hundred women, we found that an effective thickness of 24.5 cm occurs at a body weight of 90 kg. The regression was: THICKNESS (cm) = 0.182 + WEIGHT + 8 (r = 0.85; s.e.e. = 1.5 cm). The effective attenuation needed to achieve the low count rates seen by DaCosta et al. occurs at a water thickness of 28 cm with 13-mm collimation that is standard for the DP3 scanner. This would be seen in a patient weighing ~110 kg with an anatomical thickness of 31 cm (15 cm lean + 16 cm fat). It is inappropriate to use depleted sources on such obese subjects. On the other hand, studies by Dawson-Hughes et al. (*5*) have shown that accurate but not precise results can be obtained even with depleted sources on subjects of 28-cm thickness. Phantoms designed to test thickness response of DPA or DEXA scanners *cannot* consist of either water alone or plastics. Dual-energy systems begin to vary in response to soft-tissue composition at thicknesses >20 cm. Typically, scanners are calibrated at normal composition (25% fat) from 15–20 cm and produce accurate data at 25 cm only if the soft tissue is ~40% fat (15 cm of water + 10 cm of oil).

DaCosta et al. (*1*) imply that source activity is critical for precise determinations using DPA. The precision of DPA on the spine in many studies using the Lunar DP3 averaged 1.8% even when older software was used (*7*). The precision error reported by Dawson-Hughes et al. (*5*) was within 2%, and that reported by the researchers at Mt. Sinai was 2.5% (*8*). Correction for the small influence of source activity on typical patient results under usual conditions could reduce the precision error slightly. However, the major uncertainties in spinal determinations are (a) confusion of the L1-L3 sequence with the L2-L4 and (b) misplacement of edges and baselines. In a reanalysis of thousands of spine scans from many institutions, the above operator errors were several times greater than the uncertainty associated with source activity effects.

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REPLY TO DR. SORENSON: Dr. Sorenson's proposal to account for the increase in bone mineral density observed at low counting rates is appreciated. Although the 'statistical artifact' described is a potential explanation for the error observed by us, we are unable to evaluate the hypothesis further, since the actual count rate information is unavailable to DP3 users. Lunar DP3 software alters the raw count information during acquisition and stores calculated bone mineral values that cannot be converted back to raw data (i.e., high- and low-energy photon counts measured through bone and soft tissue). The software algorithms used are considered proprietary information and have not been available to users for review. This further highlights the problem of having to rely on software in which raw data are not retained and in which the basis of calculations is concealed from the users.

Dr. Sorenson's proposed correction for the statistical artifact on individual count data (Fig. 2) cannot be applied. We hope that the industry will evolve toward a standard which makes documentation of the algorithms, as well as raw count data, available to users.

Dr. Sorenson describes effects that he attributes to counts per pixel, and not source activity or attenuation; however, counts per pixel are indeed a function of source activity and attenuation.

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REPLY TO DR. MAZESS: We are pleased that Dr. Mazess, the manufacturer of the device used in our study, essentially acknowledges the validity of our observations (*1*). He incorrectly, however, implies that our findings are due to an 'unusual' scanning configuration.

Dr. Mazess suggests that our study used outmoded acquisition parameters. In fact, the manufacturer's original technical guidelines for collimation and scan speed specified the 'high resolution' parameters used in our study (8 mm and 2.5 mm/sec, respectively). In a February 11, 1985 correspondence to customers, Lunar announced an *optional* configuration of 13 mm collimation and 5 mm/sec speed as a mechanism "to allow shorter scan times and longer source life." The original configuration, which has been referred to as the 'high resolution scan,' or 'slow scan,' was still recommended "to achieve the best precision with older sources or with low bone values." Since our primary concern in the conduct of a longitudinal research study was precision (not economic considerations) and since we recognized that we might indeed be studying patients with low bone mineral values, we elected the more rigorous methodology.

On May 15, 1986, Lunar reported to users a difference in bone density values in patients scanned with 13-mm collimation which depended upon source strength:

> A discrepancy in the standard program ... could influence the calibration of values in individual patients, particularly for scans done with 13-mm collimation using a new source or with very weak sources ... use of a larger collimation (13 vs 8 mm) has shown that there can be an over-estimation of standard values at high count rates ... and this reduces the calibrated patient values proportionally.

On May 16, 1986, a follow-up technical correspondence makes clear that the aforementioned error was due to the type of count rate correction (deadtime correction) used at high photon flux. As the manufacturer points out:

> With hot sources and 13-mm collimation, the standard values typically are 6% higher than the results with a fully depleted source. As a consequence, measurements made with a depleted source could over-correct the patient scan results. We have suggested previously that 8-mm collimation be used for scanning standards at high count rates to minimize the converse problems.

In 1986, we studied the effect of changing the scan configuration (collimator and scan speed) and found consistently higher BMD when the faster scan speed (5 mm/sec) and larger collimation (13-mm) were used. We opted, therefore, to continue to use the original recommended acquisition parameters (2.5 mm/sec and 8-mm collimation) to maintain consistency in bone mineral measurements during our on-going cross-sectional and longitudinal studies.

Dr. Mazess also suggests that our cold source was weaker than recommended. In fact, the weaker gadolinium source used in our study was within the manufacturer's recommendation of a 1-yr life. This source also satisfied another criterion for source acceptability, a minimum 30,000 count air value.

As noted, our study used two different sources but this change does not invalidate the observations reported by us, since sources do have a limited useful life requiring replacement. Surely, Dr. Mazess does not mean to suggest that clinical or research studies done using different sources cannot be compared.

It also is suggested that the water depths used are not equivalent to clinically encountered patient diameter. To the contrary, in a study of several hundred nonobese women within 15% of ideal body weight by the 1983 Metropolitan Life Insurance tables (*2*), we found a maximum weight of 79.1 kg. The maximum abdominal diameter in these subjects was 28 cm. As Dr. Mazess states, the thickness of 24.5 cm of water tested is equivalent to an abdominal diameter of 26 cm in women. All measurements were taken within the range of source strengths and patient thicknesses encountered clinically. Although the absorption coefficient of water is higher than that of fat, the 8.1 cm difference in water depths evaluated in this study is equivalent to 8.8 cm of abdominal fat as seen by the 44-keV photon, and 9.9 cm of fat as seen by the 100-keV photon (*3*). The maximum abdominal AP diameter of nonobese women (28 cm), theoretically represent 12.5 cm of additional abdominal fat compared to the lowest depth studies (16.4 cm). Thus, the 8.1 cm of water used in this study (equivalent to 9.9 cm of fat) is representative of the range of abdominal fatness expected in nonobese women.

Finally, Dr. Mazess seems to imply that the long-term precision of 2.5% reported by us elsewhere (*4*) is evidence that changes in acquisition parameters and software do not have significant impact on precision. On the contrary, this precision of 2.5% was obtained only through strict adherence to consistent acquisition parameters and software.

The changes in BMD with either changes in source strength or soft-tissue attenuation levels demonstrate how sensitive the technique using the device reported is to clinically unavoidable variations in count rates. Users of DPA should be aware of these problems.

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