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# The underreporting of self-reported symptoms following sports-related concussion

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ABSTRACT

*Objectives:* This cohort study was conducted to examine patterns of symptom reporting in concussed athletes in two different testing environments.
*Design:* A prospective cohort study was conducted with repeated measures.
*Methods:* Self-reported symptoms collected by team athletic trainers using the ImPACT Post-Concussion Scale (PCS) were compared to symptoms collected in a confidential setting using structured interviews for depression and anxiety. Ratings were scaled to match scoring of the PCS and categorized into symptom-domains. Scores collected 2 days post-concussion were compared across different rating scales. Confidential self-report scores approximately 9 days post-concussion in cleared athletes were compared to PCS scores collected during return-to-play decisions. Finally, confidential self-report scores collected 9 days post-concussion were compared between cleared and not cleared athletes.
*Results:* Athletes self-reported significantly fewer symptoms to team athletic trainers using the ImPACT test compared to self-reported symptoms collected in a confidential setting during the acute phase of concussion using standard psychiatric interviews. Athletes cleared to play continued to underreport symptoms 9 days post-concussion, particularly psychiatric symptoms. Finally, cleared athletes self-reported similar magnitude of symptoms than non-cleared athletes 9 days post-concussion in confidential research setting.
*Conclusions:* The systematic underreporting of post-concussion symptoms may represent motivated behavior or differences in self-reporting data acquisition. By underreporting symptoms, many cleared athletes are still symptomatic over 1-week post-concussion. This study highlights the need for objective measures for somatic and psychiatric symptoms.


## 1. Introduction

Concussion has a clinically heterogeneous symptomology that requires assessment across multiple symptom domains.[1,2] Adding to diagnostic complexity, symptom severity is also modulated by "concussion modifiers" that include age, comorbidities, medication, style of play, and sport.[2] The degree of symptom reporting is another modifier that can mislead clinical diagnoses, treatment strategies, and recovery decisions. Underreporting is at least partially motivated by a desire to continue playing, with awareness that self-reporting symptoms will prolong return-to-play decisions in high-school football players.[3]

In an attempt to standardize concussion diagnoses and to minimize clinical reliance on self-reported symptoms, diagnosis of sports-related concussion is often supplemented with computerized or onsite testing metrics.[4–6] These metrics include objective measures such as neurocognitive testing; however, they also rely on athletes' self-reported symptoms for psychiatric and some somatic symptoms. Thus, clinical judgment regarding return-to-play decisions may be biased toward symptoms assessed using objective measures obtained from neurological and

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neuropsychological examination. This may leave cleared athletes vulnerable to participating while still symptomatic in the psychiatric and somatic domains.

International guidelines for return-to-play decisions following concussion have been established, despite the relative lack of evidence-based criteria.[2,7] A graduated return-to-play protocol is recommended, with increasing physical activity occurring at each step after athletes are fully asymptomatic. Currently, there is no distinction regarding what specific symptoms should be favored over other symptoms during return-to-play decisions. Rather, the full resolution of the hallmark symptoms of concussion, which include cognitive, somatic, mood, and sleep-related symptoms, is considered. Typically, symptoms resolve within 7–10 days, though recovery can extend for longer periods of time.[2]

Previous retrospective studies have documented underreporting of concussive events in collegiate soccer, high school football, collegiate football, and a variety of collegiate women's sports.[3,8,9] In addition, underreporting of post-concussion symptoms compared to cognitive batteries has been reported in a variety of collegiate and high school sports, including football and cheerleading.[10–12] This prospective study investigates the underreporting of post-concussive symptoms in the authentic athletic environment and in a controlled research environment. We compared self-reported symptoms collected with the ImPACT battery[4] administered onsite at athletic facilities to scores on the Hamilton Anxiety Rating Scale (HAM-A)[13] and the Hamilton Depression Rating Scale (HAM-D)[14] collected in a confidential setting. First, we tested the hypothesis that athletes underreport cognitive, psychiatric, insomnia, and somatic symptoms in the days immediately post-injury. Secondly, we tested the hypothesis that self-reported symptoms collected during the last ImPACT test used in the decision making process to clear athletes to return-to-play are significantly lower than confidential depression and anxiety measures collected approximately 1-week post-concussion. Finally, we tested the hypothesis that athletes that have been cleared to return-to-play self-report fewer symptoms on depression and anxiety scales 1-week post-concussion than athletes that have not been cleared.

## 2. Methods

A self-selection sampling method was applied to consecutive cases of athletes with concussion from a NCAA Division I university athletic program. Inclusion criteria included any collegiate-aged athlete with a clinician-diagnosed sports-related concussion. Athletes with other, non-concussion injuries that prevented return-to-play were excluded. All participants provided written consent. This study followed procedures outline in the Belmont Report for protection of human participants,[15] and was approved by the Western Institutional Review Board and by the University of Oklahoma Health Sciences Center Institutional Review. Medical professionals trained in sports medicine diagnosed concussions based on clinical symptoms. Forty concussed athletes were evaluated following concussion. The average participant age at the time of their concussion was 20.44 years (SD = 1.41) and with 13.08 years of education (SD = 1.05). Three participants were female soccer players, two were male soccer players, four were female basketball players, one was a male basketball player, one was a female volleyball player, and the remaining 29 were male football players. Athletes who participated in this study in or after 2012 were compensated monetarily following NCAA Bylaws 16.11.1.11.1 and 16.11.1.11.12. Athletes who participated prior to 2012 could not be monetarily compensated due to NCAA Bylaw 16.02.3.

Athletes completed the ImPACT battery at their athletic facilities under the supervision of athletic trainers following a clinician-diagnosed concussion. The ImPACT battery includes a series of cognitive tests comprising of four composite scores and a 22-item post-concussion symptom inventory (PCS).[4,16] This inventory asks participants to self-report post-concussion symptoms on a seven-point likert scale, with 0 indicating symptom absence, 1–2 indicating mild, 3–4 indicating moderate, and 5–6 indicating severe symptoms. Initial ImPACT testing was performed on an average of 1.30 days post-injury (SD = 0.57). Athletes performed additional post-injury ImPACT testing until they had been cleared to return-to-play by clinicians trained in sports-medicine. Return-to-play decisions were based on clinical judgment following medical exams, aided by the use of the ImPACT battery by comparing neurocognitive task performance and PCS scores to baseline levels. Athletes returned-to-play on an average of 11.77 (SD = 7.83) days following concussion. The average number of clinician-diagnosed concussions prior to the current concussion was 0.75 (SD = 1.0).

Thirty-seven of the athletes also performed neuropsychiatric testing in a confidential setting at the Laureate Institute for Brain Research on an average of 1.92 days (SD = 1.04) post-injury. Athletes were informed that their responses in this setting would remain confidential and that team officials would not have access to their test results. Experienced assessment professionals performed structure interviews for the Hamilton Depression Rating Scale with Atypical Depression Supplement (HAM-D)[13,17,18] and the Hamilton Anxiety Rating Scale (HAM-A).[14,19] The original seventeen-item HAM-D with individual questions scored on either a three-point or five-point scale, and the standard fourteen item HAM-A with individual questions score on a five-points scale were used to document post-concussion symptoms.

Twenty-nine athletes participated in a confidential research testing session on an average of 9.14 days post-concussion (SD = 2.08), during which HAM-D and HAM-A structured interviews were collected. At the time of this session, nine of the twenty-nine athletes had been cleared to return-to-play using the criteria previously described.

Scaling of responses was performed to compare the HAM-A and HAM-D scales to the PCS scale based on the number of response options in the scale and the anchors for those response options prior to examining any of the participant scores on the scales. For HAM-A items and five-point items of the HAM-D scores of 4 were converted to 6, scores of 3 were converted to 5, scores of 2 were converted to 3.5, scores of 1 were converted to 1.5, and scores of 0 remained as 0. For three-point HAM-D items scaling to PCS scale was as follows: scores of 0 remained as 0, scores of 1 were converted to 2.5, and scores of 2 were converted to 5.5.

Symptoms were grouped into four symptom-domains for analyses comparing the reporting of symptoms from the HAM-D and HAM-A interviews to the PCS score. PCS symptoms were classified into one of four domains following previous classification schemes [20]: Insomnia, psychiatric, cognitive, and somatic (Supplementary Table 1). Individual items from the HAM-D and HAM-A were also grouped into the same symptom-domains. Two of the authors independently classified HAM-D and HAM-A items into symptom-domains using both a criterion of maximum item inclusion and of best symptom fit to PCS items. We chose to use the best symptom fit approach. Items that covered two domains were included in both (Supplementary Table 1). Domain scores for the HAM-D, HAM-A, and PCS were obtained by averaging the scores of the individual items in each domain.

Supplementary Table 1 can be found, in the online version, at doi:10.1016/j.jsams.2014.07.008.

Two two-way repeated-measures analysis of variances (ANOVA) were performed with the within-subjects factors of symptom-domain (cognitive, insomnia, psychiatric, and somatic) and rating scale (HAM-D, HAM-A, PCS), on self-reported symptom-scores. One ANOVA compared the scores collected approximately two days post-concussion for all athletes, and one