MAINTAINING BONE MINERAL DENSITY

Background

The Biostatistics Laboratory (BSL) is one of several research laboratories within the Human Adaptation and Countermeasures Division which supports the Human Research Program at NASA Johnson Space Center in Houston, Texas. This laboratory provides statistical consulting in the application of statistical theory and practice to ongoing biomedical research. Lab personnel often aid in the preparation of research proposals that describe the experimental design, statistical modeling, and subsequent analysis of anticipated research data. Once data is gathered, statisticians can also assist with analysis and interpretation of results to help the investigators extract the most information consistent with the goal of maintaining statistical integrity. The Biostatistics Laboratory also provides opportunities for undergraduate students to be directly involved in the analysis and interpretation of biomedical research at NASA.

One area in which the Biostatistics Laboratory contributes to NASA's Human Research Program is in the interpretation of astronauts' bone mineral density (BMD) data during long-duration spaceflights (typically of four to six months). A shift in gravitational environment causes changes in their bodies, including the loss of BMD. This is of specific concern for astronauts' health, especially when they return to Earth's gravity.

On Earth, a person's skeletal BMD peaks around the age of 30. After the age of 35, BMD of certain skeletal sites decreases, on average, by < 1% each year. However an astronaut's BMD at those same sites can decrease by an average of 1 to 2% per month while living in space, even though he or she exercises and is otherwise a healthy individual. This weakening of the astronauts' bones is, in a way, similar to osteoporosis. With this condition, bones lose minerals (especially calcium) which make the bones weaker, more brittle, and more susceptible to fractures.

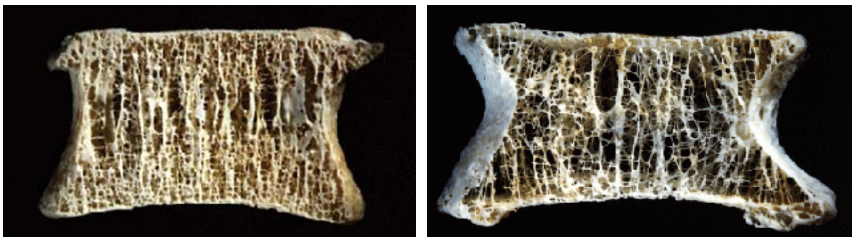

Figure 1: Normal bone compared to osteoporotic bone.
(Source: Mosekilde, L. Z rheumatol 2000; 59: Suppl 1:1-9)

In order for astronauts to best maintain bone health while in space and after returning to Earth, interventions (countermeasures) are prescribed. Exercise is the primary countermeasure used during spaceflight to help astronauts maintain BMD. The U.S. Space Station Skylab (in operation from 1973 to 1979), the Russian Space Station Mir (in operation from 1986 to 2001), and the International Space Station (ISS) (in operation from 1998 to present) all made use of various treadmills and a bicycle ergometer. In an effort to improve the effect of the exercise countermeasures, astronauts started using

resistive exercise. The Interim Resistive Exercise Device (iRED), which used an adjustable cable to provide a measured amount of resistance, was installed on the ISS in late 2000.

Figure 2: Left to right: Charles "Pete" Conrad on the bicycle ergometer aboard the Skylab, Shannon Lucid on a treadmill aboard the Mir, Edward T. Lu using the iRED on the ISS, and Robert Thursk using the ARED on the ISS.

In early 2009, the iRED was replaced by the Advanced Resistive Exercise Device (ARED), which uses two piston/cylinder assemblies which provide a constant load to simulate the use of free weights. As new exercise equipment and other countermeasures are implemented, NASA researchers and statisticians continue to assess the effect of these countermeasures on astronauts' health.

Problem

On the TI-Nspire™ handheld, open the document, *Maintaining_BD*. The problem set-up and data from Table 1 are provided on TI-Nspire pages 1.1-1.4.

Exercise during spaceflight has been used as a countermeasure to inhibit loss of bone mineral density (BMD). One research study performed by the Biostatistics Laboratory compared the differences in BMDs of astronauts from post-flight to pre-flight aboard Mir (using a treadmill and bicycle ergometer) and of astronauts aboard the ISS (using the iRED).

Is using the iRED exercise method significantly better than using the treadmill and bicycle in maintaining bone density?

Perform an appropriate test to determine the answer to this question. Add appropriate TI-Nspire pages (notes, data and statistics, and calculator) in order to give a complete answer to the problem.

Table 1: Differences in BMDs (tested at the femoral greater trochanter) from post-flight to pre-flight of astronauts using different exercise methods

Treadmill & Bicycle	iRED
-0.072	-0.07
-0.035	-0.050
-0.128	-0.034
-0.139	-0.033
-0.067	-0.030
-0.120	-0.019
-0.106	-0.018
-0.124	-0.085
-0.114	-0.014
-0.066	-0.010
-0.060	-0.038
-0.113	-0.023
	0.020
	-0.085
	-0.071
	-0.015
	-0.036
	0.004
	-0.101
	-0.052
	-0.036
	-0.067
	-0.062
	-0.105