Effect of Concussion History on Neurocognition and Neuromuscular Function of College Football Players

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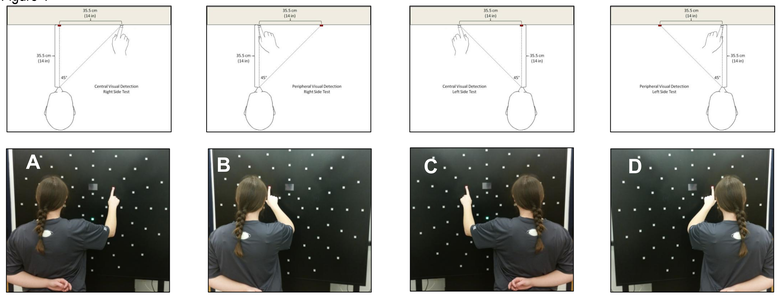
BACKGROUND AND PURPOSE

- Sport-related concussions are a growing concern, the vast majority of which result from participation in football[1]
- Post-concussion recovery of cognitive function, postural balance, and reaction time slower with concussion history[2]
- Recent evidence suggests long-term impairments, and risk for concussion recurrence and musculoskeletal injury[3,4]
- Improvement in speed of peripheral motor responses to visual stimuli associated with decreased concussion rate[5]
- The purpose of our research was to identify any associations between concussion history, neurocognitive function, neuromuscular control, and core or lower extremity (Core/LE) sprain or strain among college football players

PARTICIPANT CHARACTERISTICS AND PROCEDURES

- 34 NCAA Division I-FCS football players: 17 cases with concussion history and 17 matched controls
  - Cases: Age 20.2 ± 1.3 yrs, Mass 100.72 ± 22.72 kg, Height 183.03 ± 7.05 cm
  - Controls: Age 19.4 ± 1.1 yrs, Mass 101.92 ± 19.31 kg, Height 185.27 ± 5.54 cm
- Neurocognitive composite scores obtained from computerized test (ImPACT, Pittsburgh, PA)
  - Verbal Memory: attention processes, learning, and memory
  - Visual Memory: visual attention and scanning, learning, and memory
  - Visual Motor Speed: visual processing, learning and memory, and visual-motor response speed
  - Composite Reaction Time (CRT): response speed (ms)
  - Impulse Control: measure of response errors
- Visual detection time (VDT) quantified by visuomotor testing system (Dynavision International, West Chester, OH)
  - Elapsed time (ms) between target illumination and initial motor response (release of depressed button)
    - Central and peripheral VDT assessed for right and left tests (Figure 1 A-D)
- Unilateral Squat Hold (USH): knee maintained in 45° flexion with heel elevated ~ 2.5 cm for 60 s (Figure 2)
  - Time to loss of postural balance recorded; balance quickly re-established for completion of test
  - USH postural balance also quantified by electronic tablet accelerometer application (Sway Medical, Tulsa, OK)
    - 15 cases and 15 controls (test data corrupted in 2 cases; corresponding matched control data excluded)
- Occurrence of Core/LE sprain or strain documented throughout pre-season practice sessions and 14-game season
  - Injury defined as any acute Core/LE sprain or strain that required evaluation and received treatment
- Receiver operating characteristic (ROC) analyses used to identify cut-points for dichotomization of variables
- Cross-tabulation analyses performed to assess associations between concussion history and dichotomous variables
- Logistical Regression analyses identified models that provided maximum discrimination between cases and controls

Figure 1



RESULTS

- ROC and cross-tabulation analyses identified 7 variables strongly associated with concussion history (Table 1)
  - Fisher's exact 1-sided *P*-value reported for categorizations created by cut-points derived from ROC analyses
- Multivariable 4-factor model:
  - USH (OR_{Adj} = 5.68), Peripheral VDT (OR_{Adj} = 3.23), Visual Memory (OR_{Adj} = 3.11), and CRT (OR_{Adj} = 2.27)
    - Model $\chi^2(4)$ = 11.04; *P* = .026; Nagelkerke R^2 = .370
- Multivariable 3-factor model:
  - USH (OR_{Adj} = 7.31), Peripheral VDT (OR_{Adj} = 3.57), and Visual Memory (OR_{Adj} = 3.41)
    - Model $\chi^2(3)$ = 10.59; *P* = .014; Nagelkerke R^2 = .357
- ROC analysis provided comparison of simplified 4-factor and 3-factor models (Figure 2)
  - Model comparisons: 4-factor ≥ 3 positive, 4-factor ≥ 2 positive, and 3-factor ≥ 2 positive (Table 2)
- Concussion history was strongly associated with the occurrence of Core/LE sprain or strain
  - Fisher's exact 1-sided *P* = .007; Sensitivity 79%; Specificity 70%; OR = 8.56 (90%CI; 2.24 – 32.63)

Table 1

Variable	Cut-Point	Sensitivity	Specificity	Odds Ratio	90% CI	*P*-Value
Visual Memory Score (0-100)	≤ 73.5	65%	71%	4.40	1.31 - 14.75	.042
Composite Reaction Time (ms)	≥ 675	29%	94%	6.67	0.99 - 44.94	.087
Impulse Control Score (0-100)	≥ 8	53%	65%	2.06	0.65 - 6.55	.245
Central VDT (ms)	≥ 270	82%	41%	3.27	0.87 - 12.27	.129
Peripheral VDT (ms)	≥ 298	82%	41%	3.27	.0.87 - 12.27	.129
Postural Sway (Std Dev of m/s^3)	≥ .042	40%	87%	4.33	0.95 - 19.83	.107
Unilateral Squat Hold (s)	≤ 23	47%	88%	6.67	1.53 - 29.10	.029

Figure 2

Table 2

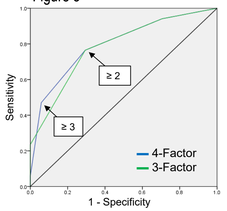
Prediction Model	Sensitivity	Specificity	Odds Ratio	90% CI	*P*-Value
3-Factor ≥2 Positive	77%	71%	7.80	2.16 – 28.19	.007
4-Factor ≥2 Positive	77%	71%	7.80	2.16 – 28.19	.007
4-Factor ≥3 Positive	47%	94%	14.22	2.18 – 92.69	.008

Table 3

Concussion History	Injury	No Injury
Yes	14	3
No	6	11
Total	20	14

OR = 8.56

Figure 3



CLINICAL RELEVANCE

- The results of our retrospective case-control analysis suggest that concussion may have long-lasting effects
  - Alternatively, pre-existing deficiencies in neural function may increase susceptibility to concussion occurrence
- The results of our prospective case-control analysis suggest that concussion history is a Core/LE injury risk factor
  - Whether a cause or an effect of concussion, deficiencies in neural function appear to be important to assess
  - Neurocognitive processes relating to detection, interpretation, and generation of responses to visual stimuli
  - Neuromuscular processes relating to maintenance of postural stability during single-leg support
- The potential for injury risk reduction through administration of screening tests and implementation of training activities for development of specific neurocognitive and neuromuscular adaptations needs thorough investigation

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