Light Therapy Device for Entrainment of Circadian Rhythm Desynchronization in Microgravity

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ABSTRACT

The circadian rhythm is an internal process of the brain that regulates the sleep-wake cycle. Outside environmental factors can affect the circadian rhythm such as light and dark. In microgravity, astronauts witness the sun rise and set approximately 16 times per day. A disruption (desynchronization) of the circadian rhythm may then occur, with some astronauts reporting to be less alert and unable to sufficiently complete tasks. **PURPOSE**: To design, fabricate, and test a pair of glasses that emit blue wavelengths of light peripheral to the eyes, for set periods of time, which may promote alertness in astronauts. **METHODS**: The custom fitted glasses were originally designed in three-dimensional modeling software (Solidworks Premium, Waltham, MA). Components of the glasses included: frames, an Arduino Nano circuit board, tactile button switch, inductive charging components and battery, a wireless charging transmitter, and blue LEDs. The glasses emit 1000 lux at approximately 468 nm wavelength of blue light. The glasses were programmed using C++ to allow the user to wear the glasses for 30 minutes with an automatic timer to turn off the lights upon completion of the session. When fully charged, the battery can sustain a total of 8 sessions with each lasting 30 minutes. To further assess the functionality of the glasses, brainwaves measured via electroencephalography (EEG) and reaction time measured via the psychomotor vigilance test (PVT) were collected before, immediately after, and one hour after a 30-min trial session while wearing the glasses in the "on" position. For one week prior to testing, participants emulated the sleep schedule of astronauts, including a strict adherence to 6.5 hours of sleep each night. Naps, caffeine, and sleep medications were also avoided during this time. **RESULTS**: For EEG data, morphology of beta wave activation in the frontal lobe noticeably changed after light exposure to a more jagged shape with higher frequency and lower amplitude. The control waveform and the waveform measured before light therapy exhibited greater intermixed frequencies of lower value. With regard to reaction time, when light exposure was administered on test days, participants exhibited faster reaction time responses immediately after (374.2 ± 58.1 msec) and 1-hour post (372.7 ± 65.9 msec) compared to before (530.4 ± 120.4 msec) the glasses were worn. **CONCLUSION**: Blue light exposure integrated into a customized pair of glasses may elicit faster response times and promote greater levels of alertness both immediately after wearing the glasses for 30 min, and one hour after the glasses have been removed.