Association of Perception-Action Coupling with Concussion History and Self-Rated Function

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BACKGROUND AND PURPOSE

- Up to 1.2 million injuries per year occur in high school and college football, most of which are sprains and strains[1]
- Athletes who have sustained a concussion appear to be at greater risk for sustaining a musculoskeletal injury[2]
  - Risk factors for football-related injury may include deficits in reaction time (RT), memory, and peripheral vision
    - RT encompasses amount of time required for: 1) perception, 2) decision, and 3) motor response[3]
    - Cognitive control refers to brain processes associated with perception, memory, and action[4]
  - Perception-Action coupling specifically refers to rapid responsiveness to environmental stimuli
    - Anticipatory and/or rapid muscle activation that initiates movement and optimizes stiffness of body segments
- The purpose of this study was to assess the potential value of a reactive agility test for identification of persisting effects of concussion on perception-action coupling and self-rated function of college football players

PARTICIPANTS AND PROCEDURES

- 71 NCAA Division 1-FCS football players (19.5 ±1.1 yrs; 103.49 ±21.53 kg; 186.45 ±6.35 cm) tested
  - Testing conducted 2 months after conclusion of football season and 3 weeks prior to initiation of spring practices
- Concussion history based on athlete self-report of previous diagnosis as having sustained at least one concussion
  - Concussion History (n=22): 19.3 ±1.0 yrs; 104.73 ±19.34 kg; 187.27 ±5.63 cm
  - No Concussion History (n = 49): 19.6 ±1.1 yrs; 102.93 ±22.61 kg; 186.08 ±6.67 cm
- 10-item Sports Fitness Index (SFI-10) used to quantify ratings of persisting effects of previous injuries (Figure 1)[5]
  - Time-loss injuries during previous season reported; analysis limited to core or lower extremity sprain or strain
- Lateral shuffle test used to assess reactive agility; TRAZER® Sports Stimulator (Traq Global Ltd, Westlake, OH)
  - Proper movement directions guided by appearance of targets on large monitor in front of athlete (Figure 2)
  - Start position 3.12 m from monitor; lateral shuffle movement of 0.91 m required to deactivate target on monitor
  - RT, speed, acceleration, and deceleration measured for 20 repetitions (10 in each direction; random order)
    - Average value and right-left asymmetry (% difference) assessed for each performance variable
- Associations of reactive agility performance values with self-reported concussion history and SFI score quantified
  - Receiver operating characteristic (ROC) analyses identified cut-points for binary performance classifications
  - Cross-tabulation used to calculate univariable odds ratio (OR) for association with binary status classification
  - Logistic regression analysis used to identify strongest variables for identification of binary status classification

RESULTS

- Reactive agility performance summary statistics for cohort of 71 college football players presented in Table 1
  - Performance differences in right-left directions found to have strong associations with Concussion History
    - Stratified RT, Speed, and Deceleration % Difference mean and median values presented in Table 2
  - Results of univariable and multivariable analyses for association with Concussion History presented in Table 3
    - Lower limit of 90% Confidence Interval for univariable OR designated as 95% Credible Low Estimate (CLE_{95})
  - 3-Factor multivariable model $\chi^2(3)=14.86$; p=.002; R^2=.266; ≥ 2 positive: OR=10.00 (90% CI 3.23, 30.96)
- Analysis of SFI-10 items demonstrated items 3-7 had strongest association with recent time-loss injury
  - Explosive Power, Speed, Endurance, Weightlifting, Sport-Specific Skills, Muscle Spasms, and Joint Instability
    - SFI-10 failed to demonstrate discernable cut-point for time-loss core or lower extremity sprain or strain
    - SFI-5 score (0-25) cut-point of ≤ 22 demonstrated 54% sensitivity; 64% specificity; OR= 2.07
  - Performance differences in right-left directions found to have strong associations with Low SFI-5 score (≤ 22)
  - Results of univariable and multivariable analyses for association with Low SFI-5 score presented in Table 4
  - 2-Factor Multivariable model $\chi^2(2)$= 14.26; p=.002; R^2=.247; Both positive: OR= 7.24 (90% CI 2.65, 19.81)


Figure 1

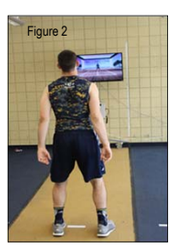
Figure 2

Table 1. Performance Values (All Players; n=71)

Factor	Mean ± Std Dev	Median
Speed	0.77 ± 0.11 m/s (2.53 ± 0.35 ft/s)	0.77 m/s (2.53 ft/s)
Deceleration	2.70 ± 0.36 m/s² (8.87 ± 1.19 ft/s²)	2.70 m/s² (8.85 ft/s²)
Acceleration	3.53 ± 0.62 m/s² (11.58 ± 2.02 ft/s²)	3.55 m/s² (11.64 ft/s²)
Reaction Time	434 ± 79 ms	420 ms

Table 2. Concussion History Stratification (No: n=49; Yes: n=22)

Factor	Concussion History	Mean ± Std Dev	Median
Reaction Time % Difference	No	14.4 ± 12.3	11.8
	Yes	25.1 ± 12.3	17.8
Speed % Difference	No	7.3 ± 5.7	5.4
	Yes	9.2 ± 7.4	6.9
Deceleration % Difference	No	10.5 ± 8.2	7.9
	Yes	13.3 ± 8.0	12.1

Table 3. Concussion History

Factor	Cut-Point	Sensitivity	Specificity	OR	CLE_{95}	Exp(B)
Reaction Time % Difference	≥ 16%	64%	65%	3.29	1.04	3.50
Speed % Difference	≥ 6%	73%	53%	3.01	1.20	3.44
Deceleration % Difference	≥ 7%	82%	45%	3.67	1.32	4.39
Positive Factors	≥ 2	86%	61%	10.00	3.23	

Table 4. Low SFI-5 Score

Factor	Cut-Point	Sensitivity	Specificity	OR	CLE_{95}	Exp(B)
Reaction Time % Difference	≥ 15%	59%	64%	2.55	1.12	2.73
Speed % Difference	≥ 6%	78%	61%	5.56	2.22	5.81
Deceleration % Difference	≥ 18%	30%	89%	3.28	1.16	-
Positive Factors	Both	48%	89%	7.24	2.65	

CLINICAL RELEVANCE

- Performance values derived from the reactive agility test appear to reflect perception-action coupling capability
  - Differences in right-left direction measures were associated with both Concussion History and Low SFI-5 score
- Averaged right-left performance values provided discrimination, but asymmetries demonstrated strongest effects
  - % Differences for RT, Speed and Deceleration appear to reflect persisting effects of Concussion History
- SFI-10 items 3-7 (designated as SFI-5) found to provide best representation of persisting effects of recent injuries
  - % Differences in RT and Speed appear to be the best indicators of injury-induced performance limitations
- The reactive agility test measures obtained from the TRAZER® Sports Simulator may relate to a perception-action coupling deficiency that underlies the association between concussion and increased musculoskeletal injury risk

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