

Attention Tracker, presented as percentile ranks using normative data built-into the ImPACT QT.

**Results** Zambian athletes scored nearly two standard deviations below the mean on Motor Speed (7th percentile), when compared to North American normative data. However, performance on Attention Tracker (44th percentile) and Memory (56th percentile) among Zambian athletes was well within the average range.

**Conclusions** This data is the first to explore Zambian athletes' performance on any concussion measure. Zambian athletes performed poorly on the ImPACT QT factor score related to motor speed. These results suggest that Zambian athletes may be unfamiliar with testing on an iPad device or there may have been cultural barriers in the interpretation of test directions. Further, understanding these preliminary performance measures are a starting point that could aid in understanding which concussion measures would be culturally appropriate to implement in the prevention, diagnosis, and care of concussion among Zambian athletes.

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### NORMATIVE BASELINE SCAT5 SCORES IN A POPULATION OF UNITED STATES PARALYMPIC ATHLETES

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**Background** The Sport Concussion Assessment Tool 5<sup>th</sup> Edition (SCAT5) is the most recent version of the concussion evaluation tool used by clinicians to evaluate athletes with suspected concussions.

**Objective** To describe normative baseline SCAT5 scores among United States Paralympic athletes.

**Design** Retrospective descriptive epidemiology.

**Setting** United States Olympic and Paralympic Sports Medicine Centers.

**Participants** Fifty-eight Paralympic athletes (60.3% female, mean age±standard deviation (SD) = 30.2±10.6) representing 7 sport federations underwent baseline SCAT5 testing between April 2018 and July 2019.

**Interventions** None.

**Main Outcome Measurements** Baseline SCAT5 scores of healthy Paralympic athletes. T-tests were used to compare scores by sex.

**Results** Athletes reported an average of 5.0±5.4 symptoms (median=2.5, IQR=1.0–8.5) with an average severity score of 11.0±14.3 (median=6.0, IQR=0–17.5). Over half of athletes (59.3%) reported having sustained at least one concussion prior to testing (range=0–16 reported concussions). Mean scores ± SD for major components of the SCAT5: 4.8±0.74 for orientation, 21.0±3.7 for immediate memory, 3.9±1.1 for concentration, 6.7±6.4 for balance, 6.9±2.2 for delayed recall, and 15.7±2.8 for Standardized Assessment of Concussion. No sex differences were observed for any component scores of the SCAT5.

**Conclusions** Normative values for baseline SCAT5 performance are presented for a population of healthy Paralympic athletes. Future research should focus on the development of normative data for specific Paralympic disability classifications.

**Clinical relevance** Knowledge of normative scores may aid clinicians' interpretation of baseline and post-injury SCAT5 scores.

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### THE TOP 1% OF HEAD IMPACTS CAUSE VISIBLE SIGNS AND 'CHECK ENGINE' RESPONSES IN ATHLETES AND MILITARY SERVICE MEMBERS

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**Background** For the past ~20 years, the scientific literature, based on data from inaccurate helmet/head-mounted sensors, has reported that there is little link between head impact magnitude and location and visible signs (VS). The current study found that VS were seen only in impacts in the top 1% as measured by head impact acceleration, velocity and/or energy.

**Objective** Head impacts were measured with an accurate head impact monitoring mouthguard and confirmed through video and data trace analysis. The athlete/military service member behavior was observed for a visible sign post-impact.

**Design** Retrospective meta-analysis from military parachute, boxing, mixed martial arts, weapons firing, as well as American football, Boxing, Ice Hockey, Karate, Lacrosse, Mixed Martial Arts, Rugby, Tae Kwon Do, Football.

**Setting** Sporting field or Military training activity.

**Participants** 50,000 verified impacts over 10,000 person-days.

**Assessment of Risk Factors** Visible signs post-impact.

**Main Outcome Measurements** Kinetic energy transfer (KE), peak scalar linear acceleration (PLA), peak scalar linear velocity (PLV), impact location, impact direction, type of VS.

**Results** There were fifty (50) single head impacts that caused visible signs. The most common visible signs were loss of consciousness, posturing, dazed, imbalance and ataxia. All visible signs impacts were in the top 1% by magnitude (40–100g, 3–8 m/s and 30–150 J). A total of 90% of the VS impacts were to the side or rear of the head.

**Conclusions** Visible signs do not occur often, but always occurred in the top 1% of head impacts by magnitude, and 90% of these were to the rear and the sides of the head. By monitoring head impacts with an accurate device, clinical staff can have access to data that identifies head impacts most likely to cause visible signs.

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### RISK FACTORS FOR POST-CONCUSSION SUBSEQUENT MUSCULOSKELETAL INJURIES

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**Background** Elevated rates (1.5 to 3.0 times) of musculoskeletal (MSK) injuries in the first year post-concussion have been recently identified in diverse athletic populations; however, clinically feasible risk factors have received limited attention.

**Objective** To identify clinical predictors of post-concussion subsequent musculoskeletal (MSK) injuries.

**Design** Prospective longitudinal.

**Setting** U.S. Intercollegiate Athletics .

**Patients (or Participants)** We enrolled 66 student-athletes (53.0% Female, Age: 20.0 ± 1.1 years old, Height: 1.75 ± 0.11m, Weight: 78.7 ± 20.9kg) from 16 sports who were diagnosed with sports-related concussions.

**Interventions (or Assessment of Risk Factors)** Electronic medical records were tracked for a year following the concussion for diagnosed lower extremity MSK injuries.

**Main Outcome Measurements** All participants completed a multifaceted concussion baseline consisting of 1) 22-item 0–6 self-reported symptom checklist with outcomes including, 1) number of symptoms endorsed, 2) total symptom score, 3) Standard Assessment of Concussion, 4) Balance Error Scoring System, 5) Immediate Post-Concussion Assessment and Cognitive Testing composite scores, 6) clinical reaction time, and 7) the King-Devick test. The concussion participants completed the same exam acutely post-concussion (<48 hours) and binary logistic regression was used to identify predictors of subsequent MSK from the change scores (Acute minus Baseline).

**Results** The participant demographics and injury characteristics ( $p=0.318$ ,  $\text{Exp}(B)=1.020$ ) and concussion clinical outcomes ( $p=0.461$ ,  $\text{Exp}(B)=1.200$ ) did not predict subsequent MSK. Exploratory analysis failed to identify any individual predictive variable from the clinical measures including total symptoms ( $\Delta=9.3$ ,  $p=0.738$ ), symptoms severity ( $\Delta=21.1$ ,  $p=0.738$ ), BESS ( $\Delta=-0.6$  errors,  $p=0.474$ ), SAC ( $\Delta=-0.7$ ,  $p=0.938$ ), Verbal Memory ( $\Delta=1.6$ ,  $p=0.064$ ), Visual Memory ( $\Delta=5.1$ ,  $p=0.724$ ), Motor Speed ( $\Delta=0.6$ ,  $p=0.297$ ), Reaction Time ( $\Delta=0.04$  s,  $p=0.642$ ), CRT ( $\Delta=15.8$  ms,  $p=0.446$ ), King-Devick ( $\Delta=6.9$  s,  $p=0.792$ ).

**Conclusions** None of the standard concussion assessments significantly predicted MSK injury in the year following concussion. Thus, clinicians are not able to utilize common neurological measures or participant demographics to identify those at risk for subsequent LE MSK suggesting injury prevention programs should be implemented for all post-concussion athletes

#### 171 MSK INJURY LIKELIHOOD IS INCREASED DURING THE 4-MONTH PERIOD AFTER A CONCUSSION

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**Background** There is evidence that concussion can increase the risk of sustaining a subsequent musculoskeletal (MSK) injury up to 24-months post injury. The reason for increased risk is unknown although irregularities in brain and motor function post-concussion that are sustained beyond clinical recovery have been implicated.

**Objective** To determine the likelihood of UK High Performance System athletes sustaining a subsequent MSK injury within a 4-month period post-concussion.

**Design** Retrospective Cohort Study. A concussion was identified by a medical records diagnostic code of ‘concussion without loss of consciousness’, ‘concussion with loss of consciousness’, or ‘concussion not otherwise specified’. The attrition rate is the average occurrence of an MSK injury during the 4-month period. An attrition rate for all MSK injuries was determined using the formula; ‘Number of MSK Injuries’/ ‘Number of Athletes’. An attrition rate for all MSK injuries subsequent to a concussion was determined by the formula;

‘Number of MSK injuries that occur in the 4-months after a concussion’/‘Number of Athletes who sustained a concussion’.

**Setting** UK High Performance System Olympic and Paralympic athletes

**Participants** 1979 athletes from 33 sports

**Main Outcome Measurements** MSK attrition rate compared to MSK/Concussion attrition rate.

**Results** Athletes were found to have a 27% increased risk of suffering a MSK injury 4-months post-concussion, with the overall MSK attrition rate of 0.78, increasing to 0.99 post-concussion. A higher MSK/Concussion attrition rate was identified in 26 of 33 sports.

**Conclusions** There is an increased risk of sustaining a MSK injury post-concussion amongst UK Olympic and Paralympic programme athletes. Therefore, identifying and addressing risk factors for subsequent MSK injury should be considered during concussion rehabilitation. This might include visio-motor, oculo-motor, balance and neuromuscular impairments alongside screening, monitoring and programming physical preparation to ensure any work-load imbalances associated with time away from sport are addressed.

#### 172 THE EFFECT OF ANXIETY DURING CONCUSSION ASSESSMENT IN RURAL LOW SOCIOECONOMIC ADOLESCENT ATHLETES

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**Background** In youth, anxiety is the most prevalent mental illness in the US, effecting 31.9% of adolescents. During concussion assessment, athletes may experience high levels of anxiety due to concerns such as the inability to perform in their sport. While it is commonly assumed lower socioeconomic (SES) adolescents are more resilient in handling anxiety, this has not been examined.

**Objective** Determine the effect of anxiety on neuropsychological testing in rural low SES adolescent athletes.

**Design** Cross-sectional between-groups cohort design.

**Setting and Participants** Rural low SES adolescent athletes (n=126) were recruited prior to their competitive season to establish anxiety levels during baseline concussion assessment.

**Interventions** Participants were given baseline tests including computerized neuropsychological test battery (ImpACT™) and the State Trait Anxiety Inventory (STAI-Y) to determine cognitive function and levels of anxiety, respectively. Participants were divided into groups based upon STAI-Y scores. Using SPSS, one-way ANOVAs were calculated on ImpACT composite scores, using an alpha level of .05 for all tests.

**Main Outcome Measurements** ImpACT composite scores.

**Results** 7% (n=9) and 17% (n=21) endorsed high state and trait anxiety respectively. Statistically significant differences existed between state anxiety groups on composite reaction time ( $F_{(1,124)} = 6.72$ ,  $p=0.011$ , eta squared = .03), composite impulse control ( $F_{(1,124)} = 8.49$ ,  $p= 0.004$ , eta squared = .01), and total symptoms ( $F_{(1,124)} = 7.09$ ,  $p<0.001$ , eta squared =.01), with high state anxiety athletes performing worse and reporting more symptoms.

**Conclusions** Rural low SES athletes endorsed lower levels of anxiety than the general population, however those with high state anxiety endorsed more symptoms and performed worse on measures of impulsivity. This study provides initial