Performance Enhancement of College Wrestlers through Immersive Virtual Reality Training

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Introduction

- Training of wrestlers has historically emphasized physical factors, such as strength, flexibility, and aerobic/anaerobic fitness[1]
- Speed and precision of body movements are clearly important for both wrestling performance and injury avoidance[2]
- Assessment and training of integrated perceptual and motor responses to rapidly changing visual stimuli have not been addressed[2]

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Introduction

- Concussion and head acceleration events are common in wrestling, which can have prolonged effects on brain information processing[3]
- Failure to identify such impairment may expose affected athletes to an unrecognized state of elevated susceptibility for injury
- Immersive virtual reality (VR) provides a means to administer challenges to visual and cognitive processes that require execution of specific motor responses[4]

Purpose

- To assess the potential value of immersive VR training for perceptual-motor performance enhancement of Division-I college wrestlers

Participants

- Cohort: 24 Division-I Male College Wrestlers on team roster
  - Age: 20.5 ± 1.8 years (Range: 18 - 25)
  - Height: 1.76 ± 0.07 m (Range: 1.63 - 1.96)
  - Mass: 79.5 ± 11.8 kg (Range: 59.9 - 105.2)
  - Exclusionary Criteria:
    - Injury precluding participation in exertional physical activity
    - Lack of complete pre- and post-training test data

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Procedures

- Pre- and post-training assessments
- Tests performed wearing wrestling shoes on mat
  - Immersive VR: 40 successive trials involving reaching/lunging responses
  - Whole-body reactive agility: 20 successive trials of lateral shuffling

Pre- and Post-Training Immersive VR Test

- 40 successive reaching/lunging responses to visual stimuli

- Left vs. Right response determined by visual stimulus characteristics
- Reaching/lunging distance based on T-pose measurement (80%)
- Response targets located beyond peripheral margin of visual field
- VR hand controller used to register response to visual stimulus
- Auditory and haptic feedback confirmed contact with response target

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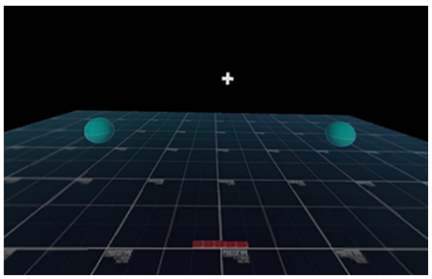
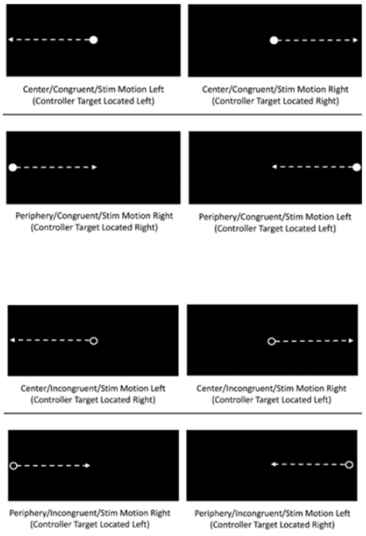
Pre- and Post-Training Immersive VR Test

Immersive Virtual Reality Test

- 40 trials requiring lunging/reaching responses to horizontally moving dots
- Auditory tone and controller vibration feedback provided when target contacted





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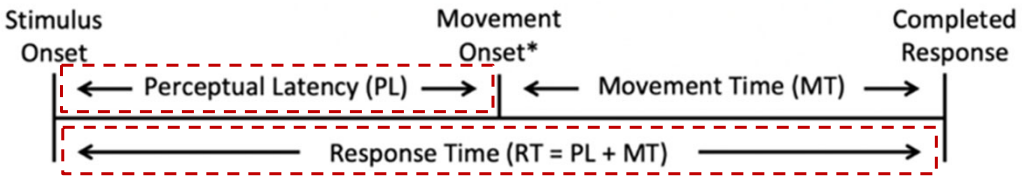
Immersive VR Metrics



* 6° Angular Rotation (Eyes and Neck) or 10 cm Linear Translation (Arm and Step)

Operational Definitions of Perceptual Latency and Response Time

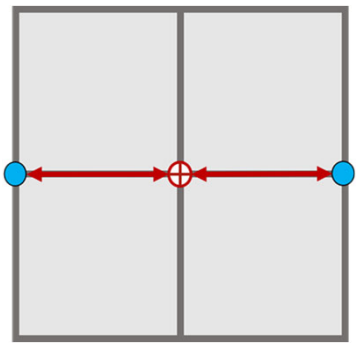
Methods: Immersive VR Test Metrics

- Perceptual Latency (PL): Eyes, Neck, Arm, Step
  - 40-Trial Average and Trial-to-Trial Intraindividual Variability
- Response Time (RT): Eyes, Neck, Arm, Step
  - 40-Trial Average and Trial-to-Trial Intraindividual Variability
- Composite Metric: Rate Correct Score (RCS: Correct Responses per Sec)
  - RCS-PL = Number Correct / Sum of PL Values
  - RCS-RT = Number Correct / Sum of RT Values
    - Calculated from Arm Movements (Hand Controller)

Whole-Body Reactive Agility Test

- Targets appear on both Left and Right sides of monitor
- Correct movement response dictated by direction of center arrow
- Distance Center to Target and back to Center = 1.83 m

Lateral Side-Shuffle Agility Test
10 Left – 10 Right



- Reaction Time (ms)* - Average
- Speed (m/s) - Average
- Acceleration (m/s^2) - Average
- Deceleration (m/s^2) - Average
- Total Distance (m) - 20 trials

* Stimulus appearance to body displacement of 20 cm

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Perceptual-Motor Training Program

- Immersive VR similar to pre-training procedure
  - Lunging responses only – no arm reaching to targets
  - 2 sets of 20 trials per session
  - 2 times a week for 3 weeks
- Statistical analysis
  - Paired-samples t-tests
    - Alpha = .05
    - No multiple comparisons adjustment

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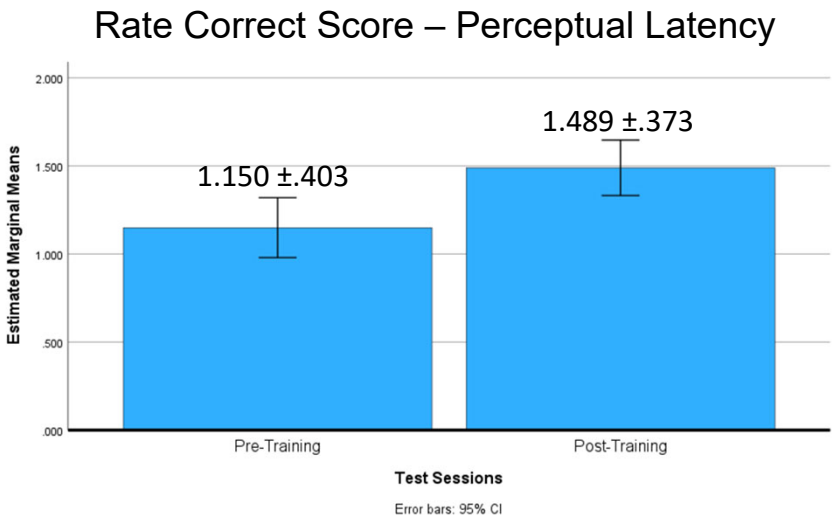
Perceptual-Motor Training Program Effect

Paired Samples t-test Result



Change = .339 ±.277
P < .001
MDC_{95} = .117

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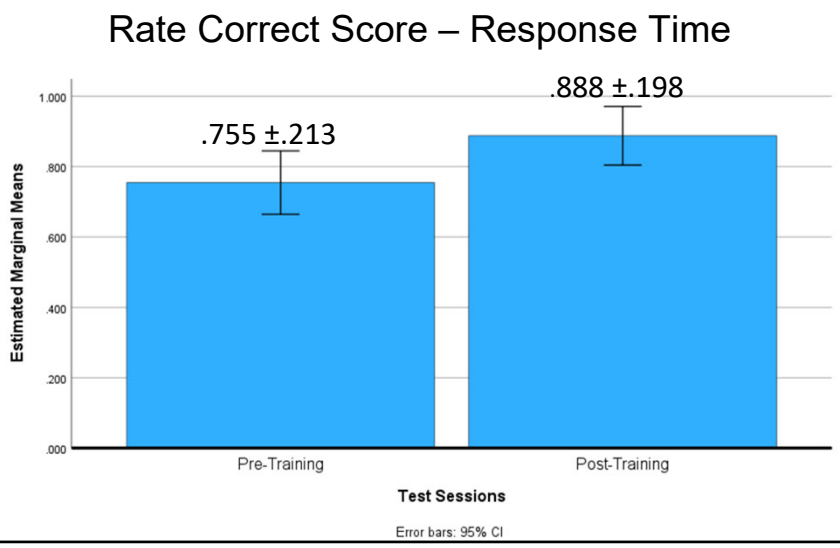
Perceptual-Motor Training Program Effect

Paired Samples t-test Result



Change = .133 ±.154
P < .001
MDC_{95} = .092

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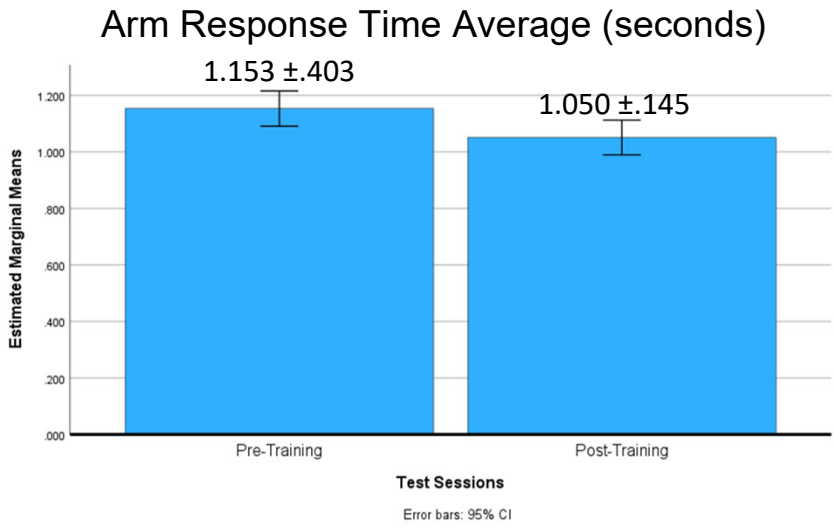
Perceptual-Motor Training Program Effect

Paired Samples t-test Result



Change = .102 ±.096
P < .001

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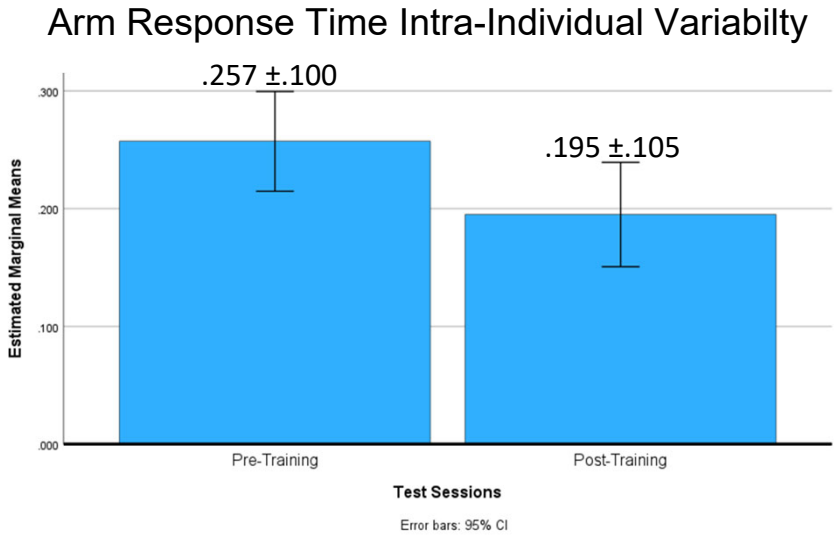
Perceptual-Motor Training Program Effect

Paired Samples t-test Result



Change = .062 ±.100
P = .006

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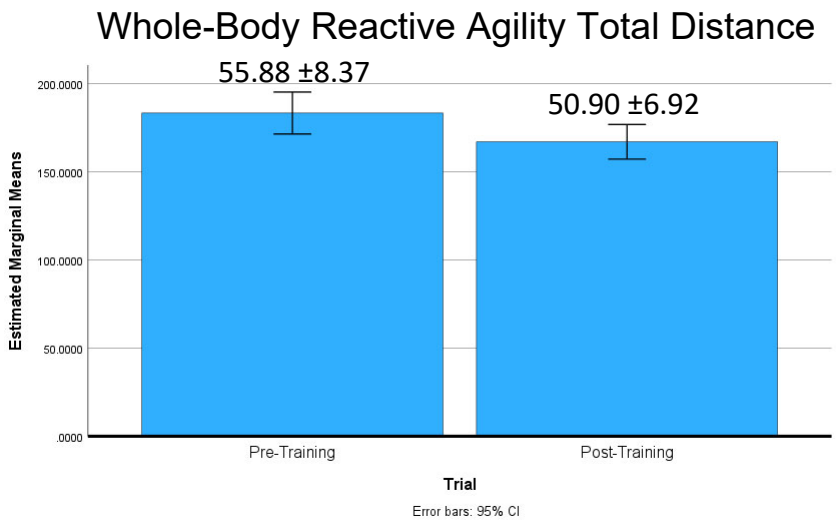
Perceptual-Motor Training Program Effect (n=23)

Paired Samples t-test Result



Change = 4.98 ±8.27
P = .009

Discussion

- Significant Pre- to Post-Training improvement:
  - Rate Correct Score (Correct Responses per Second) – Speed-Accuracy Balance
    - RCS – Perceptual Latency: Stimulus to Movement Initiation (P < .001)
    - RCS – Response Time: Stimulus to Maximum Arm Reach Toward Target (P < .001)
  - Arm Response Time (seconds)
    - 40-Trial Average (P < .001) – Faster Response Time
    - Trial-to-Trial Variability (P = .006) – More Consistent Performance
  - Whole-Body Reactive Agility Total Distance (P = .009) – Greater Precision

Discussion

- Decreased Intra-Individual Variability of Arm Responses believed to relate to efficiency of perceptual-motor processes in the brain[5]
- Cognitive stability (performance consistency) dependent on integrity of white matter tracts[6]
- Decreased WBRA Total Distance suggests improvement of visual-spatial movement precision[7]

Clinical Relevance

- Perceptual-motor training appears to provide the potential for improvement of athletic performance capabilities
- Faster and more accurate responses to visual stimuli probably result from enhanced brain processing efficiency
- Improvement of visual-spatial calibration may be particularly important to increase the movement precision of wrestlers
- Excessive focus on training muscle capabilities may neglect enhancement of the visual-cognitive component of performance

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