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Author: Dr. Da Xu
Simon Fraser University, Canada

Mr. Malcom Tremblay
Simon Fraser University, Canada
Ms. Rebecca Ruedl
Simon Fraser University, Canada
Ms. Melanie Larsson
Linköping University, Sweden
Dr. Nandu Goswami
Medical University of Graz, Austria
Dr. Andrew Blaber
Simon Fraser University, Canada

EFFECTS OF 60-DAY HEAD-DOWN TILT BED REST ON SKELETAL MUSCLE-PUMP BAROREFLEX

Abstract

Background: Post-flight orthostatic intolerance and postural deficiency remain a major concern for human missions involving extended durations of weightlessness. Our research has shown that skeletal muscle pump plays a significant role in blood pressure regulation during standing through a baroreflex response to changes in blood pressure. The present study investigated the effects of 60-day six-degree head-down tilt bed rest (HDTBR, an analog of microgravity exposure) on this skeletal muscle-pump baroreflex. We hypothesize that prolonged unloading of the cardiovascular and muscular-skeletal systems during HDTBR would cause significant reduction in muscle-pump baroreflex.

Methods: The study was conducted at the MEDES (ESA/CNES) research facility in Toulouse, France. Nineteen male volunteers completed the study after passing physical, physiological and psychological screening. A supine-to-stand (STS) test with 5-minute supine and 6-minute stand was conducted 12 and 2 days before HDTBR, and 90 minutes and 8 days after exiting bed rest. Beat-by-beat systolic blood pressure (SBP) and calf muscle electromyography (EMG) were collected simultaneously throughout the STS procedure. The maximum contraction force and EMG from the anterior tibialis (TA) muscle were measured after the STS test with participant back in supine position. Wavelet transform coherence and causality analysis were performed on SBP and EMG data (SBP->EMG impulse) during standing to characterize the muscle-pump baroreflex (MP-BR) in terms of gain, interaction time, and causality.

Results: Following bed rest, SBP (133 ± 19 to 126 ± 18 mmHg, $p<0.05$) and calf muscle EMG (85 ± 33 to 72 ± 34 μV, $p<0.05$) decreased. An overall reduction of muscle-pump baroreflex was observed after HDTBR with decreased MP-BR gain (0.79 ± 0.48 to 0.51 ± 0.37 μV·s/mmHg, $p<0.01$), percent time of interaction ($52 \pm 29\%$ to $34 \pm 27\%$, $p<0.0001$), and causality (0.88 ± 0.06 to 0.78 ± 0.12, $p<0.0001$). On the 8th day after bed rest (R+8), the interaction time and causal drive from SBP to EMG recovered to pre-HDTBR level while MP-BR gain and calf muscle EMG remained lower. The maximum TA contraction force was reduced on both R+0 and R+8 (272 ± 53 to 237 ± 43 (R+0) and 246 ± 44 (R+8) N, $n=10$, $p<0.005$) while the corresponding maximum EMG measurements showed marginal reduction on

R+8 (197 ± 74 to 190 ± 65 (R+0) and 173 ± 46 (R+8) μV, n=9, p=0.08).

Conclusion: The results indicate the skeletal muscle-pump baroreflex was impaired by HDTBR, with MP-BR gain decreased up to 8 days after HDTBR along with standing calf muscle activity and maximum TA contraction force. These new observations may advance the understanding of both cardiovascular and postural deconditioning post-flight.