Injury Risk Assessment and Effectiveness of Risk Reduction Training in Female Collegiate Lacrosse Players

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BACKGROUND AND PURPOSE

- The core (i.e., lumbo-pelvic-hip complex) and lower extremity are involved in 70% of injuries in women's lacrosse[1]
- Pre-participation identification of injury risk factors is a key consideration for prevention of sprains and strains[2]
  - Identification of players who possess elevated risk may enhance the effectiveness of preventive interventions
- Reported risk factors include:
  - High game exposure
  - Previous injury
  - Estimated mass moment of inertia (MMOI)
  - Low back dysfunction
  - Body mass index
  - Poor core musculature fatigue resistance
- Both low back dysfunction and muscle fatigue represent potentially modifiable injury risk factors
- Optimal core muscle endurance is believed to be important for core and lower extremity (LE) injury prevention
- Few studies have assessed core stability training as a means for reducing core and lower extremity injury risk
- The purposes of this study were to evaluate the relative accuracy of different injury risk assessment methods, and the effectiveness of a training program for injury risk reduction among college women's lacrosse players

PARTICIPANTS AND PROCEDURES

- Prospective analysis: 26 NCAA Division I women's lacrosse players who competed in the 2012-13 season
  - Height (1.66 .06 m), Weight (64.17 7.50 kg)
- Retrospective analysis: 17 players on 2012-13 team who also participated for the duration of 2011-12 season
  - Height (1.65 .06 m), Weight (64.70 7.70 kg)
- Potential predictors of core or LE injury quantified at pre-participation physical examination
  - Anthropometric factors: Height, weight, estimated mass moment of inertia (MMOI), body mass index (BMI)
  - Joint function surveys: Foot & Ankle Ability Measure-Sport (FAAM-S), Int. Knee Documentation Comm. (IKDC)
- Measurements obtained before and after 6-week core stability training program (Table 1)
  - Core muscle endurance: Trunk flexion hold (TFH), horizontal trunk hold (HTH), wall sit hold (WSH)
  - Low back dysfunction survey: Oswestry Disability Index (ODI)
- Observation periods: 1) 2011-12 preseason + 16 games; 2) 2012-13 preseason + 8 games (first half of season)
  - Core and LE sprains and strains that resulted in missed practice(s) and/or game(s) (Table 2)
  - Games played (GP) tracked throughout observation periods
- Data analysis: Categorization of high-risk versus low-risk status for maximum prediction accuracy
  - Receiver operating characteristic (ROC) and logistic regression analyses used to develop prediction model
    - Post-training status (immediately preceding season) used as criterion for pre-training risk categorization
  - Prospectively determined ROC cut-points for prediction model components compared to other methods
    - Retrospectively determined ROC cut-points and use of median values to define cut-points
    - Exposure-outcome analyses: sensitivity (Sn), specificity (Sp), relative risk (RR), and odds ratio (OR)
  - Different methods for cut-point determination used to assess both pre- and post-training status

RESULTS

- Prospective 2012-13 observation period:14 core/LE injuries sustained by 11 athletes
- Risk classification based on ROC-derived cut-points for post-training data identified 7 predictors (Table 3)
  - 5-factor prediction model (post-training status) derived from logistic regression analysis (Figure 1)
    - ≥ 3 positive factors: 1) High game exposure, 2) Low WSH, 3) Low TFH 4) Low HTH, 5) High BMI
      - Nagelkerke R^2=.665; RR= 6.14 (90% CI: 2.03 – 18.58); OR= 29.3 (90% CI: 4.87 – 175.69)
- Alternative cut-points for the 5 predictors derived from other methods compared to prospective model (Table 4)
  - Retrospective 2011-12 injury documentation: 33 core/LE injuries sustained by 14 athletes
- Pre- to post-training improvements in core muscle endurance were evident (Table 5)
  - Magnitude of performance improvement for players with ODI ≥10 versus <10 compared (Figure 2)
- Change in risk status (defined by prospective model) associated with reduced injury incidence (Table 6)

Table 1

First 3 Week-Period	Second 3 Week-Period
Plank Series 2x5	Plank Series 2x5
Dead Bugs 2x10	Bird Dogs 2x10
Clam Shells 2x10	Side-lying Leg Lifts 2x10
Cobra's 2x10	Ball Hip Lifts 2x10
Diagonal Chops 2x10	Ball Walk Outs 2x10
Swimmers 2x5	Superman's 2x5

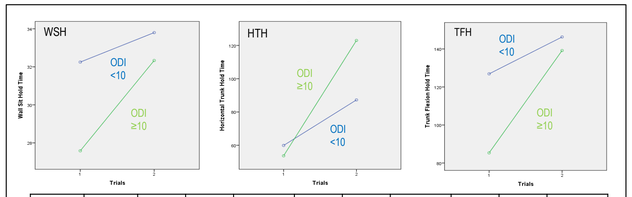
Table 5

Predictor	Pre-Training	Post-Training
WSH avg	30 seconds (12.3 SD)	34 seconds (13.9 SD)
HTH	59 seconds (24.0 SD)	79 seconds (49.5 SD)
TFH	101 seconds (60.0 SD)	125 seconds (72.8 SD)

Table 2

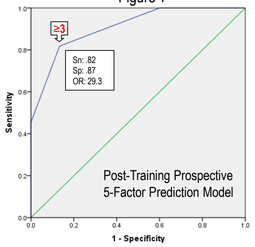
Injury Type	2011-12	2012-13
LB/SI Sprain/Strain	3	3
Hamstring Strain	3	1
Quadriceps Strain	3	2
Hip Flexor Strain	6	1
Groin Strain	5	1
Knee Sprain	6	1
Calf Strain	3	3
Ankle Sprain	2	1
Foot Sprain	2	1

Figure 2



ODI Score	n=	WSH Pre	WSH Post	% Change	HTH Pre	HTH Post	% Change	TFH Pre	TFH Post	% Change
≥10	6	28	32	14	54	123	127	85	139	64
<10	20	32	34	6	60	87	45	127	146	15

Figure 1



Factors +	Injury	No Injury
≥ 3	9	2
0 - 2	2	13
Total	11	15

Table 4

Model	BMI	WSH	HTH	TFH	GP	Sn	Sp	OR
Post-Training Prospective ROC cut-point	≥24.8	≤24	≤75	≤165	≥3	.82	.87	29.3
Pre-Training Prospective ROC cut-point	≥24.8	≤30	≤64	≤130	≥3	1.00	.67	43.9*
Post-Training Prospective Median cut-point	≥23.1	≤33	≤79	≤124	≥3	.64	.40	1.2
Pre-Training Prospective Median cut-point	≥23.1	≤30	≤59	≤100	≥3	.91	.53	11.4
Post-Training Retrospective ROC cut-point	≥24.7	≤32	≤62	≤178	≥7	.73	.53	3.0
Pre-Training Retrospective ROC cut-point	≥24.7	≤33	≤77	≤167	≥7	1.00	.53	26.1*

* 0.5 added to each cell of 2x2 table to eliminate "0" cell

Table 3

Predictor	Cut-Pt.	Sn	Sp	RR	OR
BMI	≥ 24.8	.55	.93	3.26	16.8
WSH avg	≤ 24	.45	.93	2.78	11.7
TFH	≤ 165	.91	.40	3.68	6.7
ODI	≥ 12	.46	.87	2.26	5.4
GP	≥ 3	.91	.27	2.38	3.6
MMOI	≥ 205	.46	.80	1.88	3.3
HTH	≤ 75	.45	.73	1.57	2.3

Table 6

Risk Status	Cases	Injured	Uninjured	% Injured
Remained Low-Risk	8	0	8	0%
High-Risk to Low-Risk	7	2	5	29%
Low-Risk to High-Risk	2	1	1	50%
Remained High-Risk	9	8	1	89%

CLINICAL RELEVANCE

- Core stability training appears to be effective in reducing core and LE injury risk in female lacrosse athletes
  - Pre- to post-training improvements were associated with change in injury risk classification
- A procedure is needed to select cut-points for pre-season injury risk classification (prior to practice/game exposure)
  - Sensitivity of each risk classification method decreased with improvements in performance capabilities
  - Retrospective injury data analysis classified pre-season injury risk status better than use of median values
    - Specificity remained unchanged for injury prediction based on retrospective injury data analysis
    - Specificity improved for injury prediction based on cut-points derived from prospective analysis
- High-risk players who are likely to derive greatest benefit from risk-reduction training need to be identified
  - Although ODI score was not included in 5-factor model, its association with elevated risk has been established[2]
    - Greatest improvements in core muscle endurance demonstrated by those with pre-training ODI score ≥ 10

REFERENCES

1. Dick R, Lincoln AE, Agel J, et al. Descriptive epidemiology of collegiate women's lacrosse injuries: National Collegiate Athletic Association Injury Surveillance System, 1988-1989 through 2003-2004. *J Athl Train*. 2007;42:262-269.
2. Wilkerson GB, Giles JL, Seibel DK. Prediction of core and lower extremity strains and sprains in college football players: a preliminary study. *J Athl Train*. 2012;47:273-281.