HEART RATE RESPONSES TO UNAIDED ORION SIDE HATCH EGRESS IN THE NEUTRAL BUOYANCY LABORATORY

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NASA is developing the Orion capsule as a vehicle for transporting crewmembers to and from the International Space Station (ISS) and for future human space exploration missions. Orion and other commercial vehicles are designed to splash down in the ocean where nominally support personnel will assist crewmembers in egressing the vehicle. However, off-nominal scenarios will require crewmembers to egress the vehicle unaided, deploy survival equipment, and ingress a life raft. **PURPOSE:** To determine the heart rate (HR) responses to unaided Orion side hatch egress and raft ingress as a part of the NASA Crew Survival Engineering Team's evaluation of the PORT Orion mockup in the Neutral Buoyancy Laboratory (NBL). **METHODS:** Nineteen test subjects, including four astronauts (N=19, 14 males/5 females, 38.6±8.4 y, 174.4±9.6 cm, 75.7 ± 13.1 kg), completed a graded maximal test on a cycle ergometer to determine VO_{2peak} and HR_{peak} and were divided into five crews of four members each; one subject served on two crews. Each crew was required to deploy a life raft, egress the Orion vehicle from the side hatch, and ingress the life raft with two 8 kg emergency packs per crew. Each crew performed this activity one to three times; a total of ten full egresses were completed. Subjects wore a suit that was similar in form, mass, and function to the Modified Advanced Crew Escape Suit (MACES) including helmet, gloves, boots, supplemental O_2 bottles, and a CO_2-inflated life preserver (~18 kg); subjects began each trial seated supine in the PORT Orion mockup with seat belts and mockup O_2 and communication connections and ended each trial with all four crewmembers inside the life raft. **RESULTS:** VO_{2peak} was 40.8±6.8 mL/kg/min (3.1±0.7 L/min); HR_{peak} was 181±10 bpm. Total egress time across trials was 5.0±1.6 min (range: 2.8-8.0 min); all subjects were able to successfully complete all trials. Average maximum HR at activity start, at the hatch opening, in the water, and in the raft, was 108, 137, 147, and 153 bpm, respectively; these values corresponded to 59±10%, 73±8%, 82±3%, and 84±6% of HR_{peak}, respectively. The highest HRs were seen after raft ingress and ranged from 72-99% HR_{peak}. Across all trials, cumulative averages of 5.4, 3.0, 1.1, and 0.2 min were spent at HRs >60%, >70%, >80%, and >90% HR_{peak}, respectively. **CONCLUSION:** Unaided Orion side hatch egress in the NBL is a relatively short-duration activity that elicits a high HR response for several min. Although all crewmembers successfully completed this activity, additional factors such as high seas, poor visibility, an incapacitated crewmember, neurovestibular perturbation, and neuromuscular deconditioning characteristic of a true operational environment may increase the physiologic demand (or decrease crewmembers' physiologic capacity) of unaided Orion side hatch egress. Additionally, landing conditions may require the crewmembers to egress from the top hatch, which is expected to be even more physiologically demanding; this condition will be evaluated in subsequent collaborative testing with the NASA Crew Survival Engineering Team.