data analysis procedures for assessment of association between potential predictors and injury occurrence
  - Receiver operating characteristic (ROC) analysis used to identify cut-points for dichotomization of variables
  - Logistic regression analyses utilized to develop prediction models
  - Cox regression analyses utilized to assess the hazard imposed by risk factors in relation to exposure time

RESULTS

- Univariable analyses indentified factors associated with injury occurrence for the 2 injury definitions (Tables 1 & 2)
  - VMRT demonstrated strong association with Core/LE injury occurrence (both definitions)
    - Missing data for 37 cases prohibited VMRT inclusion in multivariable prediction models
- Logistic regression analyses identified best predictor sets for both injury definitions (Tables 3-6)
  - Starter, Core/LE Hx, Sway A-P included in 3-Factor prediction model for all Core/LE sprains and strains (Table 7)
    - Group mean value for Sway A-P used to compensate for 6 cases of missing data
  - Concussion Hx and Core/LE Hx included in 2-Factor prediction models for Time-Loss Core/LE sprains and strains
    - Both factors positive yielded high specificity, but low sensitivity (Table 8)
    - Either factor or both factors positive yielded high sensitivity, but low specificity (Table 9)
- Cumulative hazard for high-risk vs. low-risk players differed over the course of the season (Figures 1-3)

Table 1 Core/LE Sprains & Strains

Predictor	n	Cut-Point	Odds Ratio	*P*-value
Sway A-P	89	.024	4.75	.006
VMRT (ms)	52	743	3.60	.037
Core/LE Hx	89	−/+	3.10	.009
Concussion Hx	89	−/+	2.48	.065
Starter	89	−/+	2.44	.028
NCRT (ms)	86	655	2.00	.136

*** No association with injury occurrence**

Table 2 Time-Loss Core/LE Sprains & Strains

Predictor	n	Cut-Point	Odds Ratio	*P*-value
Core/LE Hx	89	−/+	24.76	<.001
VMRT (ms)	52	743	3.93	.045
Concussion Hx	89	−/+	3.74	.012
Starter	89	−/+	1.66	.201
Sway A-P*	89	-	-	-
NCRT (ms)*	86	-	-	-

Table 3 Core/LE Sprains & Strains

Predictor	Cut-Point	Odds Ratio	Hazard Ratio
Sway A-P	.240	9.53*	5.68
Core/LE Hx	−/+	4.08*	3.07
Starter	−/+	3.58*	2.21
3-Factor Model	≥ 2	4.99	3.46

*** Logistic regression multivariable adjusted OR**

Table 4 Time-Loss Core/LE Sprains & Strains

Predictor	Cut-Point	Odds Ratio	Hazard Ratio
Core/LE Hx	−/+	21.58	12.69
Concussion Hx	−/+	1.68	1.67
2- Factor Model	≥ 1	20.04	12.84
2- Factor Model	Both +	5.93	3.91

Table 5 Core/LE Sprains & Strains

Risk Factors	Injury	No Injury	Incidence
0	0	6	0.0%
1	9	25	26.5%
2	18	19	48.6%
3	11	1	91.7%
Total	38	51	42.7%

Table 6 Time-Loss Core/LE Sprains & Strains

Risk Factors	Injury	No Injury	Incidence
0	2	37	5.1%
1	15	18	45.5%
2	11	6	64.7%
Total	28	61	31.5%

Table 7

3-Factor Model		
Factors	Injury	No Injury
≥ 2	29	20
0 or 1	9	31
Total	38	51

Fisher's exact p <.001

Sensitivity 76% Specificity 61%

OR = 4.99

(90% CI: 2.28 – 10.95)

Table 8

2-Factor Time-Loss Model		
Factors	Injury	No Injury
Both +	11	6
0 or 1	17	55
Total	28	61

Fisher's exact p = .002

Sensitivity 39% Specificity 90%

OR = 5.93

(90% CI: 2.29 – 15.36)

Table 9

2-Factor Time-Loss Model		
Factors	Injury	No Injury
≥ 1	26	24
0	2	37
Total	28	61

Fisher's exact p <.001

Sensitivity 93% Specificity 61%

OR = 20.04

(90% CI: 5.56 – 72.20)

Figure 1

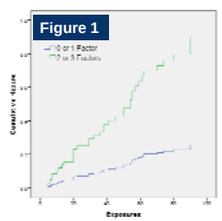


Figure 2

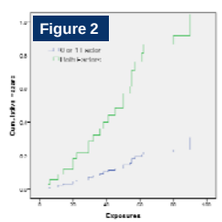
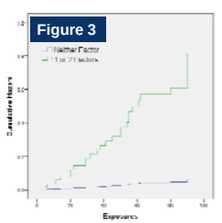


Figure 3



CLINICAL RELEVANCE

- Pre-season screening of various attributes can quantify the injury risk level of individual college football players
  - Core/LE sprain or strain was 5 X more likely among players who exhibited any 2 of 3 risk factors
  - Time-Loss Core/LE sprain or strain was 20 X more likely among players who exhibited either 1 of 2 risk factors
- High-risk players exhibited greater injury hazard than low-risk players over the course of the 19-week season
  - Greater number of injuries sustained earlier in season among high-risk vs. low-risk players
- History of concussion and/or Core/LE sprain or strain may relate to slow VMRT and/or impaired postural stability
  - Individualized training that targets deficiencies in neuromuscular responsiveness may reduce injury risk

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2. Wilkerson GB. Neurocognitive reaction time predicts lower extremity sprains and strains. *Int J Athl Ther Train.* 2012;17:4-9.
3. Zazulak BT, et al. Deficits in neuromuscular control of the trunk predict knee injury risk: a prospective biomechanical-epidemiologic study. *Am J Sports Med.* 2007;35:1123-1130.