TIME COURSE OF EFFECTS OF CARBON DIOXIDE EXPOSURE ON PHYSICAL AND COGNITIVE PERFORMANCE IN A SIMULATED SURFACE EXTRAVEHICULAR ACTIVITY CONTINGENCY SCENARIO

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INTRODUCTION

Carbon dioxide (CO_2) is a metabolic byproduct produced by humans that must be scrubbed from the atmosphere by environmental control and life support systems in space vehicles and spacesuits to prevent buildup. Current nominal CO2 limits are set by NASA Standard 3001, however, limits during contingency situations are not specified. The purpose of this study was to characterize and quantify the physiological, cognitive, and self-assessed symptom and performance metrics as a function of inspired CO_2 (P_ICO_2) during a simulated 1-hour contingency lunar EVA scenario in virtual reality (VR).

METHODS

Fifteen healthy subjects completed 7 simulated EVA scenarios walking on a passive treadmill for one hour breathing dry, ambient air mixed with added CO_2 in a blind, counterbalanced manner (P_ICO_2: 0, 5, 10, 15, 20, 25, 30 mmHg) simulating a 2.0 km contingency EVA walkback to a habitat on the lunar surface in the event of a CO_2 scrubber malfunction. Subjects were immersed in a Lunar VR environment and asked to maintain their walking speed between 2.1 km/h and an upper limit individually calibrated to a fixed metabolic workload of 1.3 L/min of O_2 consumption, and performed periodic cognitive tasks and continuous cardiopulmonary measurements. Self-assessments of symptoms and task performance were measured via verbal Likert-scale survey at the onset of the walkback and at 10-minute intervals thereafter.

RESULTS

The time course of cardiopulmonary, cognitive, and self-reported responses at each level of P_ICO_2 will be presented. All 15 subjects were able to complete the 1-hr walk back task at all CO_2 levels. Physiological responses were rapid, typically within 1 to 5 minutes. No effects of time were detected for cognitive measures. Symptomatic ratings of headache, shortness of breath, and fatigue demonstrated a time-course development, reaching asymptote after 40 minutes of CO_2 exposure.

DISCUSSION

These findings will inform the posture of risk associated with CO_2 exposure on human health and performance during microgravity and planetary surface operations, This will help inform decisions related to space suit and environmental life support hardware requirements and EVA operational limits for contingency extravehicular activity (EVA) scenarios.