Six-degree head-down tilt bed rest: forty years of development as a physiological analog for weightlessness

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Early on, bed rest was recognized as a method for inducing many of the physiological changes experienced by spaceflight. Head-down tilt (HDT) bed rest was first introduced as an analog for spaceflight by a Soviet team led by Genin and Kakurin. Their study was performed in 1970 (at -4 degrees) and lasted for 30 days; results were reported in the Russian Journal of Space Biology (Kosmicheskaya Biol. 1972; 6(4): 26-28 & 45-109). The goal was to test physiological countermeasures for cosmonauts who would soon begin month-long missions to the Salyut space station. HDT was chosen to produce a similar sensation of blood flow to the head reported by Soyuz cosmonauts. Over the next decade, other tilt angles were studied and comparisons with spaceflight were made, showing that HDT greater than 4 degrees was superior to horizontal bed rest for modeling acute physiological changes observed in space; but, at higher angles, subjects experienced greater discomfort without clearly improving the physiological comparison to spaceflight. A joint study performed by US and Soviet investigators, in 1979, set the goal of standardization of baseline conditions and chose 6-degrees HDT. This effectively established 6-degree HDT bed rest as the internationally-preferred analog for weightlessness and, since 1990, nearly all further studies have been conducted at 6-degrees HDT. A thorough literature review (1970-2010) revealed 534 primary scientific journal articles which reported results from using HDT as a physiological analog for spaceflight. These studies have ranged from as little as 10 minutes to the longest duration of 370 days. Long-term studies lasting four weeks or more have resulted in over 170 primary research articles. Today, the 6-degree HDT model provides a consistent, thoroughly-tested, ground-based analog for spaceflight and allows the proper scientific controls for rigorous testing of physiological countermeasures; however, all models have their strengths and limits. The 6-degrees HDT model must continue to be scrutinized, re-examined, validated and compared to other analog environments whenever possible. Only by understanding the strengths and limits of this model, will it continue to serve as a critical physiological analog to spaceflight for many more years to come.

Key words: Bedrest, HDT, spaceflight, analog