Prediction of Core and Lower Extremity Injuries among High School Football Players

Hillary Dreyfus, MS, ATC, Ryan Ross, DPT, MS, ATC, Gary B. Wilkerson, EdD, ATC, Marisa A. Colston, PhD, ATC

THE UNIVERSITY of TENNESSEE UT CHATTANOOGA

BACKGROUND AND PURPOSE

- Over 50% of all injuries sustained by NCAA athletes from 1988 to 2004 involved the lower extremities (LE)[1]
- Poor neuromuscular control[2] and rapid fatigue[3] of the core muscles are associated with elevated risk for LE injury
- Self-reported history of LE injury has been shown to be a strong predictor of subsequent LE injury[4,5]
- The Y-Balance Test measures postural balance and mobility, which has been related to risk for LE injury[6]
- Multivariable prediction models are needed to identify high-risk athletes through pre-participation screening
- The purpose of this study was to identify pre-participation screening measures that demonstrate a substantial association with subsequent core or lower extremity (CLE) sprain or strain among high school football players

PARTICIPANTS AND PROCEDURES

- Participants were 61 high school football players (15.4±1.2 years; 180.15 cm ± 8.63 cm; 80.31 ±15.07 kg)
- Pre-participation screening procedures:
  - Sports Fitness Index (SFI) used to quantify persisting effects of previous injuries
  - Self-reported inventory of injuries sustained during previous 12-month period acquired
  - Body Mass Index (BMI) and estimated Mass Moment of Inertia (MMOI) calculated
  - Horizontal Trunk Hold (HTH) time to failure used as an indicator of core muscle endurance (Figure 1)
  - Unilateral Vertical Jump (UVJ) assessed by instrumented mat (Probotics Just Jump, Huntsville, AL; Figure 2)
  - Y-Balance anterior reach (Y-AR) distance (Functional Movement Systems, Chatham, VA; Figure 3)
    - Y-AR distance represented as percent of leg length (%LL: anterior superior iliac spine to tibial malleolus)
  - Ankle inversion strength (INV) measured by hand-held dynamometer (Jtech Medical, Midvale, UT; Figure 4)
    - Percent difference (%Diff) between dominant and non-dominant calculated for UVJ, Y-AR, and INV
- Injury documentation: combination of injury records maintained by athletic trainer and post-season self-reporting
- Analyses performed to assess associations between screening measures and injury
  - Retrospective injury definition: CLE sprain or strain that resulted in sport time loss
    - Quantified persisting effects of time-loss injuries sustained during previous 12 months
  - Prospective injury definition: CLE sprain or strain during season that required evaluation and treatment
    - Estimated pre-participation risk status used to predict subsequent injury during season
- Data analysis methods:
  - Receiver operating characteristic (ROC) analyses identified cut-points for binary classifications of risk status
    - Cut-points derived from both retrospective (previous injury) and prospective (season injury) data
  - Cross-tabulation analyses used to assess univariable associations between screening measures and injury
    - Accuracy of prospective injury prediction using retrospectively derived cut-points assessed
  - Logistic regression analysis used to identify the strongest set of predictor variables
    - Accuracy of retrospectively developed model compared to that of prospectively developed model

RESULTS

- Logistic regression analyses identified best predictor sets for previous injury and subsequent injury during season
  - BMI, MMOI, and Starter status failed to demonstrate association with prior or subsequent CLE injury
    - 3-Factor model: SFI, Y-AR%Diff, and HTH (Table 1, Figures 5-7)
      - Cut-points derived from ROC analyses of variable associations with previous injury
        - Previous injury, ≥2 of 3 positive factors: χ^2_1 =4.35; p=0.34; OR= 3.67; 90% CI: 1.27-10.57
          - Model identified 85% of athletes who had experienced previous injury (22/26) and ruled out 40% (14/35)
        - Subsequent injury, ≥2 of 3 positive factors: χ^2_1 =4.78; p=0.26; OR= 5.23; 90% CI: 1.38-19.90
          - Model identified 90% of athletes who sustained injury during season (17/19) and ruled out 38% (16/42)
    - 5-Factor model: SFI, Y-AR%Diff, Y-AR%LL, INV%Diff, and UVJ%Diff (Table 2, Figure 8)
      - Cut-points derived from ROC analyses of variable associations with injuries sustained during season
        - ≥4 positive factors: χ^2_1 =11.70; p=.001; OR= 8.22; 90% CI: 2.77-24.43
          - 5-Factor model only identified 53% of athletes who sustained injury (10/19), but ruled out 88% (37/42)
- 3-Factor retrospective and 5-Factor prospective models performed similarly for injury prediction (Tables 3 & 4)

Figure 1

Figure 2

Figure 3

Figure 4

Table 1

3-Factor Model									
		Previous Injury				Season Injury			
Factor	**Cut**	**Sensitivity**	**Specificity**	**OR**	**Exp(B)**	**Sensitivity**	**Specificity**	**OR**	**Exp(B)**
SFI	≤ 88	.89	.37	4.53	4.42	.84	.31	2.39	1.82
Y-AR%Diff	≥ 2.4	.85	.31	2.52	1.40	.90	.31	3.81	2.92
HTH (s)	≤ 24	.39	.77	2.11	2.23	.37	.74	1.64	1.45
Factors +	**≥ 2**	**.85**	**.40**	**3.67**	**-**	**.90**	**.38**	**5.23**	**-**

Figure 5

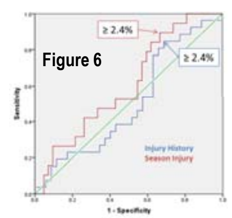

Figure 6

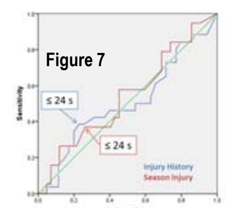

Figure 7

Table 2

5-Factor Model					
Factor	**Cut-Point**	**Sensitivity**	**Specificity**	**OR**	**Exp(B)**
INV%Diff	≥ 19%	.79	.49	3.57	5.19
Y-AR%Diff	≥ 2.4%	.90	.34	4.41	3.59
SFI	≤ 88	.84	.31	2.39	3.16
Y-AR%LL	≤ 56%	.58	.71	3.32	2.65
UVJ%Diff	≥ 10%	.37	.78	2.07	2.39
Factors +	**≥4**	**.53**	**.88**	**8.22**	**-**

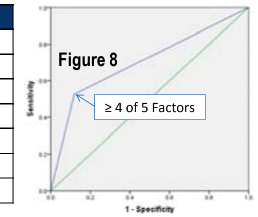

Figure 8

Table 3

3-Factor Model – Retrospective Cut-Points			
Factors	**Injury**	**No Injury**	**Incidence**
0-1	2	16	11%
2	12	19	39%
3	5	7	42%
Total	**19**	**42**	**31%**

Table 4

5-Factor Model – Prospective Cut-Points			
Factors	**Injury**	**No Injury**	**Incidence**
0-1	0	7	0%
2	3	17	15%
3	6	13	32%
4-5	10	5	67%
Total	**19**	**42**	**31%**

CLINICAL RELEVANCE

- The measures used to develop the prediction models can easily be acquired during pre-participation screening
  - A key challenge for clinicians is interpretation of measured values for estimation of an individual's level of risk
- Persisting previous injury effects appear to be critically important for prediction of subsequent injury during season
  - Retrospectively derived cut-points provided good sensitivity (90%), but poor specificity (38%)
    - ≥ 2 of 3 factors identified 39% (17/43) players who sustained season injury and ruled out 89% (16/18)
  - Prospectively derived cut-points provided lower sensitivity (53%), but much greater specificity (88%)
    - ≥ 4 of 5 factors identified 67% (10/15) players who sustained season injury, but ruled out 80% (37/46)
- Retrospectively derived cut-points were identical to those prospectively derived for SFI and Y-AR%Diff
  - Model discriminatory power greatly enhanced by inclusion of Y-AR%LL, INV%Diff, and UVJ%Diff
    - Prospective analysis required to establish cut-points that identified these 3 factors as good predictors
- Individualized training that targets remediation of bilateral performance asymmetries may reduce injury risk
  - Further research needed to assess the effectiveness of specific interventions for reduced injury incidence

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