Objective/Significance: The purpose of the present research project is to clarify the effects of prolonged isolation of human subjects under dim light conditions from the natural day-night alternation and social activities on sleep, biological rhythms, autonomic nervous system, and psychomotor performance. The study was designed with special reference to the relationship between internal desynchronization of the biological clock and physical and mental functions. In addition, the influence of prolonged isolation on human relationships and group dynamics was investigated. The outcomes will contribute to the health management of astronauts on the International Space Station (ISS).

Methods: Three Japanese subjects were housed together in the isolation facility under dim light conditions (ca.150 lx). Two of the subjects stayed there for 3 months (90 day subject) and the remaining subjects for 1 month. Circadian rhythm, sleep quality, psychomotor performances and group dynamics were examined at regular intervals. Internal desynchronization was estimated by the phases of plasma melatonin and deep body temperature rhythms, and the effect of desynchronization on sleep was evaluated by polysomnography. In addition, psychological states of the subjects were estimated by several batteries of tests and tele-interviews. The subjects followed a strict schedule during the isolation period and performed regular tasks.
Results:
(1) The biological clock of one of the two 90 day subjects showed an internal desynchronization between plasma melatonin and sleep, while the circadian rhythms of the other 90 day subject showed a phase-delay shift of ca. several hours.

(2) Regular physical exercise expected to prevent the circadian rhythms to phase-delay shift failed to do so in the present experiment. A possible cause of failure is decrease in the strength of the exercise imposed.

(3) The ambulatory actograph expresses the rest-activity precisely, but failed to demonstrate endogenous components of circadian rhythm.

(4) Sleep quality seems to be influenced by internal desynchronization as well as psychological strain.

(5) During internal desynchronization, the subject complained of physical dysfunctions (headache and muscle weakness).

(6) The plasma cortisol levels in the subjects did not change significantly throughout the entire period of isolation.

(7) There was a time-of-day dependency in the results of the CPU test and the response time was lower in the morning than at noon or in the evening.

(8) The process of adaptation to the isolation environment was similar to that indicated by the Lysgaard adaptation curve.

(9) Several signs of stress response were detected which were not even recognized by the subjects themselves.

(10) The biological clock may have influenced the adaptation process. It would be useful to evaluate the individual characteristics of the ability for stress coping as well as biological rhythms.

Potential for space experiment:
(1) The methods of circadian rhythm measurement and psychological functions used in the present study are thought to be useful to the astronauts in the ISS.

(2) The individual characteristics of the biological clock, sleep, ability for stress coping, stress managements are all useful determinants for the selection of astronaut candidates.

(3) Various psychological interactions between the subjects and the experimenters should be considered when making a support program for the astronauts in the ISS.

Publication List:
2) K.Honma: The methods for measurement of biological rhythm and sleep in astronauts, 48th Annual meeting of Japanese Society for Aerospace and Environmental Medicine, Fukushima, 2002.11