Development of a Prediction Model for Identification of High-Cost Sports Injury Cases

Kelly M. Tucker MS, ATC, Melody A. Mullis MS, ATC, Gary B. Wilkerson, EdD, ATC, Scott L. Bruce, MS, ATC

THE UNIVERSITY of TENNESSEE CHATTANOOGA

BACKGROUND AND PURPOSE

- College and university athletic programs spend thousands of dollars on student-athletes' medical costs each year
  - ACL injuries among 15-24 year-old athletes cost > $1 billion annually in the US; approximately $17,000 per injury[1,2]
- Athletes who possess elevated injury risk prior to sport participation probably impose greater injury treatment costs
  - NCAA BCS football programs incurred $550,000 of medical expenses associated with 2008 bowl games[3]
  - Deficiency in the performance capabilities of the core musculature appear to increase risk for sprains or strains[4]
  - Other injury risk factors include high exposure to game conditions and the existence of low back dysfunction[5]
- Strongest predictors of high-cost status among various sports may or may not differ from predictors of injury occurrence
- The purpose of this study was to develop a prediction model for identification of athletes who are likely to incur high treatment costs on the basis of injury history, performance tests, joint function ratings, and other relevant characteristics

SUBJECTS AND PROCEDURES

- 191 NCAA Division I athletes who participated in eleven different sports during the 2011-12 academic year
  - Height: 1.79 ± .17 m; Weight: 85.31 ± 22.12 kg
- Electronic documentation of all occurrences of musculoskeletal injury that resulted from sport participation
- Medical insurance claim review for tabulation of secondary insurance payments paid by university for each athlete
  - High-Cost versus Low-Cost classification based on Pareto 80-20 rule
    - 80th percentile cut-point: High-Cost ≥ $100 versus Low-Cost < $100
    - Costs related to treatments administered in university athletic training facility not included in the analysis
      - Fluoroscopic imaging eliminated insurance claims for diagnostic imaging in some cases
- Dichotomized classification for each potential predictor based on receiver operating characteristic (ROC) analysis
  - Core endurance tests: Wall Sit Hold (WSH) test, Trunk Flexion Hold (TFH), Horizontal Trunk Hold (HTH)
  - Joint-specific function/disability surveys (0-100 score):
    - Oswestry Disability Index (ODI)
    - Foot and Ankle Ability Measure – Sport Subscale (FAAM-S)
    - Kerlan Jobe Orthopedic Clinic (KJOC) shoulder and elbow survey
    - International Knee Documentation Committee (IKDC) knee survey
- Separate analyses performed for football (N=83) and a non-football cohort of athletes from 10 other sports (N=108)
  - Logistic regression analysis used to identify the strongest components of a prediction model for high-cost

RESULTS

- Criterion for prediction of High-Cost status for football players: ≥ 2 of 3 factors (Tables 1-2 and Figure 1)
  - Total football injury-related secondary costs for 83 players: $24,437
    - Among 24 players predicted to be High-Cost (average of $659 per player): 42% (10/24) incurred cost ≥ $100
    - Among 59 players predicted to be Low-Cost (average of $146 per player): 90% (53/59) incurred cost < $100
      - Players predicted to be High-Cost generated 4.5 X more cost than those predicted to be Low-Cost
- Criterion for prediction of High-Cost status for non-football athletes: ≥ 2 of 3 factors (Tables 3-4 and Figure 2)
  - Total non-football injury-related secondary costs for 108 athletes (10 sports): $28,122
    - Among 16 athletes predicted to be High-Cost (average of $574 per player): 44% (7/16) incurred cost ≥ $100
    - Among 92 athletes predicted to be Low-Cost (average of $206 per player): 83% (76/92) incurred cost < $100
      - Players predicted to be High-Cost generated 2.8 X more cost than those predicted to be Low-Cost
- Total secondary costs paid by university for 191 athletes: $52,559
  - Athletes predicted to be High-Cost generated 3.4 X more cost than those predicted to be Low-Cost

Table 1

FB Predictors	Cut-Point	Sensitivity	Specificity	P-Value	Odds Ratio	Adj. Odds Ratio
KJOC	≤ 98	.56	.80	.008	5.34	7.03
IKDC	≤ 95	.44	.80	.035	3.57	4.90
HTH	≤ 41	.81	.40	.090	2.93	3.84

Table 2

3-Factor Football Cost Prediction Model		
	High-Cost	Low-Cost
≥ 2 Factors	10	14
0-1 Factor	6	53
Total	16	67
Fisher's exact p = .002		
Sensitivity = .63	Specificity = .79	
OR = 6.31 (90% CI: 2.36 – 16.86)		

Figure 1

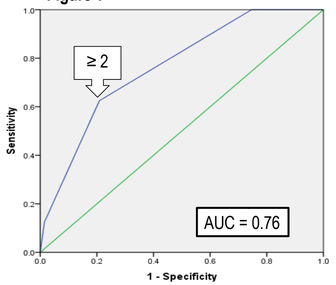


Table 3

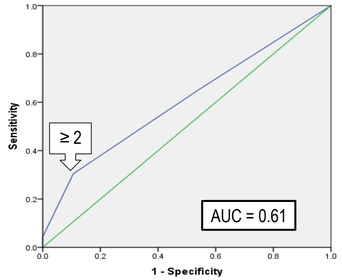
Non-FB Predictors	Cut-Point	Sensitivity	Specificity	P-Value	Odds Ratio	Adj. Odds Ratio
FAAM	≤ 79	.13	1.00	.009	29.20*	*
IKDC	≤ 92	.35	.75	.238	1.63	1.58
WSH avg.	≤ 22	.52	.60	.209	1.64	1.44

* 100% specificity associated with "0" cell

Table 4

3-Factor Non-Football Cost Prediction Model		
	High-Cost	Low-Cost
≥ 2 Factors	7	9
0-1 Factor	16	76
Total	23	85
Fisher's exact p = .025		
Sensitivity = .30	Specificity = .89	
OR = 3.70 (90% CI: 1.44 – 9.50)		

Figure 2



CONCLUSIONS

- Both the football and non-football prediction models provided much better specificity than sensitivity
  - Better for identification of athletes who are unlikely to generate high secondary insurance costs than those who will
- Differing model components suggest that injury-related costs result from different injury susceptibility factors among sports
  - Shoulder function (KJOC) and posterior core endurance (HTH) specific to football secondary costs
  - Foot/ankle function (FAAM-S) and hip/knee extensor endurance (WSH) specific to non-football secondary costs
  - Knee function (IKDC) appears to be a good predictor of injury-related costs for both groups of athletes
- Identification of athletes who possess elevated musculoskeletal injury risk and individualized risk reduction training may reduce secondary cost incurred by college and university athletic programs

REFERENCES

1. Hewett TE, et al. The effect of neuromuscular training on the incidence of knee injury in female athletes. *Am J Sport Med*. 1999;27:699-706.
2. National Center for Injury Prevention and Control. *CDC Injury Research Agenda*. Atlanta, GA. Centers for Disease Control and Prevention; 2002.
3. Fulks DL. *2004-08 NCAA Revenues and Expenses of Division I Intercollegiate Athletics Programs Report.* National Collegiate Athletics Association; 2009.
4. Wilson JD. Core stability and its relationship to lower extremity function and injury. *J Am Acad Orthop Surg*. 2005;13:316-325.
5. Wilkerson GB, et al. Prediction of core and lower extremity strains and sprains in collegiate football players: a preliminary study. *J Athl Train*. 2012;47:264-272.