

What is the effect of physical exertion on cognitive performance under various dual-task conditions?

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Background

- **Moderate to vigorous physical activity can improve cognitive performance^{1,4}**
 - A graded exercise protocol has been used to simulate sport physical demand
 - Magnitude of effect may depend on complexity of the cognitive task
- **Exertion may enhance arousal, thereby facilitating neural processing efficiency^{2,3,4}**
 - Reaction time widely accepted as an indicator of efficient brain function
 - Dual-task condition can quantify integration of cognitive-motor performance
- **Physical exertion may shift the inverted-U arousal-performance relationship⁴**

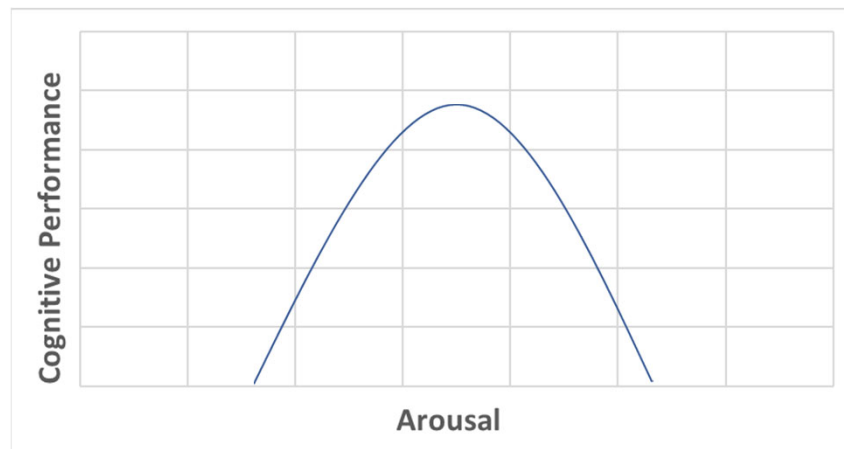


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Goldilocks Principle

- Insufficient or excessive arousal linked to poor cognitive function
- Physical exertion known to influence sympathetic nervous system activation
- Interaction of cognitive-motor task complexity and exercise unknown⁵

Inverted-U relationship



• Study Purpose

- To assess the effects of physical exertion on cognitive performance under 3 dual-task conditions imposing various motor demands among young, healthy participants

• Hypotheses

- We anticipated that a moderate level of physical exertion would alter the arousal-performance relationship, such that optimum performance would be observed after exercise and that the effect would differ for single- (cognitive) versus dual-tasks (cognitive-motor)



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Participants

- N=34; 24.03 ± 1.44 years
 - 17 Males (178.7 ±5.8 cm; 79.7 ±12.1 kg)
 - 17 Females (165.3 ±7.1 cm; 64.9 ±12.2 kg)
- All participants were graduate health professions students
 - Physical Therapy, Occupational Therapy, Athletic Training
 - Avg *Disablement in the Physically Active* score 97.2% (Range 79.7-100%)
- Exclusion criteria:
 - Persisting symptoms from a recent lower extremity injury
 - Prior history of concussion
 - Age greater than 30 years



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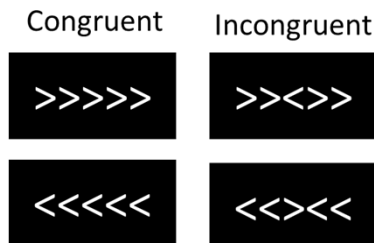
Procedures: Cognitive & Cognitive-Motor Testing

- Seated (Single-task)
 - Elbows tucked
- Dominant-leg stance (Dual-task)
 - Balancing on preferred kicking leg
- Walking (Dual-task)
 - Self-selected walking pace on a firm surface
- Lateral (Dual-task)
 - Self-selected lateral stepping pace on a firm surface, stepping to the right side



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Procedure: Flanker Test



Reaction time (RT) Milliseconds

Efficiency index (EI) = $RT + (1 - \text{accuracy proportion}) \times RT$

Flanker Conflict Effect (FCE) = $\text{Incongruent Avg RT} - \text{Congruent Avg RT}$



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Procedures: Physical Exertion

- 20-minute treadmill running session
 - Warm-up period of less than 5 minutes
 - Self-selected pace to maintain RPE in 15-18 range for final 12 minutes
 - 10-minute rest before post-exertion testing



Statistics

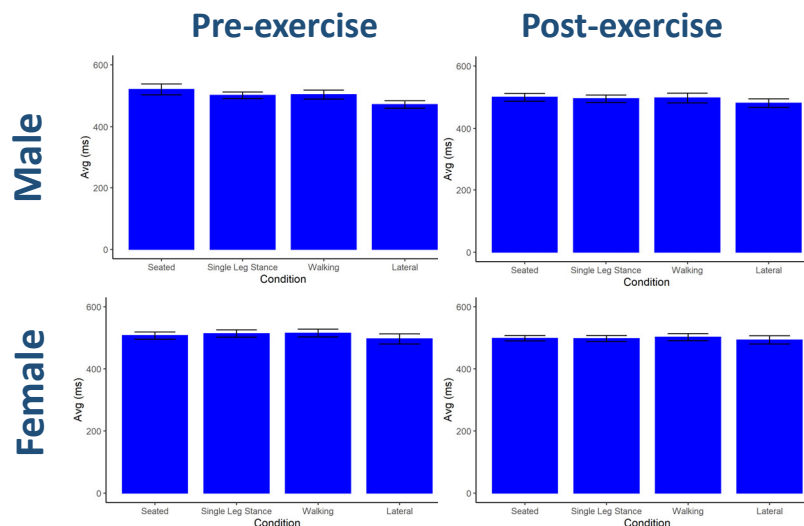
- Conducted three 4 x 2 x 2 (condition by time by sex) repeated measures analyses
 - Reaction time
 - Efficiency Index
 - Conflict Effect
- Tukey's Post Hoc testing used as appropriate
- Cohen's d used for interpretation⁶
- A priori significance level set at $p < .05$

Omnibus Results—Reaction Time

- Reaction Time
 - Three-way interaction was not significant ($p = .78$; $\eta^2 = .002$)
 - Condition effect significant ($p < .001$; $\eta^2 = .008$).
 - RT during lateral stepping quicker than during seated (Cohen's $d = .68$)
 - Between sex effect not significant ($p = .66$; $\eta^2 = .002$)



Reaction Time

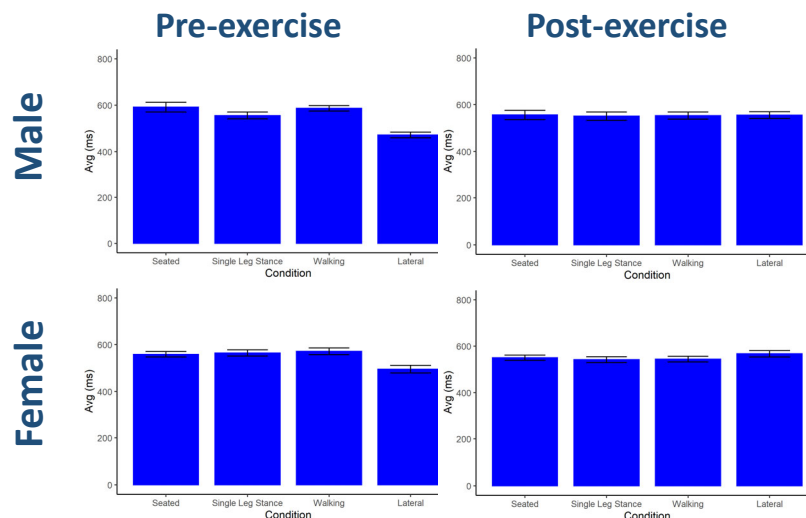


Omnibus Results—Efficiency Index

- Efficiency Index
 - Three-way interaction was not significant ($p = .36$; $\eta^2 = .004$)
 - Condition effect significant ($p < .001$; $\eta^2 = .228$)
 - El during lateral stepping quicker than during seated (Cohen's $d = 1.73$)
 - Between sex effect not significant ($p = .87$; $\eta^2 = 3.34e-4$)
 - Time effect was significant ($p = .010$; $\eta^2 = .014$)
 - Post-testing was quicker than pre-testing (Cohen's $d = 0.27$)



Efficiency Index

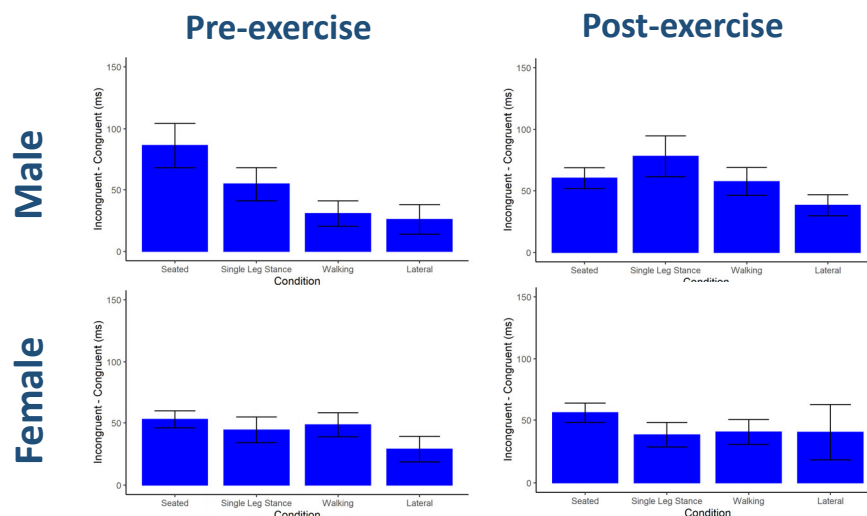


Omnibus Results—Conflict Effect

- Conflict Effect
 - Three-way interaction was not significant ($p = .12$; $\eta^2 = .017$)
 - Condition effect significant ($p = .002$; $\eta^2 = 0.046$)
 - CE during lateral stepping quicker than during seated (Cohen's $d = .64$)
 - Between sex effect not significant ($p = .46$; $\eta^2 = .003$)



Conflict Effect



Discussion

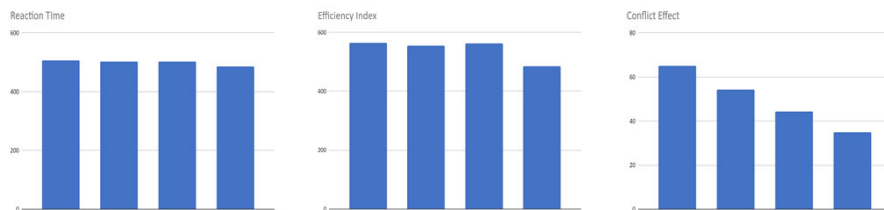
- The time hypothesis is not supported even though the difference between pre and post was significant for EI
 - The difference was 16 ms which is less than the minimally detectable change of 47 ms.⁸
- The second hypothesis is partially supported in that participants tended to have better performance in lateral walking compared to seated and this effect was more pronounced in pre-exercise.



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Condition Effect

- Seated reaction time consistently worse than lateral stepping
- Goldilocks principle



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Fitts' Law

- Inverse relationship between speed and accuracy.⁹
 - Exercise worsened accuracy but not reaction time
 - Reaction time (Cohen's $d = 0.68$) was consistent through pre- and post-exercise
 - Particularly during lateral stepping, accuracy worsened after exertion as represented by EI (Cohen's $d = 1.73$)



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Clinical Relevance

- Target appropriate task complexity
- Under exertional conditions accuracy appears to worsen
- Evidence indicates that neurocognitive errors in accuracy are also associated with poor movement quality.¹⁰
- Conflict Effect is prospectively associated with core and lower extremity injury among high school and college players¹¹



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Citations

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