Improvement of Visuomotor Performance Capabilities in Collegiate Football Players

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BACKGROUND AND PURPOSE

- Half of all football players sustain at least 1 injury during a season, with 50% affecting the lower extremity (LE)[1]
- Emerging evidence suggests that altered corticospinal neural processing is an important sport injury risk factor[2,3]
  - Visuomotor reaction time (VMRT), postural balance, and concussion history may identify athletes with elevated risk
    - Concussion risk is increased by 15-20% among athletes who have sustained a prior concussion[4]
    - Musculoskeletal injury risk is as much as 2X greater following a concussion[5]
    - Slow VMRT and postural instability may be contributing causes or consequences of prior injury[6]
- The purpose of this study was to assess the value of a VMRT training program for improvement of neuromechanical perception-action coupling capabilities among collegiate football players.

PARTICIPANT CHARACTERISTICS AND PROCEDURES

- Participants were a cohort of 49 NCAA Division I-FCS football players engaged in a summer conditioning program
  - Dynavision D2™ system (Dynavision International, West Chester, OH) used for VMRT testing and training
    - No VMRT Training (n=36): Age: 19.9 ±1.1 Mass (kg): 101.33 ±21.18 Height (cm): 185.14 ±5.62
    - VMRT Training (n=13): Age: 20.1 ±1.4 Mass (kg): 105.84 ±19.57 Height (cm): 188.16 ±4.69
  - All participants performed baseline VMRT tests, each of which was a 60-s test
    - Test 1: Proactive mode – target button remains illuminated until hit
    - Test 2: Reactive mode – ≤750 ms to hit target button while reading scrolling text on LCD screen
    - Test 3: Reactive mode – simultaneous bilateral postural balancing on "BOSU" device (Reactive – B)
  - VMRT training participants completed a total of 9 training sessions (~3 min each) over a 3-week period
    - Week 1: 3 Proactive mode training sessions
    - Week 2: 3 Reactive mode training sessions
    - Week 3: 3 Reactive mode – B training sessions

  - Post-training VMRT tests completed using the same procedures
- Paired t-tests were performed to assess change in VMRT (ms) and number of hits for each 60-s test
  - Analyses also performed to assess performance changes for each of 5 target button concentric rings
    - Average elapsed time (ms) potentially confounded by failure to hit outer ring buttons in Reactive mode
    - Number of hits for 60-s test more valid as an indicator of Reactive mode performance capability than VMRT
  - Training effect size (ES) represented in two different ways
    - Standard deviation units of difference (d) between pre- and post-training performance mean values
    - Proportion of explainable variance (η^2) derived from repeated measures analysis of variance

RESULTS

- Table 1 presents means ± standard deviations for players who did not complete the 3-week training program
- Tables 2 & 3 present pre- and post-training means ± standard deviations for players who completed VMRT training:
  - Proactive mode VMRT improved 67 ms (Table 4) and 7 additional hits (Table 5) from pre- to post-training
  - Reactive mode VMRT improved 21 ms (Tables 2 & 3) and 13 additional hits (Table 6) from pre- to post-training
  - Reactive – B mode VMRT improved 25 ms (Tables 2 & 3) and 13 additional hits (Table 7) from pre- to post-training
- Ring 4 performance demonstrated greatest improvements:
  - Average VMRT improved by 145 ms in the Proactive mode. ($p < .001$; ES = 1.28; 17% faster)
  - Average hits for ring 4 increased by 5.5 in the Reactive mode ($p < .001$; ES = 1.19; 56% more)
  - Average hits for ring 4 increased by 5 in the Reactive – B mode ($p = .008$; ES = 0.95; 57% more)
- Proactive mode outer ring (4 & 5) to inner ring (1 & 2) VMRT ratio (O/I) demonstrated significant improvement:
  - Pre-training O/I = 1.63 ±0.17; Post-training O/I = 1.44 ±0.13 ($p = .002$; ES = 1.09; $\eta^2 = 0.57$)

Table 1

NO TRAINING (n = 36)		Ring 1	Ring 2	Ring 3	Ring 4	Ring 5	Overall $\bar{X}$ ±*SD*
Proactive	VMRT (ms)	612 ±82	642 ±102	723 ±78	876 ±141	1094 ±228	805 ±128
	Hits	8.56 ±2.47	8.14 ±2.98	20.00 ±4.01	18.25 ±4.99	17.58 ±4.19	72.53 ±8.87
Reactive	VMRT (ms)	600 ±58	599 ±58	625 ±33	643 ±119	654 ±171	635 ±40
	Hits	7.14 ±1.82	6.47 ±2.89	12.02 ±6.05	6.56 ±3.80	3.78 ±2.57	35.96 ±11.72
Reactive - B	VMRT (ms)	584 ±59	598 ±60	626 ±50	631 ±119	591 ±245	628 ±41
	Hits	7.86 ±2.75	6.97 ±2.60	11.28 ±5.16	7.36 ±4.61	3.19 ±2.57	36.67 ±11.50

Table 2

PRE-TEST (n = 13)		Ring 1	Ring 2	Ring 3	Ring 4	Ring 5	Overall $\bar{X}$ ±*SD*
Proactive	VMRT (ms)	572 ±70	604 ±65	680 ±92	859 ±113	1052 ±175	754 ±86
	Hits	11.00 ±3.27	8.29 ±2.18	20.69 ±5.41	19.09 ±3.01	17.4 ±4.59	77.15 ±7.63
Reactive	VMRT (ms)	569 ±49	565 ±54	603 ±32	582 ±178	564 ±253	607 ±30
	Hits	8.31 ±3.50	8.08 ±2.47	14.31 ±5.38	9.77 ±4.59	4.38 ±3.38	44.85 ±14.08
Reactive - B	VMRT (ms)	559 ±37	590 ±47	599 ±36	625 ±64	676 ±40	610 ±26
	Hits	9.08 ±2.22	7.38 ±2.96	13.46 ±4.37	8.62 ±5.21	3.31 ±1.93	41.85 ±11.58

Table 3

POST-TEST (n = 13)		Ring 1	Ring 2	Ring 3	Ring 4	Ring 5	Overall $\bar{X}$ ±*SD*
Proactive	VMRT (ms)	579 ±127	577 ±66	632 ±89	714 ±63	932 ±155	687 ±86
	Hits	10.38 ±3.02	10.77 ±2.65	20.46 ±3.71	20.46 ±2.96	22.08 ±4.87	84.15 ±8.74
Reactive	VMRT (ms)	525 ±75	541 ±57	580 ±40	627 ±39	659 ±44	586 ±42
	Hit	9.85 ±2.94	8.38 ±3.18	18.08 ±4.63	15.23 ±6.41	6.38 ±3.89	57.92 ±13.60
Reactive - B	VMRT (ms)	519 ±55	547 ±54	587 ±44	612 ±47	659 ±19	585 ±31
	Hits	8.69 ±2.72	8.62 ±2.87	15.69 ±5.27	13.54 ±6.88	8.38 ±4.03	54.92 ±12.15

Table 4

PROACTIVE	Δ (ms)	*P*	ES (d)	η^2
Ring 1	+7	.790	-	-
Ring 2	-27	.154	0.42	0.16
Ring 3	-49	.135	0.52	0.18
Ring 4	-145	<.001	1.28	0.76
Ring 5	-120	.014	0.68	0.41
Avg. Time	-67	.007	0.78	0.47

Table 5

PROACTIVE	Δ (hits)	*P*	ES (d)	η^2
Ring 1	-0.62	.622	-	-
Ring 2	+1.85	.102	0.01	0.21
Ring 3	-0.23	.901	-	-
Ring 4	+1.38	.275	0.45	0.10
Ring 5	+4.62	.001	0.101	0.59
Avg. Hits	+7.00	.011	0.92	0.43

Table 6

REACTIVE	Δ (hits)	*P*	ES (d)	η^2
Ring 1	+1.54	.151	0.44	0.16
Ring 2	+0.30	.798	0.12	0.01
Ring 3	+3.77	.022	0.70	0.37
Ring 4	+5.46	<.001	1.19	0.70
Ring 5	+2.00	.090	0.59	0.22
Avg. Hits	+13.08	<.001	0.93	0.85

Table 7

REACTIVE – B	Δ (hits)	*P*	ES (d)	η^2
Ring 1	-0.39	.743	-	-
Ring 2	+1.24	.267	0.42	0.10
Ring 3	+2.23	.285	0.51	0.09
Ring 4	+4.92	.008	0.95	0.46
Ring 5	+5.07	<.001	2.62	0.72
Avg. Hits	+13.08	.001	1.13	0.63

CLINICAL RELEVANCE

- The 3-week training program produced substantial improvements in VMRT performance in all 3 testing modes
  - Improvement magnitude greatest for outer rings, suggesting a positive peripheral detection adaptation
    - Faster response to external environmental stimuli may be facilitated, thereby reducing injury risk
      - Lesser Ring 5 vs. 4 improvement may relate to diminished potential for training extreme limits of visual field
- Postural balance challenge during VMRT training may be beneficial for improved LE dynamic joint stability
  - Substantial improvement from pre- to post-training number of hits in outer rings while balancing on BOSU device
- Emerging evidence supports a relationship between neuromechanical perception-action coupling and injury risk
  - VMRT screening and training appear to offer great potential for injury risk reduction
    - More research is needed to establish normative values for different populations of athletes (e.g., gender)

REFERENCES

1. Steiner ME, Berkstresser BD, Richardson L, Elia G, et al. Full-contact practice and injuries in college football. *Sports Health*. 2016; doi:10.1177/1941738115626689.
2. Ward S, Pearce AJ, Pietrosimone B, Bennell K, et al. Neuromuscular deficits after peripheral joint injury: a neurophysiological hypothesis. *Muscle Nerve*. 2015;51(3):327-332.
3. Lepley AS, Ericksen HM, Sohn DH, Pietrosimone BG. Contributions of neural excitability and voluntary activation to quadriceps muscle strength following anterior cruciate ligament reconstruction. *Knee*. 2014;21(3):736-742.
4. Guskiewicz KM, Ross SE, Marshall SW. Postural stability and neuropsychological deficits after concussion in collegiate athletes. *J Athl Train*. 2001;36(3):263- 273.
5. Lynall RC, Mauntel TC, Padua DA, Mihalik JP. Acute lower extremity injury rates increase following concussion in college athletes. *Med Sci Sports Exerc Sci*. 2015;47(12):2487-2492.
6. Broglio SP, Tomporowski PD, Ferrara MS. Balance performance with a cognitive task: a dual-task testing paradigm. *Med Sci Sports Exerc*. 2005;37(4):689-695.