Estimation of the Proportion of Fat in the Body by Measurement of Skin-Fold Thickness*

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THE MEASUREMENT of body fat by total body water or specific gravity is not suitable for general use in medicine, nor for large surveys of populations. A simple way of measuring the amount of fat in the living body would be a great help to those who wished to know the approximate size of the lean body mass or the caloric reserve as stored fat of a population in a nutritional or anthropometric survey. For many years nutritionists and anthropometrists have measured skin-fold thicknesses for this purpose, but few have really been happy about what their measurements meant. If, however, the thickness of a fold of subcutaneous fat is proportional to the total body fat, and if this thickness can be measured accurately, then this measurement will give the simple estimate that we need.

The thickness of the fold is proportional to the total body fat if all the lipid-storing cells in the body take up fat at the same rate when the person stores fat, and give up fat at the same rate when the fat stores are used up. Even if this were true for any one person at any one time, the thickness of a fold would have no useful meaning unless the distribution of fat cells had the same pattern in all people in a particular broad age and sex group.

The pattern of this distribution has been found by measuring the thickness of fat-folds over the whole body in a number of age and sex groups and is remarkably constant within each group. There is some difference between the patterns of various groups and there are small differences in fat distribution between persons in a group, but much of the variation in body shape among persons of equal degrees of fatness is due to differences in the quantity and shape of the bones and muscles. This pattern of distribution of fat is the same whether the person is "fat" or "thin."

Full thickness cylinders of subcutaneous fat were taken at the same place on the body from persons with different degrees of fatness and the amounts of fat, water, and "other substances" were measured. The same quantity of "other substances" was present in all the tissue cylinders, the quantity of water was the same, but the quantity of fat was very different and was clearly responsible for the difference in the thickness of the subcutaneous fat. When body fat is made or used up, there is little or no change in the quantity of the cell material in the adipose tissue, but only a movement of fat in and out of the fat-storing cells. This has been confirmed histologically by measuring the average size of the fat globule in the fat cells. Tissues from the same place on the body of different persons, thin, average, and fat, differ widely in the size of the fat globules. When the size of the globules is plotted against the thickness of the subcutaneous fat, a curvilinear relationship is found, and when the size of the fat globules in tissues from different parts of the body of the same person are compared, they are found to be closely similar.

The conclusion is that within various age and sex groups the pattern of distribution of fat is the same for all members of the group, and that changes in the total amount of fat stored in the body involve similar changes in every fat-storing cell. Therefore, if we can measure the thickness of a fat-fold accurately, we should be able to get a good estimate of the

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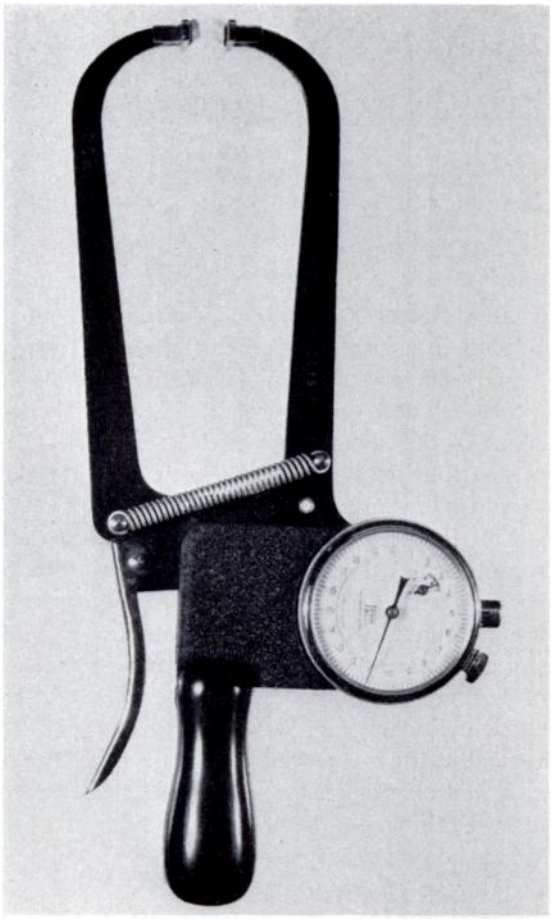

Fig. 1. Improved caliper for measuring skin-fold thickness (see test).

quantity of fat in the body from the thickness of one or more subcutaneous fat-folds.

The problem is how to measure the skin-fold accurately. There are many sources of error, but I shall only discuss the one which has so far been the greatest cause of difficulty—the calipers.

My colleagues, Messieurs Hammond, Healy, Tanner, and Whitehouse, and I have recently done some experiments to find out what are the important things in caliper design. We found that within wide limits the size of the jaw face was not important, but that the pressure in grams per square millimeter of jaw face which squeezes up the fold was most important. The fold can be compressed, so that a big pressure makes the fold smaller, and over the range of squeezing pressures generally used in calipers, very large differences in the recorded thickness of a fold were found. In most calipers there is a spring to produce the squeezing pressure, and as the caliper is opened, the pull of the spring is increased, so that a thick fold will be squeezed harder than a thin fold. We found also that there was much friction between the moving parts in some calipers which made the squeezing pressure variable and that it was generally not possible to read the scales more accurately than to the nearest millimeter. The experiments were done on behalf of the Medical Research Council's Committee on Growth and Form and are to be published in detail elsewhere,* but I will summarize our recommendations for caliper design:

(1) The calipers should have a constant squeezing pressure over the whole jaw opening range up to 50 millimeters.

(2) The squeezing pressure should be about 10 grams per square millimeter of jaw face.

(3) The scale should allow readings to be taken to the nearest 0.1 millimeter.

We have managed to make a caliper which meets these recommendations.†

In recent trials of these calipers we have found that an observer can measure a fold with such accuracy that if his average reading is 10 millimeters he will not be more than half a millimeter different from this in 19 out of 20 measurements.

The most important point which arises from all these observations, however, is that if the subcutaneous tissue fold measurements of one worker are to mean anything to him and to other workers, and they can be most informative, then the measurements must be made with accurate instruments which have a constant and known squeezing pressure. It would be best if all workers used the same pressure and I wish to urge, very strongly, that all who are interested will agree to a universally used pressure, in a precision-made caliper, which gives constant squeeze pressure, and reads accurately to 0.1 millimeter.

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† Made by British Indicators Limited, Sutton Road, St. Albans, Herts, England, and called the Harpenden Skin-fold Caliper Gauge.