BEDREST SUBJECT MEASUREMENTS AT USPHS

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Studies were undertaken to evaluate the accuracy of the absorptiometric measurement of bone mineral mass of the os calcis^{1,2}. This method is the proposed technique to evaluate the os calcis of the astronauts in Skylab Experiment M078.* The purpose of M078 is to determine the effects of weightlessness on bone and evaluate remedial measures. The bone mineral mass of the os calcis, radius, and ulna of each astronaut will be measured before and after the mission.

Previously x-ray densitometric methods have indicated a decrease in bone mineral mass during weightlessness³, but the poor precision of the method made the results difficult to interpret. The absorptiometric method provides a precise estimate of bone mineral mass, and the accuracy of the radius and ulna measurement is about 3%. The purpose of this study was to evaluate the accuracy of the measurement of bone mineral mass of the os calcis. The principle error of this technique is expected to be by the variation in the composition of soft tissue. The most significant factor is the large lipid content of adipose tissue inside and outside of the os calcis.

Method

The error caused by adipose tissue was estimated from the absorptiometric measurement of the os calcis with monoenergetic photons of different energies (28 keV, 44 keV, 60 keV and 100 keV). The magnitude⁴ of the error for each photon energy for each photon energy is different and is described by equation (1).

$$\text{Log} \frac{I_o^*}{I} - C_1 M_{BM} = C_2 M_{lipid} \quad (1)$$

where

BM = bone mineral mass traversed.

 m_{lipid} = lipid mass traversed in excess of baseline value. C_1 = difference of linear attenuation coefficients of bone mineral and soft tissue divided by the density of bone mineral. C_2 = difference of linear attenuation coefficients of lipid and soft tissue divided by the density of lipid.

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Six bedrest subjects at the USPHS hospital² were scanned three times during the study at two month intervals. They were scanned using ^{125}I (28 keV), ^{241}Am (60 keV), and ^{153}Gd (44 keV and 100 keV) as radio-nuclide sources. A K_2HPO_4 standard was scanned to calibrate each photon beam. The mass attenuation coefficients for polymethyl methacrylate and aluminum were determined.

Preliminary Results

The analysis of the subjects is not finished. The mass attenuation coefficients for each beam are shown in Table I. The results are in agreement with measurements previously made with the same sources⁵.

The measured calibration constants, $1/C_1$, are shown in Figure 1. The values were compared with the theoretical values predicted by the mass attenuation coefficients of water and bone mineral. The excellent agreement indicated the contrast between polymethyl methacrylate and K_2HPO_4 saturated solution vary as function of photon energy similarly to water and bone mineral between 28 keV and 100 keV. The calibration procedure therefore was felt to be valid with respect to the effects of the variation of chemical composition of tissues.

Analysis to be Undertaken

The precision of the subject measurements at each photon energy will be determined. This will determine the precision of the bone mineral mass measurement if a correction were made using Equation (1) and photon beams of various energies were used. Since the primary consideration in M078 is the determination of small changes of bone mineral mass and each individual is his own control, the precision of a new method should be the same or better than the absorptiometric technique using ^{125}I , if it is to be recommended as a replacement.

The effect of different size beams and different energies on the "edge effect"⁵ will be determined, so differences caused by different size beams will not be interrupted as an error caused by the variation in the adipose tissue.

Table I
Mass attenuation coefficients (cm^2/g)

	28 keV		44 keV		60 keV		100 keV	
PMM*	0.3255	0.001	0.2155	0.0003	0.1842	0.0005	0.1685	0.0031
Al	nd		0.5063	0.0014	0.2823	0.0001	0.1649	0.0003

* PMM-polymethyl methacrylate

Figure 1

Comparison of the measured and theoretical values of the density of bone mineral divided by the difference of the linear attenuation coefficients of bone mineral and soft tissue ($1/C_1$)

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