Pre-Season Characteristics of College Athletes as Predictors of Musculoskeletal Injury Risk

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BACKGROUND AND PURPOSE

- Medial longitudinal arch (MLA) height appears to be a factor that is related to lower extremity injury susceptibility
- Foot Width Index (FWI) is the ratio of narrowest middle 1/3 to widest distal 1/3 of the foot (Chippaux-Smirak Index)[1]
  - Low MLA : ≥ .40; normal MLA: .30 - .39; high MLA: ≤ .29
  - FWI outside normal range, higher or lower, has been shown to increase both acute and chronic injury risk
- FWI, derived from a footprint, may be superior to navicular drop measurement for identification of injury risk[2]
- The purpose of this study was to assess the FWI as a pre-season predictor of injury occurrence in college athletes

SUBJECTS AND PROCEDURES

- 85 NCAA Division I-FCS Football Players
  - Age: 19.7 1.5 yr; Height: 1.85 0.08 m; Weight: 102.08 19.90 kg
- Footprint obtained from imprint device (Euro-International, Inc., Tampa; Figure 1) prior to first practice session
  - Ink applied to undersurface of rubber panel of imprint device
  - Participant stepped on rubber panel with right foot; equal standing pressure distribution between feet
  - Chippaux-Smirak foot width index (FWI) derived from foot imprint (Figure 1)[1]
    - Widest portion of distal 1/3 of footprint measured (line A)
    - Most narrow portion of middle 1/3 of footprint measured parallel to line A (line B)
      - FWI = line B / line A
- Acute core and lower extremity sprains and strains documented throughout pre-season and 11-game season
  - Operational definition of injury:
    - Interruption of participation in practice session or competitive event
    - Evaluation by an athletic trainer or physician
    - Administration of any therapeutic procedure
    - Inclusion on coaches' injury report
- Relative predictive power of FWI compared to that of other pre-participation measures of injury risk
  - Anthropometric variables : Body Mass Index (BMI), Estimated Mass Moment of Inertia (MOI)
  - Core muscle endurance: Trunk Flexion Hold (TFH), Wall Sit Hold (WSH), Horizontal Trunk Hold (HTH)
  - Joint function surveys: Oswestry Disability Index (ODI), Foot and Ankle Ability Measurement score (FAAM), International Knee Documentation Committee knee function score (IKDC)
  - Neurocognitive performance: ImPACT™ test battery
  - Predisposing factors: Injury history and high frequency of exposure to game conditions
- Receiver operating characteristic (ROC) analysis utilized to establish dichotomization cut-point for each variable
- Fisher's exact test, odds ratio (OR), and relative risk (RR) were used to assess associations with injury occurrence
- Backward stepwise logistic regression analysis used to identify a set of 3-5 strongest predictors

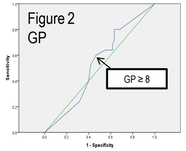
Figure 1

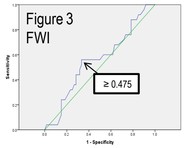
RESULTS

- A total of 25 players sustained a core or lower extremity sprain or strain
  - Hip/Groin: 5, Thigh: 6, Knee: 3, Ankle: 9, Foot: 2
- Results of 12 univariable analyses for dichotomization of risk status presented in Table 1
  - Comparison of injury occurrence for high-risk vs. low-risk status rank-ordered by RR value
- Logistic regression analysis of potential predictors yielded a 4-factor prediction model (Table 2)
  1) Hamstring strain history (HSHx) 2) Games played (GP) ≥ 8 3) FWI ≥ .475 4) BMI ≥ 29.7
  - ROC curves for GP, BMI, and FWI presented in Figures 2-4
- ROC analysis demonstrated ≥ 3 positive factors as the strongest model for discrimination (Table 3, Figure 5)
  - OR = 5.95; Confidence interval function presented in Figure 6
  - RR = 2.93; Confidence interval function presented in Figure 7

Table 1 Univariable analyses

Variable	Cut-pt	AUC	p	Sn	Sp	OR	OR 90% CI	RR	RR 90% CI
Hamstring Strain Hx	+	.705	>.001	.56	.85	7.21	2.96 – 17.57	3.43	2.03 – 3.32
FAAM	≤98.45	.622	.010	.32	.92	5.18	1.82 – 14.7	2.61	1.58 – 4.30
RT (sec)	≥.545	.572	.052	.75	.49	2.89	1.18 – 7.07	2.23	1.09 – 4.24
IKDC	≤98.3	.623	.025	.56	.72	3.22	1.43 – 7.26	2.22	1.28 – 3.84
HTH (sec)	≤29.5	.595	.051	.63	.63	2.80	1.23 – 6.38	2.07	1.15 – 3.74
FWI	≥.475	.556	.045	.56	.67	2.55	1.14 – 5.67	1.91	1.10 – 3.32
WSH-Avg (sec)	≤29.75	.546	.087	.72	.47	2.25	0.96 – 5.25	1.80	0.95 – 3.40
MOI (kg x m^2)	≥370	.514	.143	.52	.63	1.87	0.73 – 4.81	1.55	0.89 – 2.68
Games Played	≥ 8	.531	.342	.60	.53	1.71	0.77 – 3.80	1.47	0.83 – 2.59
Games Started	≥ 1	.533	.232	.48	.63	1.59	0.72 – 3.52	1.38	0.80 – 2.40
ODI	≥2	.534	.459	.44	.67	1.57	0.71 – 3.50	1.37	0.79 – 2.37
BMI (kg/m^2)	≥ 29.7	.530	.295	.44	.65	1.46	0.66 – 3.24	1.30	0.75 – 2.26





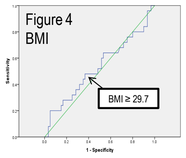


Table 2 Logistic Regression Result

Factor	Cut-pt	Adj. OR
HS Hx	+	6.62
Games Played	≤ 8	1.69
FWI	≥ .475	1.67
BMI	≥ 29.7	1.56
Model χ^2 =16.99; p = .002		
Nagelkerke R^2 = .258		

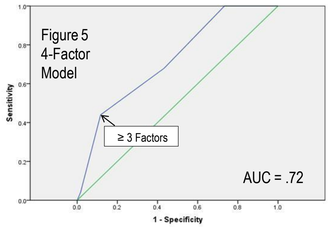


Table 3 4-Factor Model

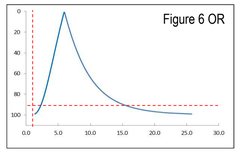
Positive Factors	Injury	No Injury
≥ 3	11	7
0 - 2	14	53
Total	25	60

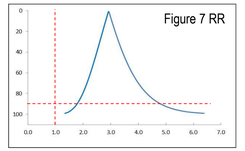
Fisher's Exact One-Sided p = .002

Sensitivity = .44 Specificity = .88

OR = 5.95 RR = .61 / .21 = 2.93

90% CI: 2.33 – 15.17 90% CI: 1.61 – 5.30





CLINICAL RELEVANCE

- FWI appears to be a reasonably good predictor of elevated risk for core and lower extremity injury (RR = 1.91)
- The ≥ 0.475 FWI cut-point identified by this analysis for injury prediction was slightly greater than the ≥ 0.40 value reported by Mei-Dan[1] as a threshold for categorization of low MLA height
- Of 12 potential predictors, FWI was retained by a backward stepwise logistic regression analysis as one of the four strongest predictors
- Each of the components of this 4-factor model are relatively easy to quantify
  - Although number of games played cannot be determined prospectively, a pre-season position depth chart could be used to identify those players who are likely to have high game exposure
- The predictive model can be used to identify a high-risk subset of players who are likely to derive greatest benefit from preventive interventions

REFERENCES

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3. Forriol F. Footprint analysis between three and seventeen years of age. *Foot* Ankle. 1990;11:101-104.