The Relation among Physical Activity, Physical Fitness and Time of Useful Consciousness

Shuo-Wen Liang
Background

• Pilots have to face the challenge of hypoxia during a flight mission.
• Hypoxia result a decrease of cognitive function, thus deteriorate judgment.
• Exercise might improve hypoxia tolerance.
Hypoxia

Hypoxia: Abnormal oxygenation
- Histotoxic hypoxia
- Hypemic hypoxia
- Stagnant hypoxia
- **Hypoxic hypoxia**
  - Deficiency in alveolar oxygenation.
  - Reduced oxygen partial pressure in inspired air.

How Does Hypoxia Affect Pilot?

• Reduce Visual Function
• Cardiovascular and Respiratory Effect
• Cognitive Impairment
  • Brain processing slow down
  • Intelligence ↓
  • Memory ↓
  • Attention ↓
  • Judgement ↓
Time of Useful Consciousness (TUC)

- What is TUC/EPT?
- How to determine TUC?
- What are the common factors of TUC?

Physical Activity (PA)

- Body movement produced by muscle action that increases energy expenditure.
- **Exercise**: repetitive and purposeful physical activity.
Physical Fitness

- How well one performs Physical Activity.
- Physical fitness has proved associated with cardiovascular function.
- Beneficial effect of physical fitness might result in better cardiovascular health and thus a **better hypoxia tolerance** and a longer TUC.

How Physical Activity Effect Your Body

• Cardiovascular System Regulation
  • Cardiac Output (CO) = Heart Rate (HR) x Stroke Volume (SV)
  • a-vO2 difference

• Brain Metabolism of Energy

• Gas Exchange and Transport Efficiency
Purpose

• Determine the Relationship of **Physical Activity** and **Time of useful consciousness (TUC)**:
  • Does TUC differ regards to different physical fitness level?
  • Does regular physical activity effect TUC?

• Help military and civil aeronautics pilot preventive of hypoxia event.
Method
Subject

- 81 air force healthy and active aircrew (72 men, 9 women, mean age 29.6) recruited in the Aerospace Physiology Research Laboratory.
- History of cardiovascular diseases or respiratory diseases was excluded.
- File up **physical activity questionnaire** and collect **physical fitness test** results before the research.
# Physical Activity Questionnaire

**FIGURE 1**

Habitual physical activity questionnaire

Please, make a circle around the appropriate answer for each question, considering the past 12 months:

1. Do you or did you practice sports or physical exercise within the past 12 months: yes/no
   - Which sport or physical exercise do you or did you practice more often?
     - how many hours a week?
     - how many months a year?

If you practice or practiced a second modality of sport or physical activity, what is it?:
   - how many hours a week?
   - how many months a year?

2. When compared to others of my age, I think my physical activity during leisure hours is: much more/more/the same/less/much less
   | 5 | 4 | 3 | 2 | 1 |

3. During leisure hours, I sweat: very often/often/sometimes/seldom/never
   | 5 | 4 | 3 | 2 | 1 |

4. During leisure hours, I practice sports or physical exercises: never/seldom/sometimes/often/very often
   | 5 | 4 | 3 | 2 | 1 |

5. During leisure time, I watch TV: never/seldom/sometimes/often/very often
   | 5 | 4 | 3 | 2 | 1 |

6. During leisure hours, I walk: never/seldom/sometimes/often/very often
   | 5 | 4 | 3 | 2 | 1 |

7. During leisure hours I ride a bike:
   | 5 | 4 | 3 | 2 | 1 |
Physical Fitness Test

Sit Up, Push Up and 3000m run

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Hypobaric Chamber

• Type V cabin flight simulate 25,000 ft altitude.
• After entering the cabin, they will inhale 100% oxygen for denitrogenation to prevent decompression sickness.
• Cabin pressure reaches 25,000 ft. Subjects will be removed from the oxygen mask and start experience hypoxia.
TUC Determination

• Subject will be asked to perform logical, arithmetic tasks from the beginning of hypoxia exposure.

• Subject SpO2 monitored.

• Termination
  • Subject SpO2 falls below 65.
  • Subject can no longer perform easy logical tasks. (cognitive function decrease)
  • TUC is recorded.
Statistical Analysis

• Subject means and standard deviations were calculated for demographics and physical fitness test results.

• **Linear regression** is used to evaluate TUC and physical fitness test association.

• Divide population into subgroups by age 21-30 and above 30.
Results
Figure 1. Relationship between TUC and physical parameters. Correlation between TUC and the scores of 3000m run ($r^2 = 0.016, p = 0.38$) (A), push-up ($r^2 = 0.001, p = 0.82$) (B), sit-up ($r^2 = 0.005, p = 0.18$) (C), and Baecke questionnaire score total index ($r^2 = 0.012, p = 0.34$) (D).
Figure 2. Relationship between oxygen desaturation rate and physical parameters. Correlation between oxygen desaturation rate and the scores of 3000m run ($r^2 = 0.001$, $p = 0.85$) (A), push-up score ($r^2 = 0.085$, $p = 0.12$) (B), sit-up ($r^2 = 0.005$, $p = 0.73$) (C), and Baecke questionnaire score total index ($r^2 = 0.001$, $p = 0.82$) (D).
Figure 3. Relationship between TUC and physical parameters in different ages. Correlation between TUC and 3000m run score under ($r^2 = 0.005, p = 0.69$) (A) or over ($r^2 = 0.37, p = 0.06$) (B) 30 years old.
Figure 3. Relationship between TUC and physical parameters in different ages. Correlation between TUC and push-up score under \( (r^2 = 0.013, \ p = 0.59) \) (A) or over 30 \( (r^2 = 0.024, \ p = 0.62) \) (B).
Figure 3. Relationship between TUC and physical parameters in different ages. Correlation between TUC and sit-up score under \((r^2 = 0.10, p = 0.13)\) (A) or over 30 \((r^2 = 0.028, p = 0.60)\) (B).
Discussion
Effect of Physical Training at Moderate Altitude (1850 m) on Hypoxic Tolerance

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Effect of systematic physical training at moderate altitude (1850 m) on hypoxic tolerance was evaluated on a group of young soldiers, by determining the Time of Useful Consciousness (TUC) at a simulated altitude of 7620 m in a hypobaric chamber together with the Critical Flicker Frequency (CFF) test. The subjects, after initial testing at Delhi (near sea level) were taken to an altitude of 1850 m and divided into two groups. One group was given systematic endurance physical training for 8 weeks, while the other group served as control. The subjects were then taken to an altitude of 3500 m and kept at that altitude for 4 weeks, after which they were brought back to Delhi and TUC was estimated again within 1 d. The results indicate that endurance physical training at moderate altitude improved hypoxic tolerance and the central nervous system activity under hypoxia.

MATERIALS AND METHODS

Twenty healthy soldiers (20-26 years old) participated in the study. The initial TUC determinations were made at Delhi in a decompression chamber fitted with an oxygen demand regulator Mk 17 (normal air Ltd. Yovil; England). Three subjects were tested per day. The chamber was maintained at a thermoneutral temperature (26-28°C) throughout the experiment. The subjects breathed through the regulator which was set at the normal air position and thus delivered an air-oxygen mixture equivalent to normal air at sea level. When the simulated altitude was stabilised at 7620 m, the subjects were given paper and pencil and were asked to perform a simple numeric writing test by counting backward from 16); hence, these two tests have been employed in this study.
The Effects of Exercise Under Hypoxia on Cognitive Function

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Abstract

Increasing evidence suggests that cognitive function improves during a single bout of moderate exercise. In contrast, exercise under hypoxia may compromise the availability of oxygen. Given that brain function and tissue integrity are dependent on a continuous and sufficient oxygen supply, exercise under hypoxia may impair cognitive function. However, it remains unclear how exercise under hypoxia affects cognitive function. The purpose of this study was to examine the effects of exercise under different levels of hypoxia on cognitive function. Twelve participants performed a cognitive task at rest and during exercise at various fractions of inspired oxygen (FI0₂: 0.209, 0.18, and 0.15). Exercise intensity corresponded to 60% of peak oxygen uptake under normoxia. The participants performed a Go/No-Go task requiring executive control. Cognitive function was evaluated using the speed of response (reaction time) and response accuracy. We monitored pulse oximetric saturation (SpO₂) and cerebral oxygenation to assess oxygen availability. SpO₂ and cerebral oxygenation progressively decreased during exercise as the FI0₂ level decreased. Nevertheless, the reaction time in the Go-trial significantly decreased during moderate exercise. Hypoxia did not affect reaction time. Neither exercise nor difference in FI0₂ level affected response accuracy. An additional experiment indicated that cognitive function was not altered without exercise. These results suggest that the improvement in cognitive function is attributable to exercise, and that hypoxia has no effects on cognitive function at least under the present experimental condition. Exercise-cognition interaction should be further investigated under various environmental and exercise conditions.


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Physiological Factors Associated with Middle Distance Running Performance

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Summary

Middle distance running involves popular race distances with performance dependent on a number of physiological factors. The physiological characteristics of successful runners are different from those of sprinters and long distance runners. Maximal oxygen uptake (VO\textsubscript{2max}), running economy and the anaerobic threshold are variables that have been shown to limit performance during long distance running, and rapid velocity and anaerobic variables have been shown to limit performance during sprinting. Success with middle distance running is dependent on an integrative contribution from aerobic and anaerobic variables which allows a runner to maintain a rapid velocity during a race. The relative contributions of the 2 energy systems are functions of distance, intensity and the physiological abilities of the runner. Middle distance runners can be successful with physiological profiles that include a variety of aerobic and anaerobic capabilities, and this characteristic separates them from long distance runners.
Discussion

• Exercise improves hypoxia cognitive function, but the mechanism is yet to be determined.

• Physical fitness is measured by multiple methods. Most research suggests physical activity has a beneficial effect on hypoxia tolerance.

• These previous research provides alternative methods to measure PA and TUC association.
Limitation

• Different gender with a different physical fitness level criteria should be separated.

• Physical Fitness test result does not objectively represent subject physical fitness level.
Conclusion

• This research suggests a regular physical activity might enhance pilots hypoxia tolerance. A further evaluation to determine the mechanism is needed.
Thank You For Listening!

Acknowledgement
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