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Sex-Related Differences in Reaction Time during Normobaric Hypoxic Hypoxia in Physically Active University Students

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Abstract

Background: Limited research has been completed on the sex-related differences in reaction time during hypoxic hypoxia. This is concerning due to the importance of reaction time during hypoxic hypoxia in aviation (particularly within the realm of military aviation). **PURPOSE:** The purpose of this study was to examine the sex-related differences in reaction time during hypoxic hypoxia in university students. It was hypothesized that females would exhibit both longer reaction times and a more rapid increase in reaction times during hypoxic states when compared to males. These hypotheses are supported by current research which has shown longer female normoxic reaction times and a decline in both physiological and cognitive response to hypoxic hypoxia in females. **METHODS:** The study used a normobaric oxygen device to simulate hypoxic states and Delphi computer software to test simple reaction time. Subjects were physically active university students (10 females, 10 males). The test consisted of each subject completing a 40-minute hypoxic exposure at 12000 feet with reaction time tests conducted every 10 minutes. A mixed-model repeated anova test was used to calculate significant differences between sexes and trials. **RESULTS:** The results of the study showed no significant between group by time interaction with p = .144, but non-statistical differences in this area were observed. Female reaction times for trials 1-4 were as follows: 0.3632 ± 0.05, 0.3535 ± 0.06, 0.3730 ± 0.07, 0.3555 ± 0.06. Males' reaction times were generally faster (trials 1-4): 0.3288 ± 0.04, 0.3240 ± 0.04, 0.3289 ± 0.04, 0.3296 ± 0.05. **CONCLUSIONS:** Based on the equivocal results using the methods of the present study, neither of the hypotheses were supported, yet future research is still warranted to delve deeper into the relationship between hypoxic hypoxia and sex.

Introduction

Within military aviation, there is an increasing need to research hypoxia. Hypoxia, as defined in an article published by the Federal Aviation Administration (FAA) is "the lack of sufficient oxygen in the blood, tissues, and/or cells to maintain normal physiological function" (n.d.). This research is needed due to hypoxic incidents still occurring within military aviation, and the dangers these hypoxic incidents can have to flight personnel.

According to *the AirForce Times*, "400 physiological events between 2017 and 2022 involved "hypoxia-like" symptoms across seven airframes." Some of these events have resulted in the death of the pilot. Flight safety technology has been advancing to lower this number through the addition of Automatic Ground Collision Avoidance System (Auto GCSA) to military planes (Cohen et al., 2023). Flight safety technology is only one part of addressing these hypoxic incidents and other fields of study are needed to increase safety in this area.

Specific physiological research can be conducted to aid in addressing the hypoxic incidents occurring within the military. These can include updating previous aviation safety guidelines during altitude such as the time of useful consciousness chart (FAA, 2009) with the addition of sex as a potential factor. Sex-related differences of hypoxic hypoxia is an important area of study, as females are gradually becoming a higher percentage in military aviation, and current research has suggested sex-related differences in areas which relate to aviation safety.

Methods

After completion of informed consent (Appendix A), subject height and weight were assessed and recorded by the primary investigator. This was followed by one familiarization trial consisting of a test of during normoxic states with the reduced oxygen breathing device (ROBD) set to 1200 MSL (FO_2 20.0% ± 0.6), and completion of one simple reaction time test. The simple reaction time test consisted of subjects responding to a fixed position visual stimulus (a blue circle) appearing at randomized intervals on the computer screen. Reaction times were recorded from the moment the visual stimulus was presented to the time they clicked on the mousepad to respond. Once the participant responded to the visual stimuli, it disappeared until the next stimuli appeared. Intervals between visual stimuli ranged from 1 second to a maximum of 5 seconds. For each trial, 10 visual stimuli were presented.

A pulse oximeter was also worn during the test and values were recorded and confirmed with normal values. After the familiarization trial, participants were provided with a 15-minute rest period before beginning the testing trial. During the rest period, the subject was allowed to remain seated without the mask and pulse oximeter.

Following the rest period, subjects were fitted again with the pulse oximeter and ROBD. The ROBD was set for oxygen levels of 12,000 MSL (13.2 ± .6 %) according to the manufacturer's directions (*Higher Peak*, 2020). Participants were asked to remain seated with minimal movement in the chair for 10 minutes. At the 10-minute mark, oxygen saturation levels were recorded, and subjects performed one simple reaction time test consisting of 10 visual stimuli randomly appearing at various intervals. Subjects repeated the same testing at each of the following times: 20 minutes, 30 minutes, and 40 minutes. If at any point, the pulse oximeter indicated dangerous values (below 70%), or the subject showed visual signs of extreme fatigue, or verbalized they felt unsafe continuing, the testing trial was immediately terminated and conducted again after 24 hours of recovery.

After the trial, participants were asked to remain seated in the lab for five minutes and then complete post-test hypoxic symptoms form to assess current presence and degree of severity of general hypoxic symptoms: headache, dizziness/nausea, and blurred vision. Level of oxygen saturation, rate of perceived exertion, and heart rate were also recorded on the form (Appendix B). If a participant continued to have severe hypoxic symptoms or oxygen saturation levels below normal values (95-100%), they were asked to remain supervised within the lab until symptoms and oxygen saturation values returned to normal.

Figure 1

Normobaric Hypoxic Testing Environment

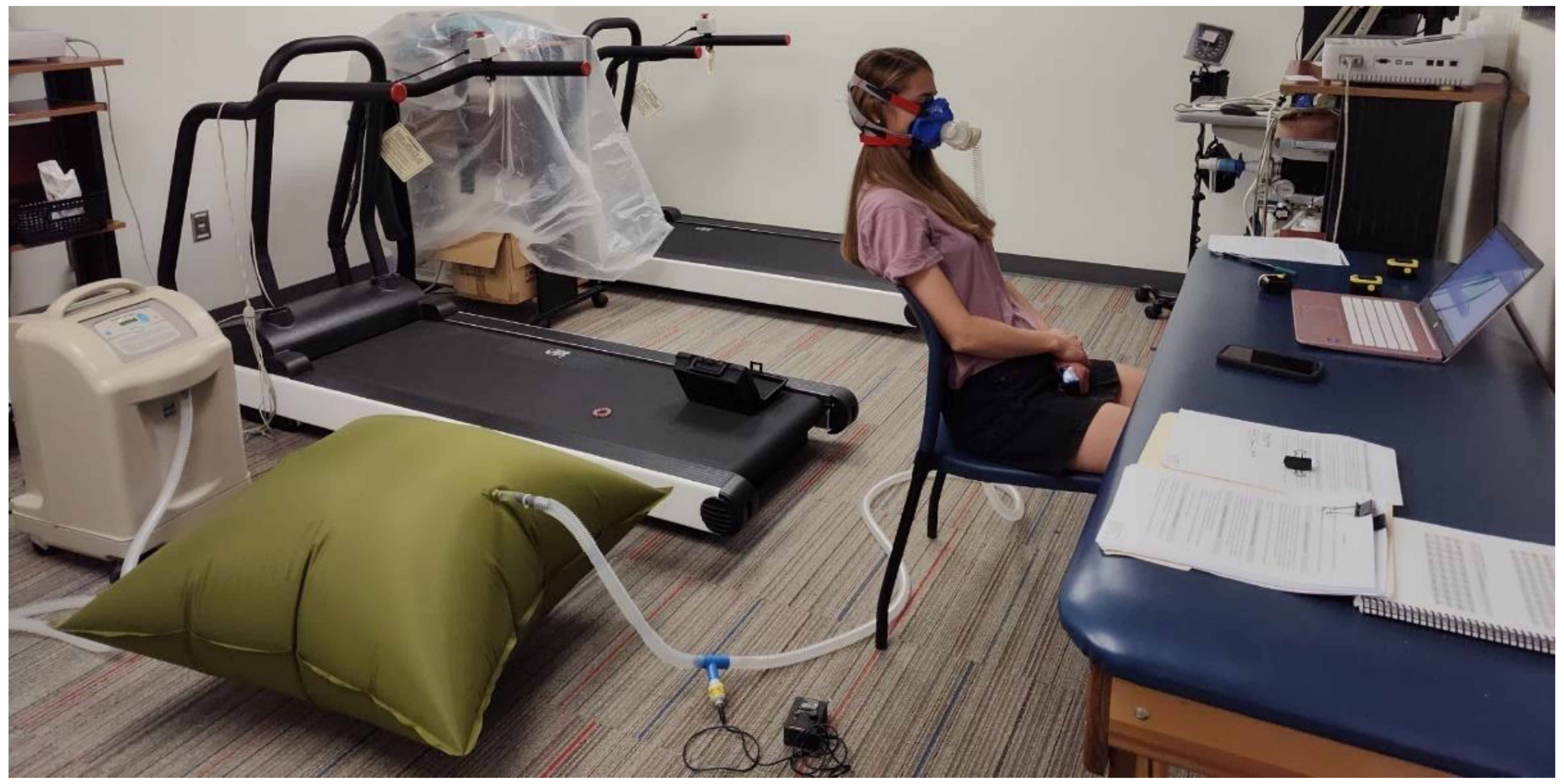

Table 3

Subject Information

	Female (n= 10)	Male (n= 10)	Total (n= 20)
Height (cm)	166.12 ± 8.90	177.80 ± 10.23	171.96 ± 11.09
Weight (kg)	64.18 ± 13.17	86.98 ± 15.65	75.56 ± 18.30
Age (years)	21.30 ± .82	21.10 ± 1.10	21.20 ± .95

Table 4

Mean and Standard Deviations for Reaction Time between Sexes

	Trial 1 (10 minutes)	Trial 2 (20 minutes)	Trial 3 (30 minutes)	Trial 4 (40 minutes)
Females	0.3632 ± 0.05	0.3535 ± 0.06	0.3730 ± 0.07	0.3555 ± 0.06
Males	0.3288 ± 0.04	0.3240 ± 0.04	0.3289 ± 0.04	0.3296 ± 0.05

Results and Conclusions

RESULTS: For the Shapiro-Wilk Test, the assumption of normalcy was violated for trial three at p = 0.008 and trial four at p = 0.047. Levene's Test confirmed the assumption of equal variance (trial 1: p = 0.371, trial 2: p = 0.194, trial 3: p = 0.210, trial 4: p = 0.476). A repeated measures ANOVA revealed no significant difference in reaction time between male or female with p = .144. A non-significant .0334 second difference between male and female groups was observed. Reaction times for both groups are reported in table 4.

No significant increase in reaction time between trials for within groups was observed. There was a non-significant increase in average reaction time between trials 2 and 4 at 0.0056 seconds for males, and between trials 2 and 3 at 0.0195 seconds for females. This trend was not consistent, as between trials 3 and 4, the female reaction time decreased by 0.0175 seconds while male reaction times increased.

CONCLUSIONS: The present study serves as a foundation for future research and indicates the need for greater control of variables and sample size when investigating sex-related differences during hypoxic hypoxia. Due to the limitations of this study, the results do not support or oppose the hypothesis that sex-related differences in reaction time during hypoxic hypoxia exist. However, study findings are not without value as the observed non-significant trends based on indicate the need to further investigation of this topic. A strong need exists for further investigation in this area, as sex-related differences in reaction time during hypoxic hypoxia could negatively affect the safety of those within military aviation due to limited response time during hypoxic events as indicated by the TUC.

Future Work

1. Control for variables such as female menstruation and sleep history due to the effects these variables have been shown to have on reaction time.
2. Add additional familiarization trials before testing to negate potential changes in reaction time during testing because of subjects' lack of familiarization with test.
3. Determine the relationship of both sex and aerobic capacity and body composition on reaction time during hypoxic hypoxia

References

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