

Physiologic Responses to Motorized and Non-Motorized Locomotion Utilizing the International Space Station Treadmill

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INTRODUCTION: Treadmill locomotion is used onboard the International Space Station (ISS) as a countermeasure to the effects of prolonged weightlessness. The treadmill operates in two modes: motorized (T-M) and non-motorized (T-NM). Little is known about the potential physiologic differences between modes which may affect countermeasure exercise prescription.

PURPOSE: To quantify heart rate (HR), oxygen consumption (VO₂), perceived exertion (RPE), and blood lactate (BLa) during T-M and T-NM locomotion at 2 and 4 mph in normal ambulatory subjects.

METHODS: Twenty subjects (10 men, 10 women; 31±5 yr, 172±10 cm, 68±13 kg, mean±SD) with a treadmill peakVO₂ of 45.5±5.4 ml·kg⁻¹·min⁻¹ (mean±SD) exercised on the ground-based ISS treadmill. Following a familiarization session in each mode, subjects completed two data collection sessions, T-M and T-NM in random order, at 2 and 4 mph. Subjects attempted to complete 5 min of exercise at each speed; if they could not maintain the speed, the trial was discontinued. At least 5 minutes of rest separated each speed trial, and at least 48 hrs separated each session. VO₂ was measured continuously (metabolic gas analysis), while HR (HR monitor) and RPE (Borg Chart, 6-20 scale) were recorded each min. Not all subjects completed 5 min during each condition, therefore the mean of the min 3 and 4 was taken as representative of steady-state. BLa was measured (finger stick) within 2 min post-exercise. Paired t-tests were used to test for differences (p<0.05) between treadmill modes within the same speed.

RESULTS: All twenty subjects completed at least 4 min of exercise during all conditions, except T-NM 4 mph when only 11 subjects completed the minimum exercise duration. VO₂, HR, RPE and BLa were significantly higher during T-NM locomotion at both speeds.

Mode	Speed (mph)	HR (bpm)	VO ₂ (l·min ⁻¹)	RPE	BLa (mmol·l ⁻¹)
T-M	2	87 ± 2	0.71 ± 0.03	7.2 ± 0.3	1.47 ± 0.10
T-NM	2	123 ± 4*	1.48 ± 0.05*	9.7 ± 0.5*	1.95 ± 0.18*
T-M	4	110 ± 4	1.51 ± 0.09	9.1 ± 0.5	1.92 ± 0.29
T-NM	4	171 ± 2*	3.11 ± 0.08*	14.5 ± 0.7*	8.76 ± 0.68*

* Significantly different than T-M (p<0.05)

CONCLUSION: Locomotion during TVIS-N requires a significantly greater physiologic demand than TVIS-M at the same speed, including an apparently greater reliance on anaerobic energy production, such that not all subjects can exercise for long periods of time at higher TVIS-NM speeds. This information will be used to refine prescriptions for in-flight treadmill exercise countermeasures during long duration space flight and can be applied to ground-based non-motorized locomotion utilizing a treadmill with similar characteristics.