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INFLUENCES OF THE ENVIRONMENTAL FACTORS ON HUMAN CIRCADIAN RHYTHMS DURING A SIMULATED 30-DAY SPACEFLIGHT IN CLOSED ECOLOGICAL LIFE SUPPORT SYSTEM (CELSS) IN CHINA

Abstract

Purpose: Circadian disruption, sleep loss and fatigue have been consistently indicated during many space flight missions in some individuals, leading to psychological issues as well as physiological problems. During China's future long-term space flight missions, it is imperative to create a regenerative environment to support human life, such as Controlled (or Closed) Ecological Life Support Systems (CELSS). Utilizing China's first ground-based simulated 30-day spaceflight in CELSS with two persons, this study aims to

assess the impacts of the environmental factors on human circadian rhythms. Methodology: Sleep-wake activity rhythms of the two subjects were tested with sleep quantity and quality analysis, which were continuously real-time recorded by a wrist-worn device (Actiwatch), and a synchronizingly filling-in daily sleep questionnaire. Heart rate and respiration rate were collected by the wireless-monitoring technique to evaluate the rhythms of cardio-pulmonary function. A SINO-GERMAN joint research project was conducted to record the core temperature circadian rhythm using double sensor (thermo-lab system). Additionally, blood and urine samples were intermittently collected to test the changes of oxidative stress and metabonomics. Results: All circadian rhythm data and biological samples of the two subjects were successfully collected before, during and after the 30-day CELSS integration experiment (pre-IC, during-IC and post-IC). Preliminary data showed that the total sleep time of all the two crew members decreased significantly and the heart rate rhythm exhibited a relatively high MESOR during-IC. Core temperature data showed that one subject responded with a phase advance, while the other subject exhibited a phase delay. By comparison with pre-IC, the levels of the majority of plasma stress parameters showed a robust (M) shape of rise-recover-rise during-IC, which was followed by a recovery decline post-IC. Conclusions: Intriguing changes of circadian rhythms and the underlying potential influencing factors during the simulated spaceflight in CELSS were identified. This study gives insights into the effects of the CELSS environment (atmosphere components change, long duration of isolation, etc.) on the stability of human circadian timing system. Given the similarities of the study with space flight, i.e. isolation, confinement and lack of 24 day/night cycles, these findings have significant practical implications as changes in the circadian timing system may affect crew health and safety. Acknowledgments: This study was supported by Medicinal Science and Techology Research Project (Grant No. BWS11J052), the National Science and Techology Major Project (Grant NO. 2012ZX09J12201), and the National Natural Science Foundation of China (Grant No. 30973686).