Toscano, W.B., P.S. Cowings, C. DeRoshia, B. Taylor and A.S. Hines. Individual differences in adaptational capacity during sustained hypergravity. In: 14th IAA Humans in Space Symposium Living in Space: Scientific Medical and Cultural Implications, Banff, Alberta, Canada, May 18-22, 2003 (abstract).

The purpose of this research is to develop and validate a quantitative method for examining the environmental effects of long duration space flight on individual crewpersons ability to adapt to microgravity. Previous studies have shown that the use of multiple converging indicators (electrophysiological measurements, behavioral responses, and self-reports of symptoms) is a more reliable method for assessing environmental effects on performance than any one indicator alone. This methodology was applied in a laboratory study, which examined the effects of an anti-motion sickness medication, promethazine, on cognitive, perceptual, and neuro-motor performance [1]. The results suggest that effective doses of this medication that are currently used to counteract motion sickness in space may significantly impair the operational performance of astronauts.

The practical application of this method was also demonstrated during a field study in collaboration with U.S. Army researchers [2]. The primary purpose of this work was to evaluate the incidence of motion sickness on individual crew performance during mobile operations in a Command and Control Vehicle (C2V), and armored tracked vehicle containing four computer workstations. During operations in the C2V military personnel were expected to make command decisions to carry out their mission objectives. By examining physiological responses, self-reports of symptoms, and a battery of performance subtests, we were able to decisively answer the following questions: “Who?” (how many soldiers were affected?), “How serious?” (what is the practical or operational impact?), and “When?” (under what environmental conditions did problems occur?). Results showed that when the vehicle was moving, motion sickness symptoms increased in all subjects. This was accompanied by degraded performance. Drowsiness and headache, not nausea, were the most pervasive symptoms occurring in 60 to 70 percent of the soldiers. Performance was degraded by at least 5 percent in 23 of the 24 soldiers. For 30 percent of these subjects, the performance degradation was operationally equivalent to having a blood alcohol level above 0.80, the legal limit in most states.

The present paper reports on the results of a recent pilot study, which used converging indicators to assess individual differences in the capacity to adapt to sustained hyper-gravity. Four adult men, 20 to 34 years old, were individually tested in the human centrifuge at NASA’s Ames Research Center. Subjects occupied a small compartment, equipped with a bed, video entertainment, a laptop computer, toilet facilities, and a supply of food and drinks. Each subject lived aboard the centrifuge for 22 hours under three conditions separated by at least seven days: 1-g (i.e., no rotation), 1.25 g and 1.5g. During their confinement on the centrifuge subjects were in video and voice contact at all times with researchers and medical monitors in the control room. Ambulatory physiological data was continuously recorded. Stand tests to evaluate orthostatic tolerance were conducted at 4-hour intervals. Performance tests, mood and symptom scales were performed on a laptop computer following each stand test.

Preliminary results indicate unique physiological patterns of individuals with orthostatic intolerance, motion sickness, and asymptomatic subjects. In one individual who experienced syncope after 14 hours at 1.25g the dominant physiological pattern was vagotonic. A second subject with better orthostatic tolerance and no syncope during stand tests reported motion sickness symptoms with elevated physiological levels (high sympathetic tone) at 1.5 g. In the two subjects who did not report any symptoms the dominant physiological profile was indicative of better homeostatic balance. For some individuals specific mood states and neuro-motor tasks were significantly degraded during hyper-gravity, while there was no change observed in perceptual or cognitive performance.

In conclusion, continuous physiological measurement in conjunction with behavioral and self-report scales may be potentially useful for predicting how well individuals adapt to other high-stress environments like spaceflight and identifying intervention strategies (i.e., pharmacologic and behavioral) for controlling symptoms and preventing performance degradation.

1. Cowings, P.S., W.B. Toscano, C. DeRoshia and R. Tauson. (2001) Effects of Command and Control Vehicle (C2V) operational environment on soldier health and performance. Human Perf. Extreme Environ. 5, (2),66-91.
2. Cowings, P.S., Toscano, W.B., DeRoshia, C., Miller, N.E. (2000). Promethazine as a motion sickness treatment: impact on human performance and mood states. Aviation, Space and Environmental Medicine. 71(10), 1013-32.