Dual-Task Training for Visual-Cognitive-Motor Neural Integration in ROTC Cadets

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BACKGROUND AND PURPOSE

- Survivability of military personnel is essential for mission success, which can be jeopardized by cognitive or physical impairments
  - Musculoskeletal injury (MSKI)[1] and mild traumatic brain injury (mTBI)[2] are common, and often result in persisting adverse effects
- Emerging evidence links brain perception-action processes to long-lasting effects of previous mTBI and MSKI susceptibility[3]
  - Performance tests are needed to identify subtle deficiencies documented by neuroimaging and electroencephalography[4]
- Integration of visual-cognitive-motor processes has been found to vary substantially among both general and elite populations[5]
  - Visual-motor reaction time (VMRT) and whole-body reactive agility (WBRA) metrics have demonstrated discriminatory power[3]
- The purpose of this study was to assess the potential for improvement of perception-action capabilities of ROTC cadets through brief training sessions that involved whole-body responses to visual stimuli presented in a manner requiring cognitive interpretation

PARTICIPANTS & PROCEDURES

- Baseline and follow-up testing of ROTC cadets (15 male; 11 female) included assessments of VMRT and WBRA
  - 18 to 30 year-old ROTC cadets: 15 male (69.6 ±3.5 cm; 174.0 ±32.2 kg); 11 female (69.6 ±3.5 cm; 174.0 ±32.2 kg)
- VMRT Single-task (ST) and dual-task (DT) quantified by 60-s tests (Dynavision D2™, West Chester, OH; Figure 1)
  - Buttons illuminated until hit; 60-s ST test trial, followed by two different 60-s DT trials (A & B)
    - A: Flanker test – center arrow direction verbal responses (<<<<<, >>>>>, >><>>, <<><<); 20 LCD displays (DT-A)
    - B: Flanker test – center arrow direction motor responses (<<<<<, >>>>>, >><>>, <<><<); 48 LCD displays (DT-B)
- WBRA quantified by 20-target lateral (Lat) and 12-target diagonal (Diag) movements (TRAZER® Westlake,OH; Figure 2)
  - Movements guided by randomized target appearances on monitor, which disappeared when contacted by avatar
  - Metrics included Reaction Time (RT), Acceleration (Acc), Deceleration (Dec), Speed (Spd), and Asymmetry (Asym)
- Receiver operating characteristic (ROC) analysis used to define optimal cut-point for each potential predictor variable
  - Cross-tabulation and logistic regression analyses used to quantify exposure-outcome associations
  - Odds ratio (and one-sided 95% credible lower limit) calculated to quantify univariable and multivariable associations
- Reactive agility training performed with FITLIGHT™ system (Aurora, Ontario; Figure 3); training conducted over a 7-week period
  - Contact-sensitive light attached to top of cone (46 cm height) initiated training sequence of 25 diagonal movements to targets
    - 3-light display of 4 possible colors presented a duplicated color, which served as the visual cue for correct target
      - 4 possible targets located at 45° and 60° to right and left of 3-light display; 2 m distance from start position (Figure 4)
- Post-training assessments completed using same pre-training procedures with Dynavision D2™ and TRAZER® systems
  - Paired t-tests, standardized response mean (SRM), and percent change used to assess training effect
- Most recent Army Physical Fitness Test (APFT) score available for 77% (20/26) of FITLIGHT™ training program participants
  - Median used to classify fitness level as Low (< 255) or High (≥ 255); improvement magnitude from first to last session compared

RESULTS

- Participants completed an average of 8 training sessions (minimum of 6 and maximum of 12), followed by post-training assessment
  - Pre- and post-training VMRT testing completed by 100% (26/26); 69% (18/26) completed pre- and post-training WBRA testing
    - Change in VMRT greatest for ST (t_{25}=4.16; P<.001) and ST O/I (t_{25}=2.34; P=.014); less change in same DT values (Table 1)
    - Change in WBRA greatest for Lat Spd (t_{17}=2.34; P=.032); no significant change (P<.05) in any other metric (Table 2)
- All cases (Low or High fitness) demonstrated improvement from first to last training session for FITLIGHT™ Test Duration (Figure 5)
  - SRM=.57; Change=8%; (t_{25}=2.92; P=.007); comparable improvement magnitude of 3-4 seconds for Low and High fitness groups
  - FITLIGHT™ Test Duration substantially reduced from Week 1 to Week 3; less reduction from Week 3 to Week 7 (Figure 6)
    - Most improvement observed within 3 weeks of training initiation; plateau apparent beyond 5 weeks after training initiation

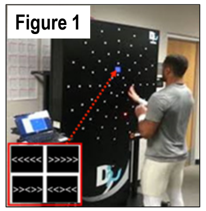

Figure 1

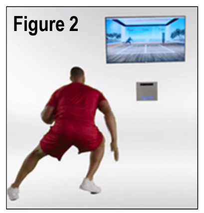

Figure 2

Figure 3

Table 1	Pre Mean	Post Mean	Change	SRM	%
VMRT ST (ms)	918 ±158	814 ±100	103 ±127	.81	11%
VMRT DT-A (ms)	1147 ±241	1090 ±203	57 ±178	.31	5%
VMRT DT-B (ms)	885 ±216	900 ±101	– 16 ±196	.08	– 2%
VMRT ST O2/I2	1.46 ±0.21	1.33 ±0.13	0.13 ±0.25	.52	9%
VMRT DT-A O2/I2	1.75 ±0.37	1.66 ±0.30	0.08 ±0.35	.24	5%
VMRT DT-B I-C (ms)	–66 ±120	– 65 ±67	– 08 ±129	.01	1%

Table 2	Pre Mean	Post Mean	Change	SRM	%
WBRA Lat RT (ms)	593 ±114	615 ±142	– 22 ±102	– .22	– 4%
WBRA Lat Speed (m/s)	0.70 ±0.06	0.79 ±0.14	0.09 ±0.17	.55	14%
WBRA Lat Acc (m/s²)	3.19 ±.54	3.16 ±.55	– .03 ±.50	– .06	– 1%
WBRA Lat Dec (m/s²)	2.40 ±0.35	2.44 ±0.37	0.04 ±0.35	.10	1%
WBRA Diag RT (ms)	647 ±134	636 ±135	11 ±171	.06	2%
WBRA Diag Spd (m/s)	1.03 ±0.22	1.07 ±0.48	0.04 ±0.56	.07	4%
WBRA Diag Acc (m/s²)	2.54 ±0.48	2.35 ±0.53	0.19 ±0.61	– .32	– 8%
WBRA Diag Dec (m/s²)	2.16 ±0.37	2.32 ±0.67	0.16 ±0.74	.22	8%

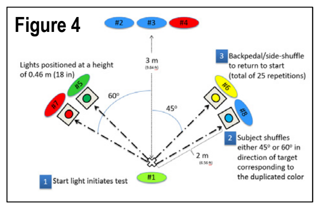

Figure 4

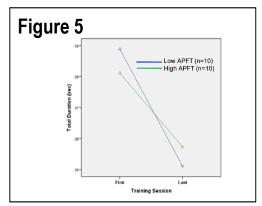

Figure 5

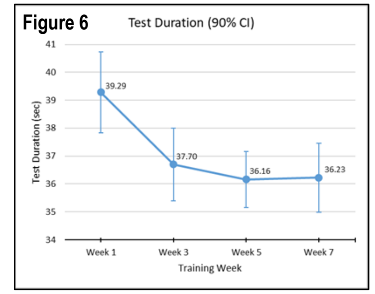

Figure 6

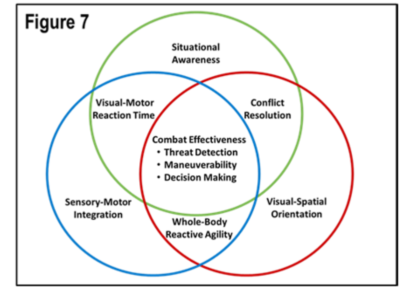

Figure 7

CLINICAL RELEVANCE

- Our findings support the potential for improvement of perception-action processes through completion of brief training sessions
  - Perception-action performance appears to represent a critically important capability that differs from that measured by the APFT
    - Training that integrates visual-cognitive-motor demands may produce adaptations that enhance neural processing efficiency
- Perception-action training may provide an important means to optimize military capabilities and to reduce injury susceptibility
  - Improvement in reactive agility across training sessions associated with improvement in some VMRT and WRBA metrics
    - VMRT and WRBA metrics may directly relate to threat detection, maneuverability, and rapid decision-making (Figure 7)
- Combat effectiveness critically depends on the ability to accurately perceive and appropriately respond to complex and rapidly changing environmental conditions, which our findings suggest can be improved through appropriately designed training

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