Crew State and Risk Model Development to Predict Hydration Status During Extravehicular Activity Training Events

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Introduction:

Hydration is critical for optimal human health and performance and dehydration can lead to impaired cardiovascular function, thermal dysregulation, decreased blood plasma volume, and cognitive impacts, particularly during physical activity. Prolonged and repeated extravehicular activities (EVA) without sufficiently available drinking water may increase risk for dehydration, which could impair crew health and impact mission success. Understanding hydration needs and potential effects on health and performance are necessary to optimize crew well-being and enable successful EVA objectives. This study aims to develop a model of hydration status during EVA using water balance techniques.

Methods:

Water balance measures were collected on 15 healthy astronauts who performed ≈6-hour simulated microgravity extravehicular activity (EVA) training in the NASA Neutral Buoyancy Laboratory (NBL). Data collected included pre- and post-EVA nude body weight (BW), maximum absorption garment (MAG) weight, Disposable In-suit Drink Bag (DIDB) weight, urine specific gravity (USG), and extra pre-EVA intake (W). Variables were combined to create the water balance model as pre-EVA (H_n) = $BW_n + MAG_n + DIDB_n + W_n$ and post EVA (H_{n+1}) = $BW_{n+1} + MAG_{n+1} + DIDB_{n+1}$. Urine specific gravity values were used to refine water balance measures into hydration categories: Hydrated, Marginally Hydrated, and Dehydrated.

Results:

Pre-EVA modeling indicated 53% of crew were hydrated, 20% were marginally hydrated, and 27% were dehydrated. Alternately, H_{n+1} showed 13% of crew remained hydrated, 47% were marginally hydrated, and 40% were dehydrated at the end of the EVA. Furthermore, 75% of the crewmembers who started sufficiently hydrated finished the run marginally hydrated or dehydrated. According to USG indices presented by Casa and Lawrence, et al. (2000), only 25% of the crew started and remained hydrated throughout the EVA, and those who were dehydrated at the outset stayed dehydrated.

Conclusion:

Model outcomes assessing hydration status during 6-hour simulated microgravity EVAs demonstrate the necessity to further address hydration requirements for optimal human performance during spaceflight and EVA. This study enables additional baseline development of the Crew State and Risk Model Hydration, Nutrition, and Waste Management component that aims to provide individualized crew state and risk predictions during EVAs.

Reference:

Casa, D. J., Armstrong, L. E., et al. (2000). National Athletic Trainers' Association Position Statement: Fluid Replacement for Athletes. *Journal of Athletic Training*, 35:212-224.