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LONG-TERM ANALYSIS OF ELECTRO-MECHANICAL ACTIVITY DURING THE TWO ANALOG LUNAR MISSIONS EMMPOL 10 AND EMMPOL 11

Abstract

Future manned space exploration will involve human settlement on satellites and planets, with prolonged permanence of astronauts in isolated and confined extreme environments, with altered light-dark cycle, leading to alterations in circadian rhythms of all physiological systems, including the cardiovascular one, compromising crew health and performance. This study aims at assessing the alterations in cardiac electro-mechanical circadian rhythms during a period of isolation and confinement during two 7-day analog missions: EMMPOL 10 and EMMPOL 11 (EuroMoonMars, Analog Astronaut Training Center). Ten healthy volunteers participated in the study. Continuative 6-day 24h ECG and seismocardiographic (SCG) signals were simultaneously recorded (EcgMove4, Movisens GmbH). Cardiac beats were automatically identified on ECG and SCG using custom software, and the feasibility of SCG cardiac beats detection compared to the gold standard ECG was evaluated. The fiducial points for isovolumetric contraction (IVC) and aortic valve opening (AO) were then identified on the SCG beats. Beat-to-beat temporal and morphological parameters were thus computed: AO-AO intervals (i.e., beat duration), LVET (Left ventricular ejection time), PEP (Pre-ejection period), IVC-AO peak-to-peak amplitude and slope. The Cosinor analysis was then applied to the computed parameters in order to study relevant circadian rhythms, resulting in a value of midline (MESOR), oscillation amplitude (OA) and acrophase (φ). Statistical analysis (Friedman test, $p<0.05$) was applied to day and night SCG parameters and to the cosinor parameters to assess possible alterations during the isolation period, and sleep-wake differences were assessed for each isolation day (Wilcoxon Signed Rank, $p<0.05$). Results showed a high day (53.92[47.30;59.31]%) and night (80.59[62.86;90.78]%) beat identification feasibility with the SCG. A progressive decrease of the circadian OA of both IVC-AO amplitude and slope was observed throughout the isolation period (up to 37.7[27.5;43.15]%), although sleep-wake differences were maintained in all parameters. Also the diurnal PEP decreased by 2.27[2.24;9.99]% between Day 1 and Day 4 of isolation. The study provides the first combined assessment of cardiac electro-mechanical circadian rhythms during

permanence in an isolated and confined environment in lunar analog missions, showing the possibility to assess cardiac electro-mechanics activity using prolonged SCG recordings. Specifically, although the circadian rhythms of the computed parameters were maintained in all subjects, a reduction in the amplitude of circadian oscillation in morphological SCG parameters correlating with stroke volume and myocardial contractility, together an unchanged electrical heart rate circadian pattern, highlights a possible effect of isolation on the mechanical activity of the cardiovascular system.