

Female Astronauts Exhibit Greater Reductions in Aerobic Peak Power Following Long-Duration Space Flight than Males

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BACKGROUND: Long-duration exposure to microgravity during space flight causes cardiovascular deconditioning, ultimately reducing aerobic fitness. While sex-based differences play an integral role in health on Earth, there is a paucity of data to inform space flight-induced health and performance implications for female astronauts, which may be critical to ensure health, safety, and mission success. Therefore, this retrospective investigation characterized aerobic capacity in female and male astronauts to inform whether sex differences exist from pre to postflight.

METHODS: A NASA historical database (n=47 crew; 11 female, 36 male) of International Space Station (ISS) crewmembers was used to characterize sex differences in aerobic capacity changes from pre to postflight to update the NASA Aerobic and Muscle Risk Evidence Report. Aerobic capacity (VO₂pk; ml/kg/min) and peak power (W) were assessed using a graded cycling exercise protocol that included a 3-min warmup at 50 W, with stepwise increases in resistance (25 W/min) until volitional fatigue. Group differences in baseline demographics and the percent change in aerobic capacity from preflight (~90 days before launch) to postflight (~3 days after return) were compared using independent t-tests. Significance was set at $P < 0.05$ (Mean \pm SD).

RESULTS: At preflight, females were younger (44.5 ± 6.6 vs 48.6 ± 5.6 yrs; $p = 0.041$), weighed less (68.8 ± 10.0 vs 81.0 ± 8.8 kg; $p < 0.001$), with lower VO₂pk (32.8 ± 5.9 vs 37.8 ± 6.0 ml/kg/min; $p = 0.021$) and aerobic peak power (229 ± 42 vs 299 ± 52 W; $p < 0.001$) than males, but had similar heart rate at VO₂pk (176.0 ± 7.3 vs 173.0 ± 10.8 beats/min; $p = 0.406$). ISS flight durations (F: 205.0 ± 58.3 vs M: 176.0 ± 40.5 days; $p = 0.061$) and reductions in VO₂pk from pre to postflight were comparable between sexes (F: $-11.8 \pm 10.7\%$; M: $-8.8 \pm 7.9\%$; $p = 0.32$). However, females had a greater reduction in aerobic peak power than males ($-13.3 \pm 8.9\%$ vs $-4.9 \pm 8.8\%$; $p < 0.01$).

CONCLUSIONS: These data indicate that some indicators of fitness (i.e., aerobic peak power) are more impacted in female astronauts compared to males after long-duration space flight missions. Future investigations with larger sample sizes are necessary to identify the physiological basis of sex-based differences and develop effective countermeasure approaches for both sexes.