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Retrospective analysis of injuries and persisting injury effects among students who have participated in club sports and intramural activities during the prior year

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Key Words: injury risk screening, sport-related concussion, musculoskeletal injury

Abstract: Research suggests that previous injury and history of sport-related concussion place athletes at a greater risk for subsequent injury. The primary purpose of this study was to assess the validity of self-perceived wellness and performance capabilities survey responses for retrospective classification of the injury risk status of individual athletes as a means to estimate risk magnitude for intramural and club sport athletes. The surveys used to collect this data were the Sport Fitness Index (SFI), Overall Wellness Index (OWI), Depression, Anxiety, and Stress Survey (DASS), and the Pittsburgh Sleep Quality Index (PSQI). The SFI was a strong discriminator (AUC= .728) for history of sport-related concussion, with the OWI having lesser discriminatory power (AUC= .618). Association with history of core and lower extremity injury was also strong for SFI (AUC= .704), but weaker for OWI (AUC= .623). The results of this study suggest that self-reported functional status and overall wellness strongly relate to injury history, which may have value for identification of individuals who are most likely to sustain another injury during participation in intramural and club sports.

Introduction

Previous injury has consistently been identified as the strongest determinant of risk for subsequent injury.[1-7] Research suggests that athletes who have experienced prior injuries are four to seven times more likely to sustain subsequent injuries, of either the same or a different type,[1-2] and as the number of injuries that an athlete has sustained increases, as does their risk for future injury.[3] Further complicating this issue, other factors have been identified to increase risk for subsequent injury, including psychological factors, sleep quality, and sport-related concussion. A history of sport-related concussion (SRC) has been identified as a strong indicator for future risk of concussion,[8] as well as increased risk of musculoskeletal injury.[9-16] The risk for musculoskeletal injury doubles following a SRC, and the risk for subsequent SRC could be as much as 5 times greater.[12]

Psychological factors, such as mood and emotional problems, have previously been identified to not only increase the risk for musculoskeletal injury,[17-19] but also increase the risk for SRC.[20] Conversely, psychological issues have been identified as a long-term adverse effect of SRC.[21-22] Sleep quality has regularly been associated with a history of concussion and identified as a risk factor for subsequent concussion and musculoskeletal injury.[23] While these issues associated with cognitive impairment have been identified in athletes who report having a history of SRC, many of these post-concussion symptoms are prevalent in athletes who report having no history of SRC, but due to the symptoms they experience, they could also be identified as having an increased risk for injury.[22]

Collegiate athletes sustain injuries at a rate of 5.6 injuries per 1000 athlete exposures (AE's), with these numbers steadily increasing for athletes participating in contact sports such as football players who experience injuries at a rate of 20 injuries per 1000 AEs,[1] and almost 65%

of these being classified as core or lower extremity injuries (CLEIs).[24] Identifying athletes who might possess an increased risk for injury based on their previous injury history, history of concussion, persisting effects of these issues, and their overall well-being and quality of life is a pertinent first step to possible prevention of future injury.[25] Further, injury risk screening should be viewed as a mechanism for identification of the subset of athletes who would potentially derive greatest benefit from a more advanced assessment of functional capabilities, which would not be feasible to provide for every member of a sport team.[4]

Whereas much recent research has focused on injury risk identification and injury prevention programming for National Collegiate Athletic Association (NCAA) athletes, very little research has been conducted involving college students who are engaged in physically demanding activities such as club and intramural sports, although many compete at an elite level and are exposed to conditions that might increase their risk for injury. To date, there has been no documentation of injury occurrences, risk assessment, or pre-participation evaluation of students who elect to participate in club sports and intramural activities at the University of Tennessee at Chattanooga (UTC). The purpose of this study was to assess the validity of self-perceived wellness and performance capabilities survey responses for retrospective classification of the injury risk status of individual athletes as a means to estimate risk magnitude for intramural and club sport athletes.

Methods

A cohort of 89 athletes (Table 1) participating in 11 club sports and 5 intramural activities (Table 2) provided electronic survey responses. Informed consent was obtained from each participant and all procedures were approved by the Institutional Review Board of the

University of Tennessee at Chattanooga. The electronic survey included the combined Sport Fitness Index (SFI) and Overall Wellness Index (OWI), referred to as the Sport Fitness and Wellness Index (SFWI). The SFI is a 10-question survey that quantifies an athlete's perceptions of previous injury effects and life stresses on current performance capabilities.[4] The OWI is a survey containing 10 categories of symptoms or problems designed to document the temporal proximity and frequency of physical, cognitive, behavioral, sleep-related, and mood disorders.[21] Responses to the 10 items on both the SFI and OWI were used to generate 0-100 scores for each, with low values indicating suboptimal status. These 82 symptoms (Sx) were grouped into 10 problem categories (e.g., memory-related, muscle control, mood/emotional, etc.) without reference to prior sport-related concussion (SRC) or head impacts.[21]

Musculoskeletal injuries sustained during the previous 12-month period and any history of concussion, neurological symptoms and/or diagnosed conditions, attention deficit hyperactivity disorder, or learning difficulty were self-reported through responses entered into an injury inventory section of the electronic SFWI survey. A shortened 21-item version of the Depression Anxiety Stress Scales (DASS) was used, which is a set of three self-report scales of depression, anxiety, and stress that measure negative emotional states of the participants. Scores for Depression, Anxiety and Stress are calculated by summing the scores for the relevant items and multiplying by 2 to simulate the original DASS, with high scores indicating severe emotional state.[26] Lastly, the Pittsburgh Sleep Quality Index (PSQI) was used to measure the quality and patterns of sleep in the participants. Scoring is based on a 0 to 3 scale, whereby 3 reflects the negative extreme on the Likert scale, and a global sum of 5 or greater indicates a "poor" sleeper.[27]

We used receiver operating characteristics (ROC) analyses to assess the discriminatory power of survey responses for identification of history of sport-related concussion (HxSRC) and history of core or lower extremity injury (HxCLEI). We used Youden's Index to identify the ROC curve cut-points providing optimal discrimination, which were used to create binary variables for cross-tabulation analyses that provided an odds ratio (OR). A confidence interval (CI) of 95% lower limit >1.00 for the OR was established to determine a significant association. The relative predictive value of individual survey responses was assessed by magnitude of ROC area under curve (AUC). Further, we assessed bivariate correlations among OWI, SFI, DASS, and PSQI scores. We conducted all analyses with SPSS version 27.

Results

A history of SRC was reported by 39% of the athletes (35/89), with 46% reporting experiencing a single SRC and 54% reporting 2 or 3 SRCs. The median SFI score was 58 for individuals who reported HxSRC, while the median score was 78 for individuals who reported no history of SRC (NoSRC). The median OWI score was 58 for individuals who reported HxSRC, while the median score for individuals who reported NoSRC was 68. A history of CLEI in the previous 12 months was reported by 21% of the athletes (19/89). The median OWI score was 50 for individuals who reported HxCLEI, while the median score for individuals who reported no history of CLEI (NoCLEI) in the previous 12 months was 68. The median SFI score was 56 for individuals who reported HxCLEI, while the median score for individuals who reported NoCLEI was 75.

On the basis of AUC, discrimination between HxSRC and NoSRC was strongest for SFI score (AUC= .728), OWI score (AUC= .618), and the number of OWI Sx reported (AUC= .607).

An SFI score ≤ 66 had a sensitivity of 68.6% and a specificity of 27.8% (OR= 5.67; 95% CI: 2.24, 14.37). To further assess SFI survey responses, ROC analysis of each of its 10 items demonstrated AUC values that ranged from .522 (impact of negative life events) to .775 (current post-activity joint symptoms). The survey scores with least discriminatory power were PSQI (AUC= .571) and DASS (AUC= .592).

On the basis of AUC, discrimination between HxCLEI and NoCLEI was strongest for SFI score (AUC= .704) and OWI score (AUC= 0.623). Number of OWI Sx demonstrated an AUC of .587. A moderately strong association was found between HxSRC and HxCLEI within the previous 12 months (OR= 3.50; 95% CI: 1.22, 10.083). We found an inverse bivariate correlation between OWI score and DASS score (r = -0.780; $P < .001$), which is depicted in Figure 1.

Discussion

Research suggests that previous musculoskeletal injury and sport-related concussion are important factors that relate to an athlete's risk for subsequent injuries. The results of this study suggest that persisting effects of previous CLEI on functional abilities and problems associated with HxSRC quantified by SFI and OWI survey responses can identify individuals who possess elevated injury risk. Furthermore, the results of this study provide evidence of an association between HxSRC and HxCLEI. Although individuals with elevated injury risk may be identified solely on the basis of self-reported HxSRC or HxCLEI, SFI and OWI survey responses might better identify individuals who could derive the greatest benefit from individualized injury prevention strategies.

Each of the surveys had discriminatory power for both HxCLEI and HxSRC (Figure 2 and Figure 3), but the SFI score was the strongest predictor of both HxSRC and HxCLEI. Each of the 10 SFI items had discriminatory power for HxSRC, with strongest discriminatory power demonstrated for severity of current post-activity joint symptoms (AUC= .775) and current chronic joint symptoms (AUC= .745). This finding is consistent with that of previous research that suggests HxSRC might affect joint injury recovery and chronic extremity pain.[28-29]

Although OWI score was not the strongest predictor for either HxSRC and HxCLEI, it had a strong association with the well-validated DASS survey for representation of depression, anxiety, and stress level, which has previously been linked to sport performance capabilities and related to a history of sport-related concussion.[30] When compared to DASS score, the OWI score had stronger discriminatory power for HxSRC, and therefore, might serve as a more all-encompassing measure for identification of individuals who might be experiencing post-concussion symptoms, including physical, mental, emotional, and sleep-related problems.

An important factor that may have impacted the strength of our results was the lack of participation in club and intramural sports during 2020 due to the COVID-19 pandemic. The typical intramural Flag Football was transitioned to Punt/Pass/Kick football and basketball, along with several other sports that typically have high injury rates, were cancelled. These changes prohibited prospective analysis of injury occurrences. Our findings related to injury history, which probably included injury events that were unrelated to participation in intramural and club sports. Future research on this population should be conducted when the university resumes regular intramural and club sport activities to document injuries sustained as a direct result of participation. Other limitations of this study were the relatively small sample size and reliance on self-reported survey responses for documentation of persisting effects of injury. Our results may

have been affected by lack of truthfulness in survey responses. Future prospective research is needed to demonstrate a reduction of injury occurrences among individuals who exhibited a high-risk profile prior to participation through targeted injury risk reduction interventions.

Conclusion

Our findings support use of the SFI and OWI surveys for identification of individuals who possess elevated risk for future injury. Furthermore, the results support the use of the OWI survey to quantify persisting effects of SRC. Healthcare providers could apply the methods we used to identify the subset of athletes who might derive greatest benefit from follow-up clinical assessment and possible implementation of an injury prevention program.

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Tables and Figures

Table 1. Demographics for Intramural and Club Sport Athletes

	Males (n= 33)	Females (n= 56)
	Mean (SD)	Mean (SD)
Age (yrs)	21.8 (2.7)	20.6 (1.4)
Weight (lbs)	189.3 (43.0)	143.4 (28.8)
Height (in)	71.3 (2.6)	65.8 (3.4)

Table 1. Anthropometric data of intramural and club sport athletes who participated in the study.

Table 2. Number of Participants per Sport

	Participants (n)
	Count
Club Sports	
Baseball	4
Climbing	1
Fencing	1
Men's Lacrosse	2
Women's Lacrosse	5
Rowing	3
Men's Rugby	2
Women's Rugby	1
Men's Soccer	2
Women's Soccer	3
Swim	2
Table Tennis	2
Tennis	5
Women's Ultimate Frisbee	3
Women's Volleyball	6
Intramural Sports	
Kickball	10
Punt/Pass/Kick Football	3
Sand Volleyball	6
Soccer	9
Spikeball	2

Table 2. Sports that were included as part of the survey and the number of participants for each sport.

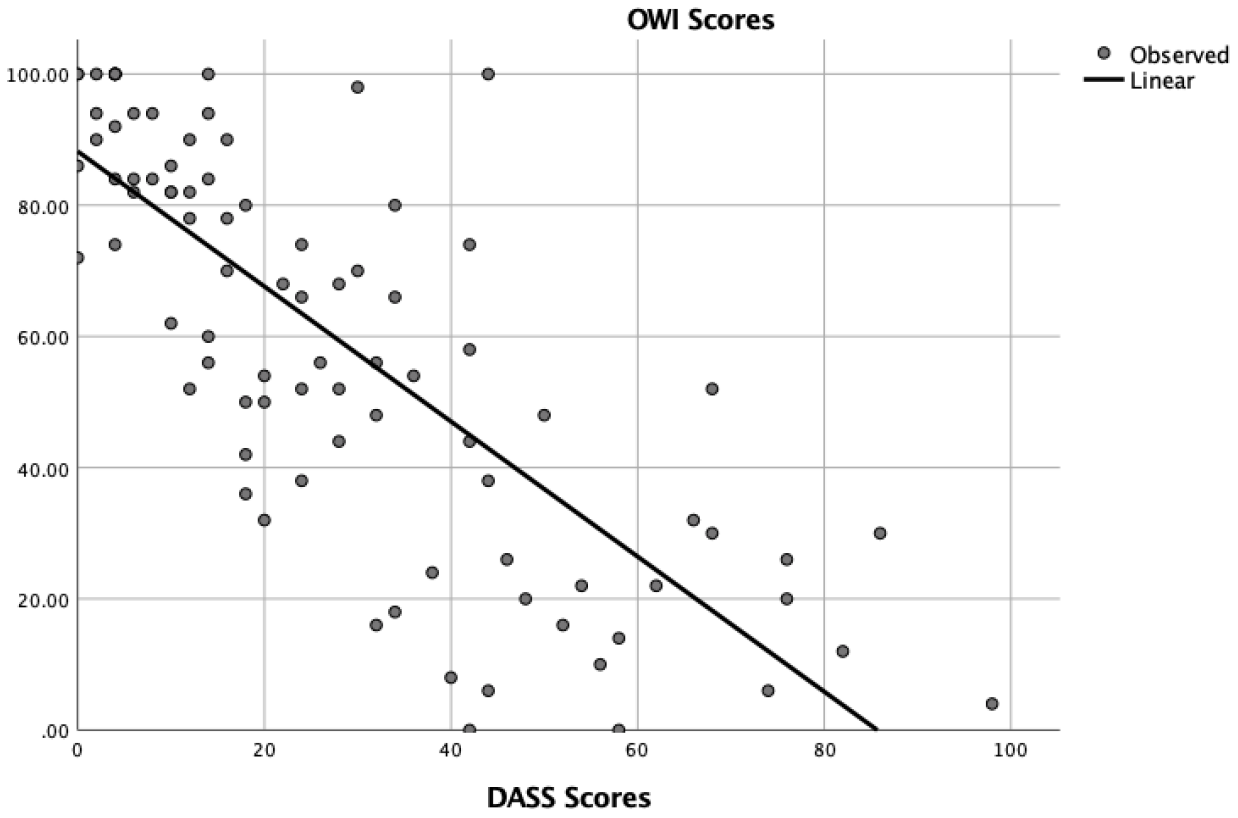

Figure 1. Bivariate relationship between DASS score and OWI score.

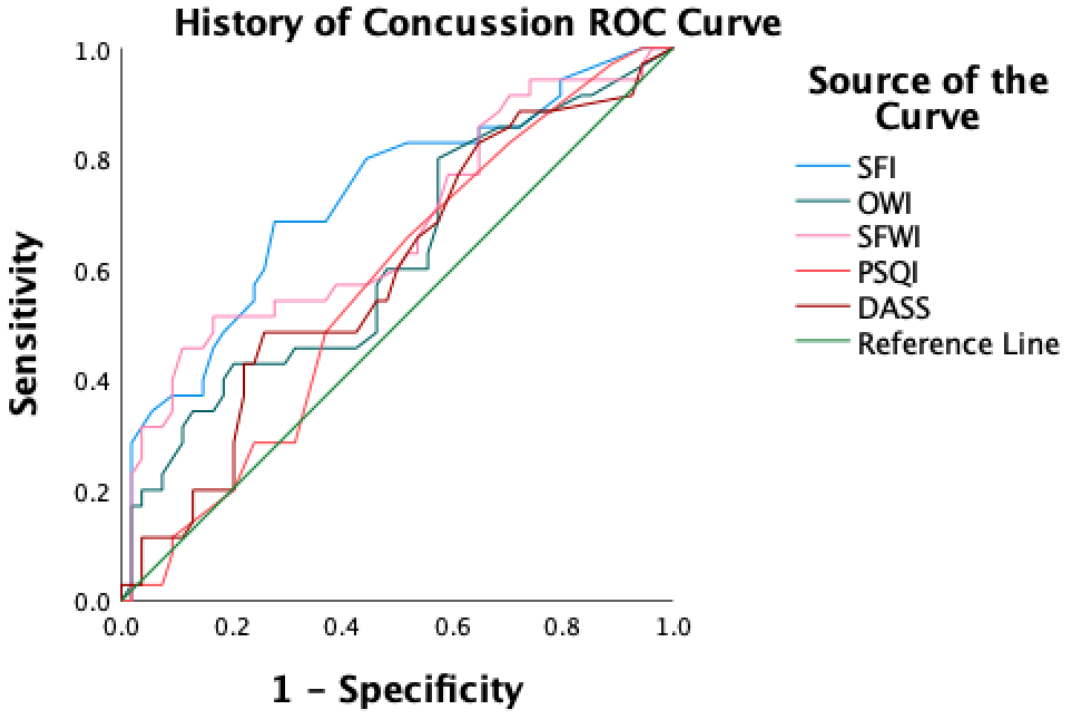

Figure 2. Receiver operating characteristic curve for retrospective analysis of SFI, OWI, SFWI, DASS, and PSQI score association with history of sport-related concussion.

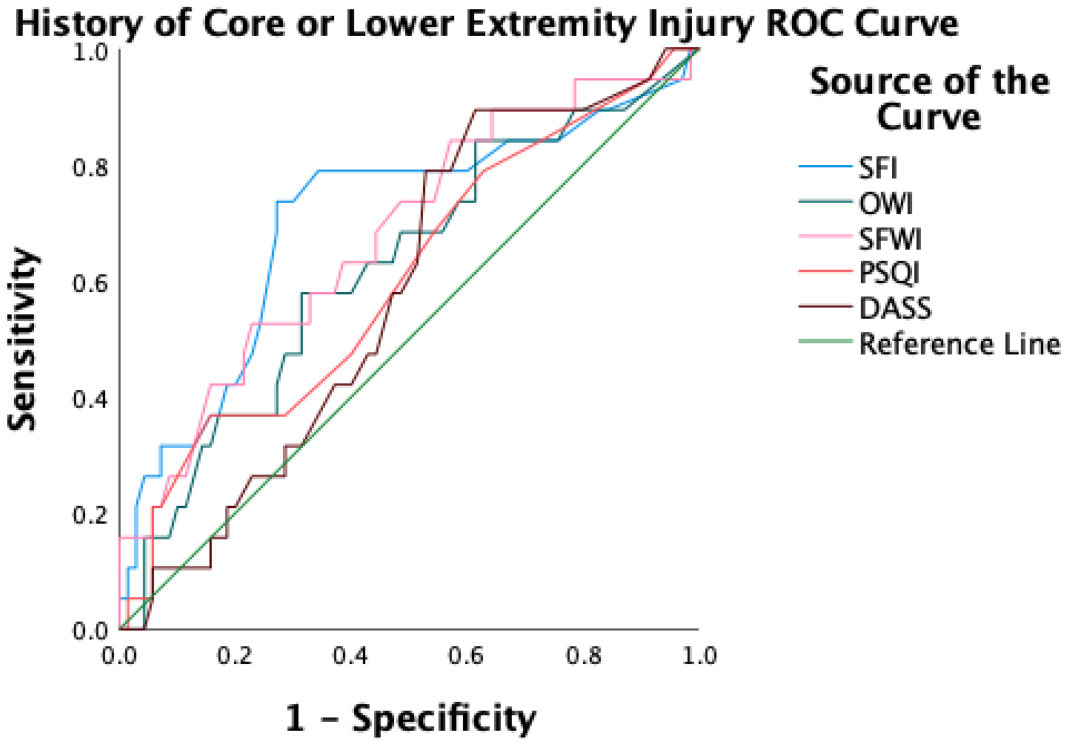

Figure 3. Receiver operating characteristic curve for retrospective analysis of SFI, OWI, SFWI, DASS, and PSQI score association with history of core and lower extremity injury.