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Physiological Effects during Aerobatic Flights on Science Astronaut Candidates

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Abstract : Spaceflight is considered the last frontier in terms of science, technology, and engineering. But it is also the next frontier in terms of human physiology and performance. After more than 200,000 years humans have evolved under earth’s gravity and atmospheric conditions, spaceflight poses environmental stresses for which human physiology is not adapted. Hypoxia, accelerations, and radiation are among such stressors, our research involves suborbital flights aiming to develop effective countermeasures in order to assure sustainable human space presence. The physiologic baseline of spaceflight participants is subject to great variability driven by age, gender, fitness, and metabolic reserve. The objective of the present study is to characterize different physiologic variables in a population of STEM practitioners during an aerobatic flight. Cardiovascular and pulmonary responses were determined in Science Astronaut Candidates (SACs) during unusual attitude aerobatic flight indoctrination. Physiologic data recordings from 20 subjects participating in high-G flight training were analyzed. These recordings were registered by wearable sensor-vest that monitored electrocardiographic tracings (ECGs), signs of dysrhythmias or other electric disturbances during all the flight. The same cardiovascular parameters were also collected approximately 10 min pre-flight, during each high-G/unusual attitude maneuver and 10 min after the flights. The ratio (pre-flight/in-flight/post-flight) of the cardiovascular responses was calculated for comparison of inter-individual differences. The resulting tracings depicting the cardiovascular responses of the subjects were compared against the G-loads (Gs) during the aerobatic flights to analyze cardiovascular variability aspects and fluid/pressure shifts due to the high Gs. In-flight ECG revealed cardiac variability patterns associated with rapid Gs onset in terms of reduced heart rate (HR) and some scattered dysrhythmic patterns (15% premature ventricular contractions-type) that were considered as triggered physiological responses to high-G/unusual attitude training and some were considered as instrument artifact. Variation events were observed in subjects during the +Gz and –Gz maneuvers and these may be due to preload and afterload, sudden shift. Our data reveal that aerobatic flight influenced the breathing rate of the subject, due in part by the various levels of energy expenditure due to the increased use of muscle work during these aerobatic maneuvers. Noteworthy was the high heterogeneity in the different physiological responses among a relatively small group of SACs exposed to similar aerobatic flights with similar Gs exposures. The cardiovascular responses clearly demonstrated that SACs were subjected to significant flight stress. Routine ECG monitoring during high-G/unusual attitude flight training is recommended to capture pathology underlying dangerous dysrhythmias in suborbital flight safety. More research is currently being conducted to further facilitate the development of robust medical screening, medical risk assessment approaches, and suborbital flight training in the context of the evolving commercial human suborbital spaceflight industry. A more mature and integrative medical assessment method is required to understand the physiology state and response variability among highly diverse populations of prospective suborbital flight participants.

Keywords : g force, aerobatic maneuvers, suborbital flight, hypoxia, commercial astronauts
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