

PEAK OXYGEN UPTAKE DURING AND AFTER LONG-DURATION SPACE FLIGHT

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Aerobic capacity ($\text{VO}_{2\text{peak}}$) previously has not been measured during or after long-duration spaceflight. **PURPOSE:** To measure $\text{VO}_{2\text{peak}}$ and submaximal exercise responses during and after International Space Station (ISS) missions. **METHODS:** Astronauts (9 M, 5 F: 49 ± 5 yr, 175 ± 7 cm, 77.2 ± 15.1 kg, 40.6 ± 6.4 mL/kg/min [mean \pm SD]) performed graded peak cycle tests ~90 days before spaceflight, 15 d (FD15) after launch and every ~30 d thereafter during flight, and 1 (R+1), 10 (R+10), and 30 d (R+30) after landing. Oxygen consumption (VO_2) and heart rate (HR) were measured from rest to peak exercise, while cardiac output (Q), stroke volume (SV), and arterial-venous oxygen difference (a- vO_2diff) were measured only during rest and submaximal exercise. Data were analyzed using mixed-model linear regression. Body mass contributed significantly to statistical models, and thus results are reported as modeled estimates for an average subject. **RESULTS:** Early inflight (FD15) $\text{VO}_{2\text{peak}}$ was 17% lower (95% CI = -22%, -13%) than preflight. $\text{VO}_{2\text{peak}}$ increased during spaceflight (0.001 L/min/d, $P = 0.02$) but did not return to preflight levels. On R+1 $\text{VO}_{2\text{peak}}$ was 15% (95% CI = -19%, -10%) lower than preflight but recovered to within 2% of preflight by R+30 (95% CI = -6%, +3%). Peak HR was not significantly different from preflight at any time. Inflight submaximal VO_2 and a- vO_2diff were generally lower than preflight, but the Q vs. VO_2 slope was unchanged. In contrast, the SV vs. VO_2 slope was lower ($P < 0.001$), primarily due to elevated SV at rest, and the HR vs. VO_2 slope was greater ($P < 0.001$), largely due to elevated HR during more intense exercise. On R+1 although the relationships between VO_2 and Q, SV, and HR were not statistically different than preflight, resting and submaximal exercise SV was lower ($P < 0.001$), resting and submaximal exercise HR was higher ($P < 0.002$), and a- vO_2diff was unchanged. HR and SV returned to preflight levels by R+30. **CONCLUSION:** In the average astronaut $\text{VO}_{2\text{peak}}$ was reduced during spaceflight and immediately after landing but factors contributing to lower $\text{VO}_{2\text{peak}}$ may be different during spaceflight and recovery. Maintaining Q while VO_2 is reduced inflight may be suggestive of an elevated blood flow to vascular beds other than exercising muscles, but decreased SV after flight likely reduces Q at peak exertion.