Perception-Action Coupling Assessment and Training in ROTC Cadets

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BACKGROUND AND PURPOSE

- Musculoskeletal injuries are sustained by 600,000 soldiers each year, resulting in >2.2 million medical encounters[1]
  - An estimated 68,000 soldiers per year are unable to deploy as a result of musculoskeletal injuries[2]
    - Force readiness is directly impacted, and consequently, national defense capabilities[3]
- Perception-action coupling specifically refers to responsiveness to rapidly changing environmental stimuli[4]
  - Deficiencies in cognitive and visual-motor processes may expose healthy service members to elevated injury risk
    - Dual-task assessment and training appear to offer potential for risk reduction and performance enhancement[5]
- The purposes of this study were to identify perception-action coupling associations with elite warrior status and sub-optimal functional status, and to assess the extent to which visual-motor training could enhance capabilities.

PARTICIPANTS & PROCEDURES

- Baseline testing included different assessments of visual, cognitive, and motor abilities of 42 ROTC cadets
  - 5 cases excluded due to incomplete data and 2 cases excluded due to abnormal test results (>2 SD below mean)
    - Analysis limited to 35 cases (20.5 ±3.1 yrs; 69.6 ±3.5 cm; 174.0 ±32.2 kg); Ranger (n=15); Non-Ranger (n=20)
  - 10-item Sports Fitness Index (SFI) used to obtain self-ratings of persisting effects of previous injuries
  - Visual-motor reaction time (VMRT) assessed and trained with Dynavision D2 System™ (West Chester, OH)
    - 60-s single-task (ST) test and 60-s dual-task (DT) test (VMRT with simultaneous performance of flanker test)
      - Verbal responses to indicate direction of center arrow of 5-arrow flanker displays on LCD screen (Figure 1)
  - Whole-body reactive agility (WBRA) assessed by TRAZER® Sports Simulator (Traq Global Ltd, Westlake, OH)
    - 20 lateral movements (0.9 m) in response to virtual reality targets (10 in each direction; random order)
      - Reaction time (RT) for whole-body target responses; total time (TT) elapsed for test completion (Figure 2)
  - Dual-task VMRT training performed 2X per week for 6 weeks; various secondary cognitive tasks presented
    - Training sessions with description of secondary cognitive tasks performed presented in Table 1
  - Post-training assessment of VMRT and WBRA involved same tests and procedures administered prior to training
    - Corruption of WBRA test data for 2 cases required imputation of cohort mean value for WBTT
  - Statistical analyses focused on baseline discrimination between cadet subgroups and performance improvements
    - Ranger vs. Non-Ranger status and Suboptimal vs. Optimal Function (≤ vs. > SFI median score)
      - Receiver operating characteristic analysis, logistic regression, and repeated measures analysis of variance

Figure 1

Figure 2

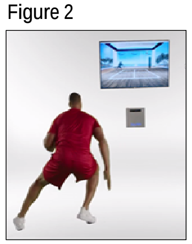


Table 1. Dual-Task Visual-Motor Training Program

Session	Secondary Task	Dual-Task Test Description
1	Alphabet Backward	Letter appears on screen; preceding letter recited
2	Numbers by 2s	Number appears on screen; number plus 2 recited
3	Digit Span Forward	String of 3-7 numbers appears on screen; sequence recited
4	Word Association	Letter appears on screen; word that starts with letter recited
5-6	Flanker	Verbal response to indicate direction of center arrow
7	Math Equation	Simple math equation appears on screen; answer recited
8	Word Recognition	Recall of words on 15-word list; verbal yes/no response
9	Digit Span Backward	String of 3-6 numbers on screen; recited in reverse order
10	5-Word Recall	5 words appear on screen 3s; after test, words recited

RESULTS

- Prediction of Ranger status from baseline data yielded 3-factor model; $\chi^2(3) = 17.22$; $P = .001$ (Table 2)
  - Hosmer & Lemeshow goodness-of-fit $\chi^2(4) = 1.33$; $P = .856$; Nagelkerke $R^2 = .522$
- Prediction of Ranger status from post-training data yielded 2-factor model; $\chi^2(2) = 14.81$; $P = .001$ (Table 3)
  - Hosmer & Lemeshow goodness-of-fit $\chi^2(2) = 1.63$; $P = .444$; Nagelkerke $R^2 = .463$
- Prediction of Optimal Function (SFI > 80; baseline data) yielded 2-factor model; $\chi^2(2) = 16.64$; $P < .001$ (Table 4)
  - Hosmer & Lemeshow goodness-of-fit $\chi^2(2) = 0.53$; $P = .767$; Nagelkerke $R^2 = .506$
- Baseline to post-training change in VMRT-ST and VMRT-DT depicted for Rangers vs. Non-Rangers (Figures 3 & 4)
  - VMRT-ST trials difference: $F_{1,33} = 40.21$; $P < .001$; VMRT-DT trials difference: $F_{1,33} = 52.79$; $P < .001$
- Baseline to post-training change in WBRA-TT depicted for Optimal vs Suboptimal Function (Figure 5)
  - WBRA-TT group X trial interaction: $F_{1,33} = 4.98$; $P = .032$

Table 2. Results of Univariable & Multivariable Analyses – Prediction of Elite Warrior Status (Baseline)

Predictor	Cut-Point	AUC	P-Value*	Sensitivity	Specificity	OR ($CLL_{95\%}$)	Adj OR ($CLL_{95\%}$)
WBRA-TT	≤ 60 s	.670	.006	47%	95%	16.63 (2.51)	22.78 (2.58)
DASS	≤ 17	.595	.049	87%	45%	5.32 (1.25)	10.75 (1.28)
VMRT-ST	≤ 890 ms	.683	.039	80%	55%	4.89 (1.34)	6.06 (1.13)
WBRA-RT	≤ 660 ms	.523	.144	87%	35%	3.50 (0.81)	—
VMRT-DT	≤ 1110 ms	.523	.226	73%	45%	2.25 (0.57)	—
3-Factor Model	≥ 2	.849	.001	87%	78%	15.17 (3.44)	—

* Fisher's Exact One-Sided Test

Table 3. Results of Univariable & Multivariable Analyses – Prediction of Elite Warrior Status (Post-Training)

Predictor	Cut-Point	AUC	P-Value*	Sensitivity	Specificity	OR ($CLL_{95\%}$)	Adj OR ($CLL_{95\%}$)
VMRT-DT	≤ 825 ms	.758	.002	73%	80%	11.00 (2.91)	8.49 (2.03)
WBRA-TT	≤ 60 s	.723	.007	53%	90%	10.29 (2.31)	7.35 (1.41)
DASS	≤ 17	.595	.049	87%	45%	5.32 (1.25)	—
VMRT-ST	≤765 ms	.642	.026	73%	65%	5.11 (1.49)	—
WBRA-RT	≤ 668 ms	.672	.091	73%	55%	3.36 (1.00)	—
2-Factor Model	Both +	.820	.004	80%	70%	9.33 (2.47)	—

* Fisher's Exact One-Sided Test

Table 4. Results of Univariable & Multivariable Analyses – Prediction of Optimal Function (Baseline)

Predictor	Cut-Point	AUC	P-Value*	Sensitivity	Specificity	OR ($CLL_{95\%}$)	Adj OR ($CLL_{95\%}$)
WBRA-TT	≤ 66 s	.760	.002	78%	75%	11.25 (2.99)	13.46 (2.89)
VMRT-ST	≤ 885 ms	.625	.013	80%	58%	6.58 (1.64)	10.78 (1.81)
DASS	≤ 17	.645	.030	47%	88%	6.38 (1.47)	—
VMRT-DT	≤ 1110 ms	.625	.042	53%	81%	4.82 (1.32)	—
2-Factor Model	Both +	.838	.001	68%	88%	15.17 (3.44)	—

* Fisher's Exact One-Sided Test

Figure 3

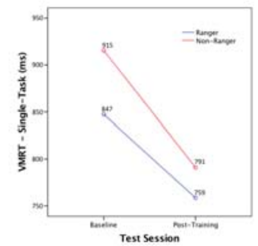


Figure 4

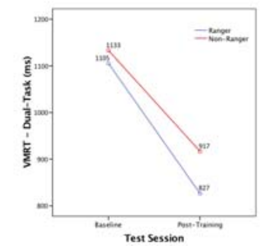
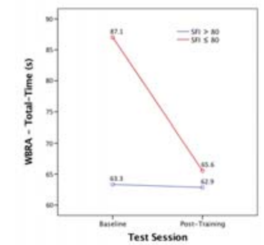


Figure 5



CLINICAL RELEVANCE

- Screening of perception-action coupling ability is valuable for identification of persisting effects of previous injuries
  - WBRA-TT and VMRT-ST demonstrated strongest power for discrimination between low versus high function
- Military personal are frequently required to perform demanding cognitive and physical tasks simultaneously
  - WBRA-TT and VMRT-ST demonstrated strongest power for discrimination between Ranger versus Non-Ranger
    - Self-reported low levels of depression, anxiety, and stress provided further characterization of Ranger status
- Dual-task VMRT training clearly resulted in improved perception-action coupling ability, including WBRA-TT
  - After training, VMRT-DT and WBRA-TT were strongest discriminators for Ranger versus Non-Ranger status
    - Both groups demonstrated substantial improvement in VMRT-DT, but Rangers improved to greater extent
  - Low-function cases (SFI ≤ 80) demonstrated major WBRA-TT improvement following VMRT-DT training
- ROTC programs should consider baseline screening and dual-task visual-motor training as a strategy to optimize perception-action capabilities that are highly relevant to both injury prevention and elite military performance

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