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Psychosocial Variables and Time to Injury Onset: A Hurdle Regression Analysis Model

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Context: Psychological variables have been shown to be related to athletic injury and time missed from participation in sport. We are unaware of any empirical examination of the influence of psychological variables on time to onset of injury.

Objective: To examine the influence of orthopaedic and psychosocial variables on time to injury in college athletes.

Patients or Other Participants: One hundred seventy-seven (men = 116, women = 61; age = 19.45 ± 1.39 years) National Collegiate Athletic Association Division II athletes.

Main Outcome Measure(s): Hurdle regression analysis (HRA) was used to determine the influence of predictor variables on days to first injury.

Results: Worry ($z = 2.98$, $P = .003$), concentration disruption ($z = -3.95$, $P < .001$), and negative life-event stress ($z = 5.02$, $P < .001$) were robust predictors of days to injury. Orthopaedic risk score was not a predictor ($z = 1.28$, $P = .20$).

Conclusions: These findings support previous research on the stress-injury relationship, and our group is the first to use HRA in athletic injury data. These data support the addition of psychological screening as part of preseason health examinations for collegiate athletes.

Key Words: stress, anxiety, collegiate athletes

Key Points

- Worry, concentration disruption, and negative life-event stress predicted days to onset of injury, but orthopaedic risk score did not.
- The hurdle regression analysis might present a more effective model for use in future studies of psychological variables and time to onset of injury.
- More psychosocial screening tools are needed in athletic health care and should be employed and interpreted by trained health care providers.

The relationship between psychological factors and athletic injury is well established.[1] Based on the broad examination of National Collegiate Athletic Association (NCAA) injury epidemiology, researchers have called for preventive interventions aimed at the mitigation of modifiable risk factors in the athletic arena.[2] Overall, researchers generally agree that life events and psychosocial variables influence risk of athletic injury and severity of injury.[1,3]

Andersen and Williams[4] developed the dominant model in injury psychology. The model suggests many variables as potential mediators of athletic injury, including history of stressors, personality characteristics, and coping resources. These variables interact to affect the cognitive appraisal and physiologic response to a stressful situation. The central premise is that athletes with high levels of life stress, low levels of coping resources, and personality characteristics that contribute negatively to stress response will evaluate stressful situations more negatively than those with opposite profiles, resulting in physiologic disruptions to the attentional field and leading to increased risk of injury.[3,4] Many others have reported results supporting this model.[5–9]

We are unaware of any empirical reports in which investigators have examined the relationship between psychological constructs and time to injury onset, which is a potentially robust and meaningful variable, particularly regarding preventive interventions. Furthermore, investigators in this area historically have relied on statistical methods that might not account for the variance that often is seen in psychological data (eg, overdispersion within the data). Therefore, the purpose of our study was to highlight the use of hurdle regression analysis (HRA) in examining the influence of orthopaedic and psychosocial variables on time to injury in college athletes. We hypothesized that orthopaedic risk score, life stress, and competitive anxiety would be related to days to onset of injury. Sibold et al[8] recently reported using the more rigorous HRA in support of the model of Andersen and Williams.

METHODS

Participants

One hundred seventy-seven NCAA Division II athletes (men = 116, women = 61; age = 19.45 ± 1.39 years) participated. Participants represented American football, men's and women's soccer, women's volleyball, women's tennis, and men's and women's cross-country running (Table 1). Athletes who were not cleared by the team physician and athletic training staff for full participation

Table 1. Team Injury Data (Mean ± SD)[a]

Sport	N	Injured, % (n)[b]	Days Missed	Days to Injury
Football	75	80 (60)	11.41 ± 14.77	18.96 ± 18.71
Men's soccer	30	80 (24)	13.03 ± 19.60	13.20 ± 13.79
Women's soccer	26	50 (13)	11.58 ± 20.27	8.04 ± 17.90
Women's volleyball	13	92.3 (12)	10.62 ± 9.17	21.53 ± 19.81
Women's tennis	7	42.8 (3)	3.43 ± 5.03	7.57 ± 11.71
Cross-country running	26	61.5 (16)	8.12 ± 9.93	12.80 ± 17.36
Total	177	NA	10.85 ± 15.43	15.21 ± 17.85

Abbreviation: NA, not applicable.

[a] Reprinted with permission from: *Athletic Insight*, volume 3, number 2, "A Comparison of Psychosocial and Orthopedic Data in Injured College Athletes: A Novel Application of Hurdle Regression," pp. 153–164, 2011, Jeremy Sibold, Alan Howard, and Samuel Zizzi.

[b] Indicates percentage of team injured.

after the preseason screening and those athletes who had undergone operative repair of any body part in the calendar year before the study were excluded. All participants provided written informed consent, and the study was approved by both participating institutional review boards.

Instruments

Competitive Trait Anxiety. Competitive trait anxiety was assessed with the Sport Anxiety Scale (SAS).[10] This 21-item, multidimensional measure of competitive trait anxiety has been validated for the assessment of somatic anxiety (SA), worry, and concentration disruption (CD). Internal consistency coefficients have been found to be 0.92, 0.86, and 0.81 for SA, worry, and CD, respectively.[10] For the total scale, the α coefficient has been reported to be as high as 0.93.[10]

Life-Event Stress. The assessment of life-event stress was completed with the Life Events Survey for College Athletes (LESCA).[6] The LESCA is a 69-item survey that instructs participants to rate the effect of the previous year's life events on an 8-point Likert-type scale ranging from -4 (*extremely negative*) to +4 (*extremely positive*). Negative, positive, and total life-stress score can be calculated by adding the scores within each subscale. The LESCA has been reported as psychometrically sound.[6]

Orthopaedic Screening. The institutional orthopaedic screening instrument was used to assess physical data. Subscales included (1) injury history, (2) hamstring flexibility, (3) groin flexibility, (4) low back flexibility, (5) hip flexor and quadriceps flexibility, (6) iliotibial band flexibility, (7) gastrocnemius flexibility, (8) ligamentous stability at the shoulder, (9) ligamentous stability at the knee, and (10) ligamentous stability at the ankle. Scores were assigned for each section based on the following criteria. For the history section, 1 point was given for each orthopaedic injury reported in the 3 years before the study. In the joint-stability section, 1 point was added for each joint that demonstrated impaired stability. In the flexibility sections, scores of excellent, good, average, and poor are available; a score of poor was given 1 point. Points were summed on the orthopaedic screening form to tabulate an orthopaedic screening risk score for each athlete. Higher scores on this instrument indicate higher risk for injury. This method has been reported by Sibold et al.[8]

Injury Data. Head certified athletic trainers assigned to each sport by the institution recorded injuries and days to first injury for each athlete. *Injury* was defined as requiring 1 or more days missed from practice or competition, which was similar to definitions provided in previous investigations.[2,8]

Procedures

After completion of preseason psychosocial batteries, injury records were monitored across competitive seasons by certified athletic trainers. The first day of participation was the first day of preseason practice for each athlete. The HRA was employed to determine the effect of psychosocial and orthopaedic data on days to first injury.

Data Analysis

These data are part of a larger dataset[8] in which a different dependent variable was examined. We employed HRA to examine the influence of psychosocial and orthopaedic variables on time to first injury. This tool is a 2-part model in which *injury/no injury* is the hurdle one must overcome to have a count of days until first injury. The first part of the model uses a binary logistic regression to predict the probability of being injured. For those injured, the second part of the model uses a zero-truncated, negative-binomial regression to predict the expected number of days to first injury. This component of the model is zero truncated because zero days until first injury does not exist in this part of the HRA. Each part of the model can have different independent predictor variables. Both parts of the HRA had the following variables in common: sex, age, worry, CD, SA, total negative life-event stress (NLES), and orthopaedic screening score and interaction variables between total NLES and worry, SA, and CD.

The use of HRA is important to note when examining psychosocial and injury-related data. Specifically, data that follow a negative-binomial distribution instead of a Poisson distribution will tend to be overdispersed (ie, large number of zero days to first injury in those uninjured), resulting in variance that is much greater than the mean, whereas in a Poisson distribution, the mean and variance are equal. Regarding past reports,[6,7] it is unclear whether overdispersion of injury data because of participants who incurred zero days missed or zero injuries was taken into account. In these types of datasets with an excessive number of zeros, HRA is preferable to other models that assume Poisson or other less sensitive distributions.[11] We specifically addressed this issue with the use of HRA. The likelihood-ratio test for overdispersion in our dataset

Table 2. Hurdle Regression Analysis Zero-Truncated, Negative-Binomial Model

Variable	Injury Rate Ratio	Standard Error	*z*	*P*	95% Confidence Interval
Days missed	0.99	0.01	−1.75	.08	0.982, 1.001
Sex	1.17	0.26	0.69	.49	0.746, 1.833
Age	1.08	0.07	1.30	.19	0.958, 1.233
Injuries, no.	0.73	0.05	−4.75	<.001	0.639, 0.830
Worry	1.11	0.04	2.98	.003	1.037, 1.190
Concentration disruption	0.88	0.03	−3.95	<.001	0.834, 0.940
Somatic anxiety	0.99	0.02	−0.36	.72	0.947, 1.038
Negative life-event stress	1.04	0.01	5.02	<.001	1.029, 1.067
Orthopaedic screen score[a]	1.01	0.02	1.28	.20	0.989, 1.049
Interaction between worry and negative life-event stress	0.99	0.01	−2.42	.02	0.986, 0.998
Interaction between somatic anxiety and negative life-event stress	0.99	0.01	−0.22	.83	0.997, 1.002
Interaction between concentration disruption and negative life-event stress	1.01	0.01	2.47	.01	1.001, 1.016

[a] Standard error adjusted for 6 clusters in sport.

showed that overdispersion was present in the data ($P <$ .001); thus, a negative-binomial regression model for the second part of the HRA clearly is preferred over a Poisson or other regression model. The α level was set a priori at .05. Data analysis was completed using the STATA Data Analysis and Statistical Software (version 10.0; StataCorp, College Station, TX).

RESULTS

One hundred twenty-five athletes (70.6%) incurred injuries that resulted in at least 1 day missed during the season, and 52 athletes (29.4%) did not. Overall, for injured athletes, the average number of days to first injury was 15.21 $\pm$ 17.85 days. Team data are shown in Table 1.

The HRA revealed number of injuries ($z = -4.75$, $P <$ .001), worry ($z = 2.98$, $P = .003$), CD ($z = -3.95$, $P <$ .001), and NLES ($z = 5.02$, $P < .001$) as predictors of days to first injury. As one might expect, HRA also revealed that interactions between NLES and worry ($z = -2.42$, $P = .02$) and CD ($z = 2.47$, $P = .01$) were predictors of days until first injury (Table 2).

DISCUSSION

The results partially supported our hypothesis: the number of injuries, NLES, worry, and CD were all related to days to first injury. We were surprised that SA and orthopaedic risk score were not related. The direction of the relationships also necessitates discussion.

As expected, the number of injuries was related inversely to days to first injury. In other words, athletes with higher numbers of injuries had fewer days to first injury. A similar and predictable relationship also was shown for CD. However, worry was related positively to days to injury. Practically speaking, this would suggest that an athlete carrying more worry would take longer to sustain an injury. This is counterintuitive; however, we contend that high levels in this construct might have resulted in less risk taking or aggressive play by the athletes.

A similarly surprising relationship was revealed between life stress and days to first injury. The NLES was related positively to the criterion, suggesting that as life stress increased, time to first injury increased. This is difficult to rationalize; however, participants possibly buffered the effects of this construct with social support or other positive coping mechanisms that we did not evaluate, or it might reflect how *injury* was defined for this protocol. Life stress was evaluated using an instrument that retrospectively inquires about incidence and intensity of life stress for the year before the evaluation. Thus, these stressors might not have been disruptive for the athletes at the time of the study, consequently resulting in atypical findings regarding onset of injury. In the future, investigators might consider the use of a daily hassles scale or more real-time measures of stress to capture its transient ebb and flow across a season. Regardless, given the variance that is inherent in these types of data, we believe that worry and NLES still are important variables to consider in athletic injury.

A limitation of our study included the social desirability of self-report measures. In addition, caution should be taken in generalizing our results to athletic populations other than sports we examined. Furthermore, although challenging, the use of in situ measures of anxiety and stress might reveal more precise information about the relationship between psychosocial constructs and athletic injury. Notwithstanding these particular results, we encourage those interested in the relationship between stress and injury to use the more rigorous and more appropriate HRA technique when exploring these types of data.

CONCLUSIONS

To date, researchers generally have supported the Stress and Injury Model.[3] Our findings concurred with others in this area[1,6,7,9] because we found relationships between days to injury and worry, CD, and NLES in collegiate athletes. We believe that HRA strengthens this body of research and might present a more effective model for future studies in this area. Practically, we believe these results substantiate the need for additional psychosocial screening tools in athletic health care; however, psychological assessment and interpretation should be employed by clinicians with adequate training in these measures or by trained psychology personnel as part of the athletic medicine team. Based on these data, one can make a compelling argument for psychological screening and prophylactic intervention as part of the athletic medicine paradigm. Future research in athletic training might include exploration of the validity and reliability of our novel scoring technique for orthopaedic data, as well as the use of preventive psychosocial interventions related to onset and severity of injury and other multidimensional studies that include both physical and psychological markers in prediction and prevention of injury using rigorous statistical modeling.

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