

## Decline in Aerobic Fitness after Long-Term Stays on the International Space Station

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U.S. and non-Russian International Partner astronauts who participate in long-term International Space Station (ISS) expeditions perform submaximal cycle exercise tests before, during, and after space flight. The heart rate (HR) and oxygen uptake ( $\text{VO}_2$ ) responses to exercise are used to estimate peak  $\text{VO}_2$  ( $\text{EVO}_{2\text{pk}}$ ).

**Purpose:** To determine if the following factors are associated with the preflight-to-post flight change in  $\text{EVO}_{2\text{pk}}$ : gender, age, body weight (BW), number of aerobic exercise sessions/wk during flight, length of flight,  $\text{EVO}_{2\text{pk}}$  measured before and late during the flight, ISS Expedition number and time between landing and the first post flight test. **Methods:** Records of 37 ISS astronauts (30 ♂,  $\text{BW}=81.6\pm 8.6$  kg; 7 ♀,  $\text{BW}=66.1\pm 4.9$  kg [mean $\pm$ SD]), age  $46\pm 4$  years, were retrospectively examined. Peak HR and  $\text{VO}_2$  were measured ~9 months before flight to establish the test protocol. The submaximal cycle test consisted of three 5-minute stages designed to elicit 25, 50, and 75% of  $\text{VO}_{2\text{pk}}$ .  $\text{EVO}_{2\text{pk}}$  was calculated using linear least-squares extrapolation of average HR and  $\text{VO}_2$  during the last minute of each stage to predict  $\text{VO}_2$  at maximal HR.  $\text{VO}_2$  was not measured during flight and was assumed to not be different from preflight. Testing was performed ~45 days before launch, late during flight, and during the week after landing. A random-intercept multivariate model was used to determine which characteristics significantly contributed to post flight  $\text{EVO}_{2\text{pk}}$ . **Results:** In-flight aerobic exercise averaged  $5.4\pm 1.2$  sessions/wk. ISS flight duration averaged  $163\pm 39$  d. Mean  $\text{EVO}_{2\text{pk}}$  values were  $3.41\pm 0.64$   $\text{L}\cdot\text{min}^{-1}$  before flight,  $3.09\pm 0.57$   $\text{L}\cdot\text{min}^{-1}$  late in flight, and  $3.02\pm 0.65$   $\text{L}\cdot\text{min}^{-1}$  after flight. Late- and after-flight values were lower ( $p<0.05$ ) than preflight values and did not differ from each other. Time between landing and post flight testing was  $4.5\pm 1.6$  days. The only factor significantly associated with the post flight  $\text{EVO}_{2\text{pk}}$  value was the late-flight  $\text{EVO}_{2\text{pk}}$  score. **Conclusion:** Testing performed late during a mission provides a prediction of  $\text{EVO}_{2\text{pk}}$  after landing. This approach may be implemented during longer missions.