The effect of a perceptual-motor training program on the neural processing efficiency of college football athletes

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1

Background

- Efficiency of brain processes is essential for success in cognitively demanding sports[1]
  - Visual, cognitive and motor integration determines performance capabilities
  - Open-skill sport athletes exhibit fast reaction time and low response variability[2]
- Speed and accuracy of responses to visual stimuli may relate to injury susceptibility[3]
  - Time required to process complex stimuli and generate proper motor responses
  - Trade-off between speed and accuracy may be an important consideration

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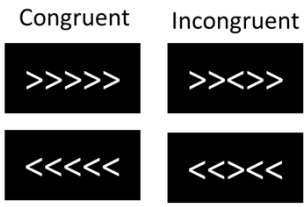
Study Purpose

- Injury avoidance and performance enhancement are key concerns for college football programs
- Potential for improvement of perceptual-motor efficiency has not been clearly established
- Purposes of this study were to assess: 1) improvement of performance through motion detection training and 2) relationships among performance metrics and injury occurrences

Methods

- Baseline assessment of 87 Division I-FCS football athletes prior to beginning of pre-season practice sessions
  - Age: 20.7 ± 1.7 years; Height: 185.2 ±10.1 cm; Mass: 102.5 ±19.5 kg

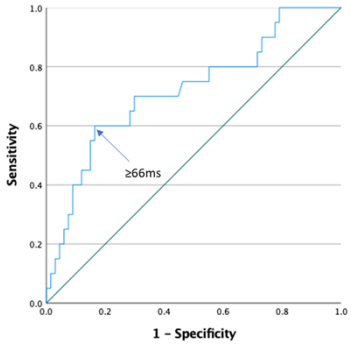


- 2 trials of 20 repetitions (10 Incongruent & 10 Congruent)
- 5-arrow displays presented for 300 ms (random order)
- Inter-stimulus intervals range from 500 ms to 1500 ms

- Flanker Conflict Effect (FCE) = Incongruent Avg RT – Congruent Avg RT
- Rate Correct Score (RCS) = Number of Correct Responses / Total RT for 20 repetitions
- Reaction Time Variability (RTV) = Intra-Individual Std Dev of 20 test repetitions

Methods: Retrospective Analysis

- Optimal FCE cut point for history of core or lower extremity injury (CLEI) during prior 12 mo
  - CLEI: any sprain or strain that ended participation in any practice session or game



Assigned to Train Group n=25

		CLEI – Previous 12 Months: Yes	CLEI – Previous 12 Months: No	Incidence
Flanker Conflict Effect ≥ 66 ms	Yes	12	13	48%
	No	8	54	13%
	Total	20	67	

Sensitivity 60% Specificity 81%

$\chi^2(1)=12.40$ **OR=6.23**

P<.001 95% CI: 2.12, 18.35

Train Group
186.9 ±6.3 cm
104.6 ±19.3 kg

No Train Group
184.6 ±11.2 cm
101.6 ±19.7 kg

- Previously documented prospective association of CE≥ 69 ms with CLEI occurrence[4]

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5

Methods

- 25 players completed 4-week perceptual-motor training program initiated after pre-season practice period (first week of season); 1-3 sessions per week
  - Smartphone flanker test administered pre- and post-training
  - End of season testing planned for all players who completed baseline test

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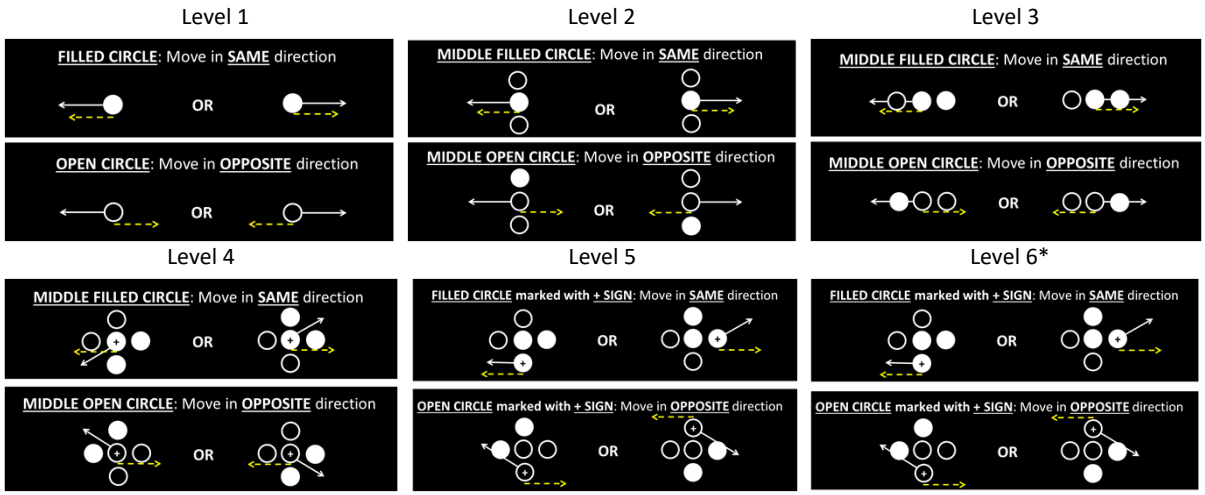
6

Motion Detection Training Program



* Target Clusters Located in Any 1 of 4 Screen Quadrants

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7

Results

- Baseline (Pre-participation) Assessment: N=87
- Pre-training Assessment: Data available for 20 of 25 in Train Group
- Post-training Assessment: Data available for 20 of 25 in Train Group
- End Season Assessment: Data available for 55 of 87 assessed at Baseline
  (15 of 25 in Train Group + 40 of 62 in No Train Group)

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8

Results (Nonparametric): Pre- to Post-Training Change

Median (IQR) performance improvement and result of Wilcoxon Signed-Rank test for Training Group (n=20)

Performance Metric	Baseline to Pre-Train	Pre-Train to Post-Train	Baseline to Post-Train
Rate Correct Score (per second)	0.03 (0.19) *P*=.108	0.05 (0.11) ***P*=.005**	0.06 (0.17) ***P*<.001**
Flanker Conflict Effect (ms)	33 (43) ***P*<.001**	−3 (98) *P*=.881	31 (73) ***P*=.007**
Reaction Time Variability (standard deviation)	12 (48) *P*=.232	−4 (45) *P*=.478	1 (71) *P*=.433

Participation in training sessions: Median 8; Inter-Quartile Range 6-10; Minimum-Maximum 3-12

* Electronic transmission failure resulted in loss of data for 5 training program participants

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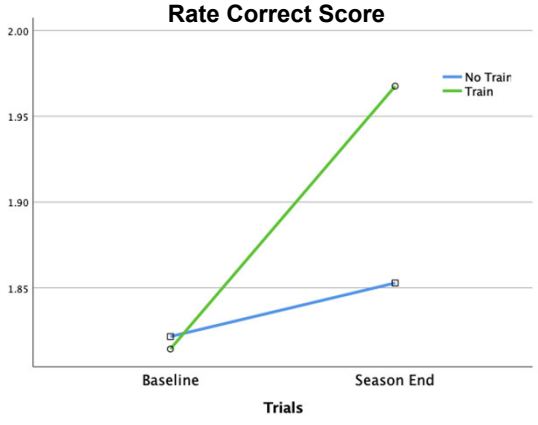
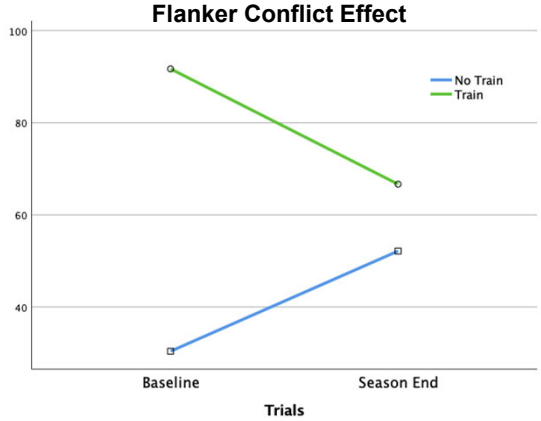
9

Results (Parametric): Baseline to End of Season





* End of season data available for 63% (55/87) of players: No Train 65% (40/62) Train 60% (15/25)

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10

Results (Parametric): Baseline to End of Season

Mean (± standard deviation) for players with End Season data and Independent t-test results for differential performance changes between No Training Group (n=40) and Training Group (n=15).

Performance Metric	Group	Baseline	End Season	Improvement	Cohen's d	*P*
Rate Correct Score (per second)	No Training	1.82 ±0.23	1.85 ±0.20	0.03 ±0.24	0.13	**.008**
	Training	1.81 ±0.15	1.97 ±0.14	0.15 ±0.09	1.78	
Flanker Conflict Effect (ms)	No Training	30 ±29	52 ±48	−22 ±49	−0.44	**.001**
	Training	92 ±38	67 ±24	25 ±30	0.84	
Reaction Time Variability (standard deviation)	No Training	70 ±37	71 ±41	−1 ±47	−0.01	**.084**
	Training	84 ±36	62 ±27	22 ±29	0.79	

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11

11

Results (Nonparametric): Baseline to End of Season

Median (interquartile range) for players with End Season data and Mann-Whitney test results for differential performance changes between No Training Group (n=40) and Training Group (n=15).

Performance Metric	Group	Baseline	End Season	Improvement	*P*
Rate Correct Score (per second)	No Training	1.84 (0.33)	1.87 (0.21)	0.00 (0.30)	**.039**
	Training	1.86 (0.28)	2.00 (0.25)	0.16 (0.10)	
Flanker Conflict Effect (ms)	No Training	42 (50)	56 (52)	−19 (38)	**<.001**
	Training	74 (36)	72 (34)	27 (34)	
Reaction Time Variability (standard deviation)	No Training	52 (26)	60 (27)	0 (33)	**.047**
	Training	66 (56)	56 (20)	17 (31)	

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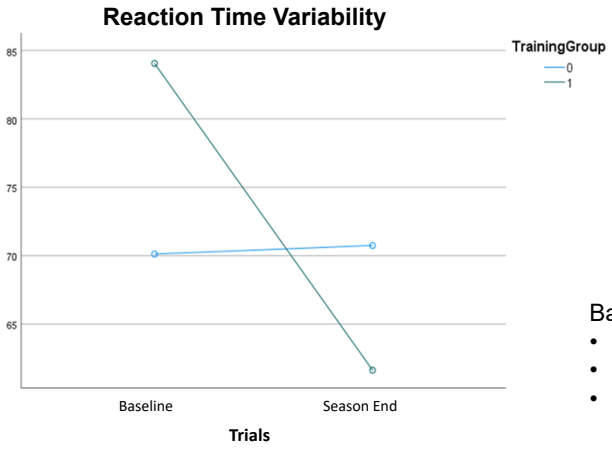
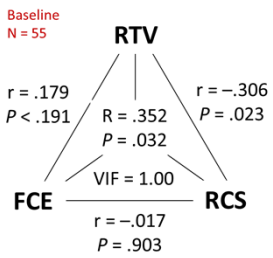
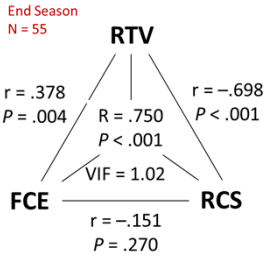
12

12

Results



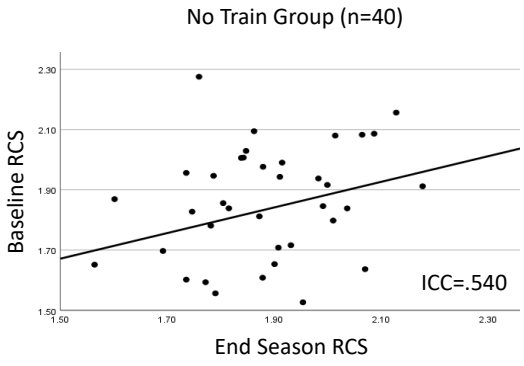


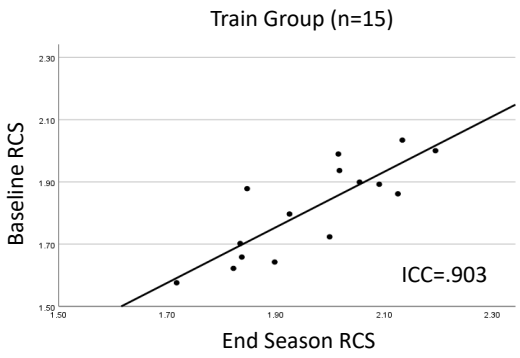


Baseline test-retest Intraclass Correlation Coefficient (2,K)

- FCE = Inc Avg RT – Con Avg RT FCE ICC: .308
- RCS = Number Correct / Total RT RCS ICC: .770
- RTV = Intra-Individual Std Dev RTV ICC: .731

Baseline and End Season Assessments – Rate Correct Score



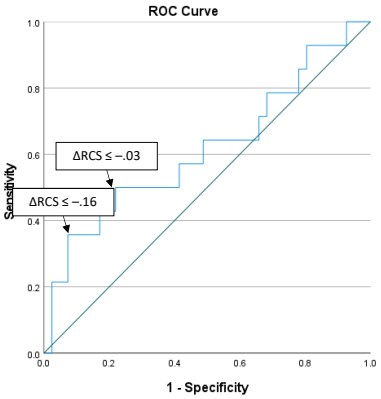


* ICC: 2-Way Random, Average Measures, Consistency

Results: Post-Season Retrospective Analysis

Change in Rate Correct Score (ΔRCS) = Baseline RCS – End Season RCS

- Metric that provided strongest retrospective association with CLEI



Core/LE injuries*
Ankle: 8
Lower Leg: 1
Knee: 5
Hamstring: 2
Hip/Groin: 2
Quad/Thigh: 4
LBP: 1
Abdomen: 1

		CLEI Occurrence in Practice or Game*		
		Yes	No	Incidence
ΔRCS ≤ –.16	Yes	5	3	63%
	No	9	38	19%
	Total	14	41	

Sensitivity 36% Specificity 93%

$\chi^2(1)=6.77$ **OR=7.04**
P=.020 95% CI: 1.41, 35.04

* Total of 24 CLEI sustained by 18 players
Among 55 players available for post-season assessment, CLEI sustained by 14

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15

15

Results

- Distribution of "starters" approximately equal for groups
  - 39% (34/87) of full cohort
    - No Train Group: 39% starters (24/62)
    - Training Group: 40% starters (10/25)

		CLEI Occurrence		
		Yes	No	Incidence
Starter Status Not in Training Group	Yes	9	15	37.5%
	No	7	31	18.4%
	Total	16	46	

Sensitivity 56% Specificity 67%

$\chi^2(1)= 2.80$ **OR=2.66**
P=.086 95% CI: 0.83, 8.51

		CLEI Occurrence		
		Yes	No	Incidence
Starter Status In Training Group	Yes	1	9	10.0%
	No	1	14	6.7%
	Total	2	23	

Sensitivity 50% Specificity 61%

$\chi^2(1)= 0.91$ **OR=1.56**
P=.065 95% CI:0.09, 28.15

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16

16

Discussion

- Baseline to end of season change in performance metrics significantly differed between players who completed training and those who did not train
  - Substantial change in metrics with high reliability included RCS and RTV
- Findings consistent with previous research documenting neural impairments in football players across season, believed due to head acceleration events[5,6]
  - FCE increased in no train group and reduced in training group
- Variability in fMRI and EEG signals inversely related to consistency in behavioral performance (e.g., low RTV)[7]
  - Increased correlation of RCS with RTV from baseline to end of season

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17

17

Clinical Relevance

- Changes in associations between FCE and RCS with RTV suggest positive training effect that may represent improved efficiency of neural processes
- Improved neural processing efficiency believed to decrease injury occurrence and enhance sport performance capabilities
- Perceptual-motor training may enhance resilience to the effects of repeated head acceleration events experienced across season

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18

18

References

1. Wilkerson GB, Nabhan DC, Crane RT. Upper-extremity perceptual-motor training improves whole-body reactive agility among elite athletes with history of sport-related concussion. *J Sport Rehabil*. 2021;30(6):844-849.
2. Wang C-H, Yang C-T, Moreau D, Muggleton NG. Motor expertise modulates neural oscillations and temporal dynamics of cognitive control. *Neuroimage*. 2017;158:260-270.
3. Wilkerson GB. Neurocognitive reaction time predicts lower extremity sprains and strains. *Int J Athl Ther Train*. 2012;17(6):4-9.
4. Wilkerson GB, Bruce JR, Wilson AW, et al. Perceptual-motor efficiency and concussion history are prospectively associated with injury occurrences among high school and collegiate American football players. *Orthop J Sports Med*. 2021;25;9(10). doi:10.1177/23259671211051722.
5. Hirad AA, Bazarian JJ, Merchant-Borna K, et al. A common neural signature of brain injury in concussion and subconcussion. *Sci Adv*. 2019;5(8):eaau3460. doi:10.1126/sciadv.aau3460.
6. Papa L, Slobounov SM, Breiter HC, et al. Elevations in microRNA biomarkers in serum are associated with measures of concussion, neurocognitive function, and subconcussive trauma over a single National Collegiate Athletic Association Division I season in collegiate football players. *J Neurotrauma*. 2019;36(8):1343-1351.
7. Grady CL, Garrett DD. Brain signal variability is modulated as a function of internal and external demand in younger and older adults. *Neuroimage*. 2018;169:510-523.