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"BIOMETRIC ESTIMATION OF CHEST WALL THICKNESS OF FEMALE RADIATION WORKERS AS AN AID IN IN-VIVO DETECTION OF THE ACTINIDES"

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One of the important factors in detection of actinide deposition in humans is the differential attenuation of low-energy photons and X rays within the chest of an exposed individual. For example, it has been shown that every millimeter error made in estimating the thickness of the chest wall, through which these photons must pass, will result in at least 20% error in the final assessment of any ^{239}Pu lung burden.[1] Until recently, the Oak Ridge National Laboratory Whole Body Counting Facility has used A-Mode ultrasonic techniques for measuring the chest wall thickness of count subjects. A cross-calibration with Lawrence Livermore Laboratory, which uses imaging or B-Mode ultrasound, demonstrated that the ORNL measurements were in error by greater than 100%. To temporarily circumvent this difficulty, we used the following algorithm provided by LLNL[2] for chest wall thickness estimation for adult males.

$$y = 2.0038 + 0.115x$$

where y is chest wall thickness in cm, and x is the ratio of body mass (kg) to height (m). Since that time, we have purchased an imaging ultrasound (B-Mode) system to replace the A-Mode system. While measurements made with the new device on ORNL males show good agreement with the LLNL algorithm, measurements on ORNL female radiation workers showed variations of greater than 200% when compared with the LLNL equation. This is understandable in light of the unique thoracic structure of females versus males.

The ORNL Whole Body Counter staff undertook the task of deriving an algorithm for estimating biometrically the thickness of the female chest wall using imaging ultrasonic techniques, the results of which are summarized in this report. The ultrasound unit in use is an electronically sequenced linear-array, dynamic imaging system. It employs a focused transducer probe with an array of 384 elements. Many scans can be completed and converted to video displays. The complete

system is equipped with electronic calipers, two standard cathode ray tube displays with 16-step gray scales, foot-pedal controlled freeze frame, synchronized polaroid camera, and a video cassette recorder for mass data storage.

Biometric measurements were performed on each female volunteer for this study; which included the circumference of the abdomen, hips, right thigh, right calf, right upper and lower forearm, chest while in the vertical position, and the chest while in the supine position. The orientation of these same measurements are depicted for a male volunteer in Figure 1. Percent body fat is calculated by the method of Katch and McArdle.[3] The anterior-posterior (A-P) diameter of each subject at the xiphoid process, is also measured. With the subject lying on her back, the sternal notch is located and a line is drawn down the midline with a water soluble marker. Parallel lines are drawn at three, six, nine, and eleven cm from the midline mark on the left and right side of the chest. Radiation detector positions are marked using templates.[4]

After preparing subject and transducer probe with acoustic coupling gel, an image is obtained and measurements made for each of the eight positions. These measurements were averaged for the left, right, and total chest and correlated with various combinations of biometric measurements in order to derive a method of estimating the thickness of the female chest wall without the use of ultrasound. The best correlation was found between average chest wall thickness and percent body fat times the ratio of vertical chest circumference and supine chest circumference. A graph of these results is found in Figure 2. The following equation provides the statistical fit for the data obtained in this study:

$$y = 8.376 + 1.572x \qquad R^2 = 0.79$$

where y is the chest wall thickness in millimeters, x is the ratio of vertical chest circumference to supine chest circumference times percent body fat, and R^2, the coefficient of determination, indicates the quality of fit achieved by the regression. The estimation of chest wall

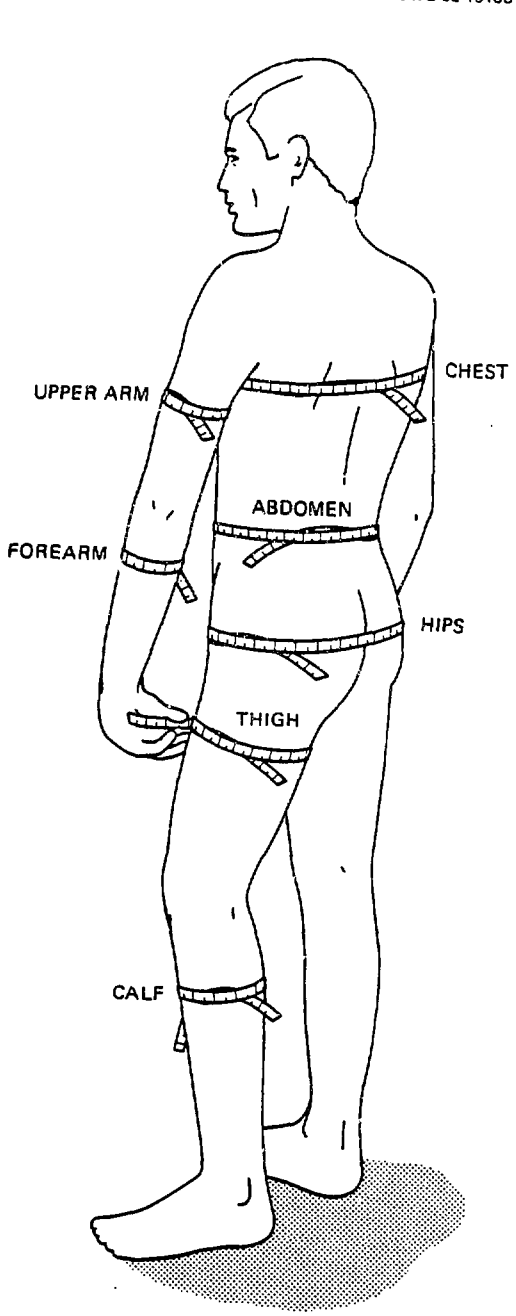

Fig. 1. Biometric Measurement Positions.

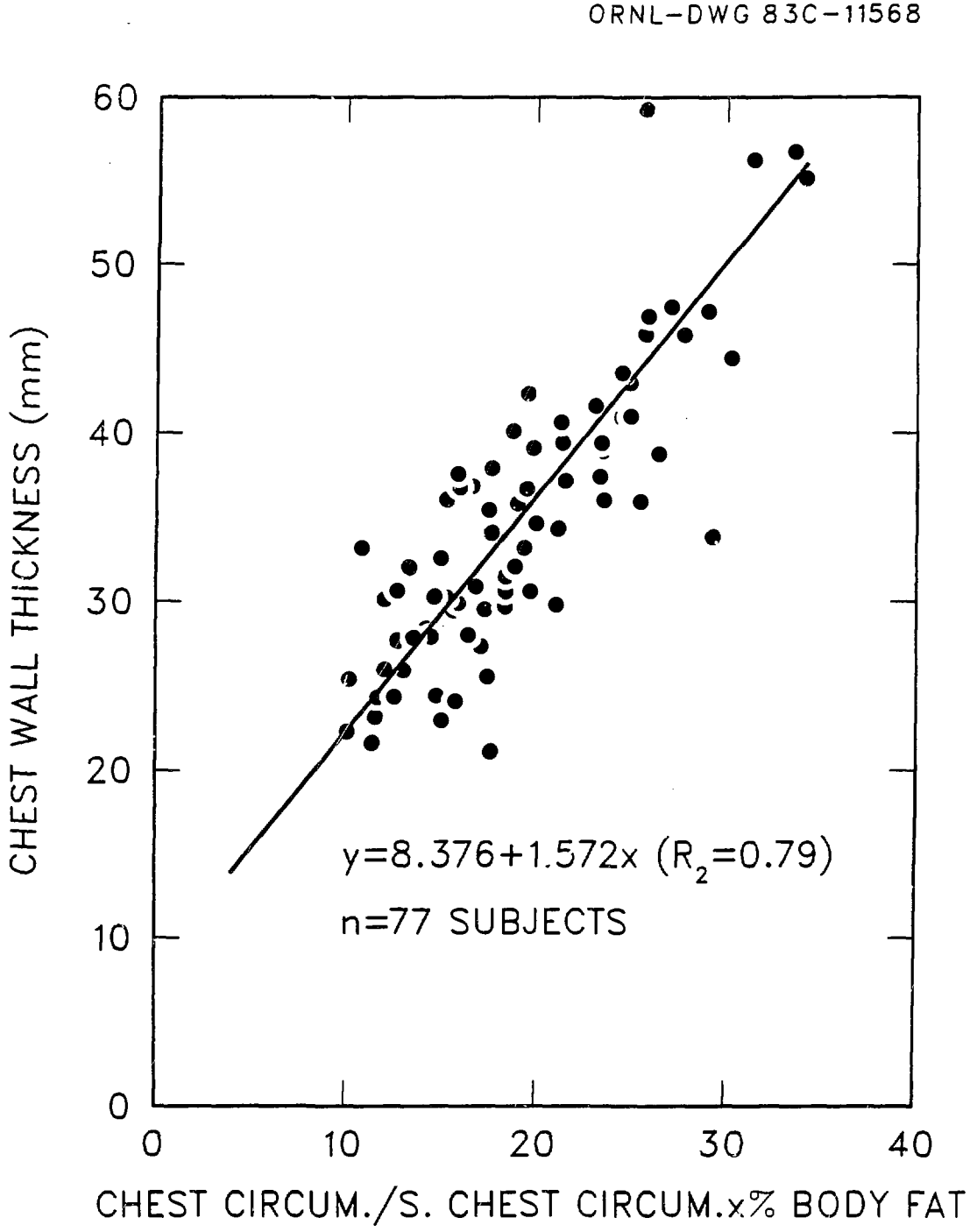
ORNL-DWG 83C-11568
CHEST WALL THICKNESS (mm)
60
50
40
30
20
10
0
0
10
20
30
40
CHEST CIRCUM./S. CHEST CIRCUM.x% BODY FAT
y=8.376+1.572x (R2=0.79)
n=77 SUBJECTS

Fig. 2

thickness by the above means may be in error by approximately 20%, which encompasses a 40-50% correction in detector efficiency for ^{239}Pu detection.

In summary, an equation was derived to estimate female chest wall thickness from a series of biometric measurements. This technique will result in improved performance for actinide detection in females by accounting for variations in chest wall thickness in derivation of calibration factors. Data collection is continuing in the hope of narrowing the range of error for this technique.

References

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