The Effect of Cognitive Demand on Exercise Capacity and Performance

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ABSTRACT

PURPOSE: In the context of many of high-stress environments, such as NASA and the military, physiologic stress is often accompanied by the requirements to complete neurocognitive tasks. This study sought to investigate the effect of cognitive demand on exercise capacity ($\dot{V}O_2$max and Anaerobic Threshold) and performance (Agility).

METHODS: An agility T-test and $\dot{V}O_2$ max test were performed on two nonconsecutive days with cognitive tasks (algebraic problem during the agility T-test and N-back (2-back) test during the $\dot{V}O_2$max test) added on the second testing day to measure T-test completion time, T-test cognitive test results, $\dot{V}O_2$ max, RER, aerobic threshold (%$\dot{V}O_2$ max when RER ≥ 1), the stage of Bruce protocol the participant was able to reach to, and n-back test results. A Paired T-test was used to analyze the data to determine significant changes in physical capability and ability to complete cognitive tasks.

RESULTS: While there was no significant difference in agility and anaerobic threshold between tests with or without cognitive demand, $\dot{V}O_2$ max (P=0.018) and Bruce Protocol stage achieved (P=0.02) were higher when performed without cognitive demand.

CONCLUSION: Our results show that while cognitive demand does not affect exercise performance (agility) and how long an individual can sustain a prolonged exercise before lactate accumulation (anaerobic threshold), it lowers $\dot{V}O_2$ max and the workload an individual can achieve until exhaustion, indicating that when performing physical activity with cognitive demand, the capacity to achieve maximal intensity may be lowered while the performance is unaffected in young and healthy adults.

BACKGROUND

Vital roles, such as those in the National Space and Aeronautical Association (NASA), require the completion of cognitively challenging tasks while in situations of high stress or physical exertion. However, studies investigating the capability of performing physical activities while completing tasks requiring a high level of attention and cognition is absent. This study sought to determine the effects of cognitive demand on exercise capacity and performance using $\dot{V}O_2$max, anaerobic threshold, and agility testing. $\dot{V}O_2$max is a quantitative test used to determine the oxidative capacity or the highest level of oxygen consumption that a person can achieve while performing at a maximum level of exertion. The anaerobic threshold is the point at which a person would begin to rely on anaerobic metabolism and accumulate lactate. Increased levels of lactate are associated with much quicker rates of physical exhaustion. Agility represents an individual's ability to change directions while paying attention to the surrounding. In a stressful environment, the rate of fatigue and capacity to perform may determine the success of an important task or function.

PURPOSE

The purpose of this study is to investigate the effect of cognitive demand on exercise capacity and performance including $\dot{V}O_2$max, anaerobic threshold, and agility.

METHODS

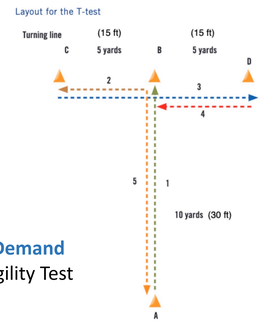
SUBJECTS

- **30 participants were recruited**
  - 18 Males
  - 12 Females
- **19 participant completed both test sessions**
  - 10 Males
  - 9 Females
  - 17 Athletes
  - 2 Non-athletes

	Range	Mean ± SEM
Age (years)	18-23	20.17 ± 1.49
Height (cm)	151-191	172.50 ± 10.38
Weight (Kg)	44-115.22	71.81 ± 13.69

1st TEST SESSION

- **Agility Test**
  - T-test
- **$\dot{V}O_2$max Test**
  - Bruce protocol
  - TrueOne 2400 system



2nd TEST SESSION

- **Agility Test with Cognitive Demand**
  - **Cognitive Demand** for Agility Test
    - An algebraic problem
    - Example: 6 x 6 +5
  - Participants were shown the algebraic problem 3 seconds prior to starting and required to give an answer immediately following the completion of the test
- **$\dot{V}O_2$max Test with Cognitive Demand**
  - **Cognitive Demand** for $\dot{V}O_2$max
    - N-back test (N=2)
  - participants completed the $\dot{V}O_2$max test while performing an N-back test (N=2)

ANAEROBIC THRESHOLD

- Anaerobic Threshold = $\frac{\dot{V}O_2 \text{ when RER} \geq 1}{\dot{V}O_2\text{max}}$
- RER was obtained during the $\dot{V}O_2$max test

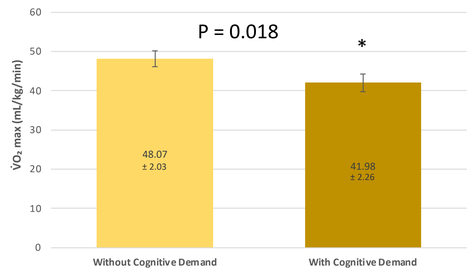
METHODS

STATISTICS

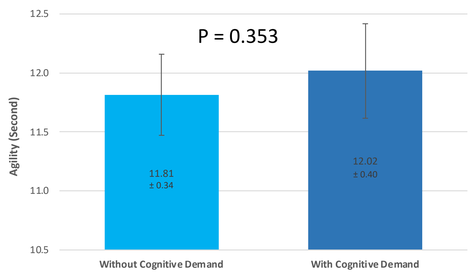
- Data were analyzed using IBM SPSS 25
- Paired t-test was used to test the difference between exercise test results with and without cognitive demand
- Statistically significant level: P ≤ 0.05
- The results are expressed as Mean ± Standard Error Mean (SEM)

RESULTS

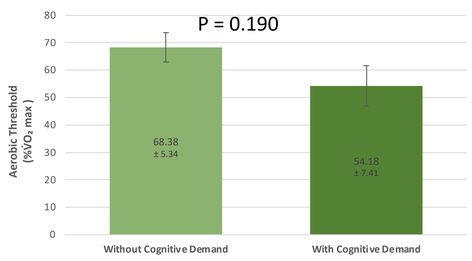
Oxidative Capacity ($\dot{V}O_2$max)



Agility Test Time (Lower is Better)



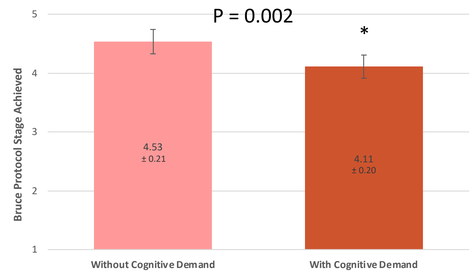
Aerobic Threshold (%$\dot{V}O_2$max when RER ≥ 1)



Data are Mean ± SEM

RESULTS

Stage of Bruce Protocol Achieved



Data are Mean ± SEM

DISCUSSION

Our results show that there is no effect of cognitive demand on agility and the ability to sustain a prolonged exercise until lactate accumulation (anaerobic threshold). However, $\dot{V}O_2$max and the completion stage of the Bruce protocol during the $\dot{V}O_2$max test was significantly lower when the participants were required to complete cognitive tasks, indicating a much quicker onset of fatigue while performing challenging cognitive tasks. It should be noted that our participants are healthy young college students. Many of them are athletes. Further research may include participants with a wider range of age and compare the accuracy of cognitive task tests while performing physical activity and at rest.

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