MEASUREMENT OF TRICEPS SKINFOLD THICKNESS AN INVESTIGATION OF SOURCES OF VARIATION

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A measurement of the thickness of subcutaneous skinfolds has been widely used as an index of body fat. Edwards *et al.* (1955) investigated the design and accuracy of skinfold calipers and made a number of recommendations for their construction which were incorporated in the Harpenden skinfold calipers. They found that the precision of the Harpenden skinfold calipers was adequate and that the difference between examples of this instrument was small. In contrast, the difference in skinfold measurements found between observers was large. They therefore suggested that the limitations of accuracy depend on locating the skinfold, and also on the manner in which it is picked up. We have investigated the variation of skinfold thickness when location of the skinfold site was varied, the depth of bite changed, and the skinfold either held or released while the skinfold thickness was read.

METHOD

A single observer (L.R.) made all the measurements, using the same Harpenden skinfold caliper. A standard technique was employed. The observer and subject were always standing. Subjects rolled up the left shirt sleeve and stood with the left arm hanging freely. The posterolateral border of the left acromion was identified by palpation and the upper end of a cloth measuring-tape was placed against this border and the tape run down to touch the upper border of the olecranon. The distance between these two points was read to the nearest $\frac{1}{8}$ in (3.2 mm) and an ink mark was placed mid-way between them. The position of this ink mark is referred to as being at the standard mid-point. A skinfold was pulled out in the vertical plane approximately 1 in (2.5 cm) above the standard mid-point with the left thumb and forefinger. Holding the calipers horizontally in the right hand, the jaws were applied so that the ink mark was in the centre of the jaws. The jaws were then allowed to grip and the skinfold was smoothly released by the forefingers. The dial was read when the indicator needle had stopped moving. In a few subjects the needle, after the period of fast

initial movement, continued to move slowly. In these circumstances the dial was read as the needle changed from the phase of fast movement to slow. Each reading was made to the nearest 0.1 mm below. Two measurements were made at each site. Only the first measurements at each site have been used in the analysis because examination of the data showed no large or systematic differences within individuals between the pairs of measurements made at the same site.

Different subjects were used in each part of the study. They were all male subjects aged 40 years or over.

RESULTS

1. VERTICAL DISPLACEMENT OF SITE OF BITE (124 MEN)

Paired skinfold measurements were made at the following points:

- (a) at the standard mid-point;
- (b) 1 in (2.5 cm) vertically above it;
- (c) 1 in (2.5 cm) vertically below it.

The first subject had measurements made in the sequence (b), (a), (c), the second subject (c), (a), (b), the third (b), (a), (c), and so on. The results are given in Table I. The standard mid-point mean skinfold thickness was 11.7 mm. The mean skinfold measurements made 1 in (2.5 cm) below the standard mid-point was 2 mm less than at the standard mid-point. At the site 1 in (2.5 cm) above the standard

TABLE I
VERTICAL DISPLACEMENT OF SITE OF BITE
GROUP MEAN LEFT TRICEPS SKINFOLD (mm)

No. of Subjects	Position of Skinfold Measurement		
	2.5 cm. below Standard Midpoint	At Standard Midpoint	2.5 cm above Standard Midpoint
124	9.7	11.7	14.6

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TABLE II
HORIZONTAL DISPLACEMENT OF SITE OF BITE
GROUP MEAN LEFT TRICEPS SKINFOLD (mm)

No. of Subjects	Position of Skinfold Measurement		
	2.5 cm medially to Standard Midpoint	At Standard Midpoint	2.5 cm laterally to Standard Midpoint
120	11.2	14.1	16.3

mid-point the mean skinfold thickness was 2.9 mm greater than at the standard site.

2. HORIZONTAL DISPLACEMENT OF SITE OF BITE (120 MEN)

In this group measurements were made:

- at the standard mid-point;
- 1 inch (2.5 cm) medially to it;
- 1 inch (2.5 cm) laterally to it.

The first subject had measurements made in the sequence (b), (a), (c), the second (c), (a), (b), the third (b), (a), (c), and so on. It can be seen in Table II that the mean skinfold thickness at the standard mid-point is 14.1 mm. The medial site had a mean skinfold thickness 2.9 mm less than the standard site while the lateral site had a mean 2.2 mm larger.

3. SIZE OF BITE (62 MEN)

Skinfold measurements were made at the standard mid-point

- using the standard technique;
- as above, except that a deep bite was made with the caliper;
- using the standard technique except that a superficial bite was made.

Thirty-two subjects had measurements using a superficial bite and standard bite; a further 30 subjects had a deep bite measurement and standard bite. Table III lists the findings.

There is a trend; the superficial bite yielded a lower mean skinfold thickness than the standard procedure. The deep bite yielded higher values than the standard. These differences are smaller than those found in sections 1 and 2 of this study.

TABLE III
SIZE OF BITE
GROUP MEAN LEFT TRICEPS SKINFOLD (mm)

No. of Subjects	Superficial	Standard	Deep
32	13.9	15.6	—
30	—	12.7	13.1

4. EFFECT ON MEASUREMENT OF HOLDING OR RELEASING SKINFOLD (123 MEN)

Measurements were made at the standard mid-point

- while the fold was still held by the left fore-finger and thumb;
- after the caliper had been applied in the standard way and the skinfold smoothly released.

The first subject had measurements made in the sequence (a), (b); the second subject (b), (a), and so on. There is no systematic difference in skinfold thickness between measurements made with the skinfold held or released. Mean skinfold thickness was 13.3 mm with skinfold held and 13.4 mm when released.

ANALYSIS

The differences between skinfold measurements obtained at different sites have been calculated by taking the within-subject differences between pairs of sites, e.g., between the skinfold thickness measured at the standard mid-point and 2.5 cm vertically above this point, and comparing the mean of these differences with zero using the one-sample *t* test. The mean differences in skinfold thickness due to vertical and horizontal displacement of the site of bite were all highly significantly different from zero ($P < 0.001$), as was the difference between the standard and superficial bite. In the comparison between the standard depth of bite and the deep bite, $t = 2.55$ and P lay between 0.02 and 0.01. There was no significant difference between measurements made while holding the skinfold or when it was released; $t = 1.68$ ($0.1 < P < 0.05$).

DISCUSSION

This study has demonstrated the considerable variation in triceps skinfold measurement that may result from vertical and horizontal displacement of the site of measurement. The distribution of subcutaneous fat in the upper arm is not uniform, being thicker proximally. Also the medial aspect of the limb has less subcutaneous fat than the lateral aspect. A lack of precision in the identification of the standard mid-point from subject to subject could lead to a large random variation in these measurements.

In studies where more than one observer measures skinfold thickness a consistent difference between observers in their site of measurement may result in a systematic difference between their measurements. From the findings in this study even a fairly trivial divergence from the standard mid-point could produce important, systematic differences in the skinfold measurements obtained.

The size of bite, whether deep or superficial, has been found to produce a small systematic difference in skinfold thickness. The difference between the superficial and standard bite was larger than between standard bite and deep. In practice it is difficult to take a superficial bite and it is unlikely that bite size would be other than a minor source of variation.

Experience in this study has emphasized the difficulties in locating accurately the standard mid-point. The technique being used at present is imprecise. It relies upon the observer accurately locating the bony points, measuring the distance between them with a tape-measure, dividing this distance in half, and then finally placing the mark, which can either be placed at the side or under the tape-measure. If the latter the tape-measure has to be lifted up before the mark is made and judgement may then be needed in placing the mark. There are thus several opportunities for errors to occur in identifying the mid-point.

We suggest that the precision of the measurement of triceps skinfold thickness depends in large part upon accurate location of the standard mid-point and to a lesser extent upon the size of bite. Whether or not the skinfold was held during the measurement was unimportant.

Precision will be improved only when a simplified and repeatable method is evolved to identify the standard mid-point. Such a technique is under development by one of us (J.R.T.C.).

SUMMARY

Variation in left triceps skinfold thickness has been investigated by changing the technique and site

of measurement. One observer using a Harpenden caliper made skinfold measurements on four groups of men aged 40 and over. It was found that skinfold thickness 2.5 cm above the triceps mid-point was significantly ($P < 0.001$) greater than at the mid-point, skinfold thickness 2.5 cm below the mid-point was thinner than at the mid-point ($P < 0.001$).

Skinfold thickness 2.5 cm medial to the mid-point was significantly thinner than at the mid-point ($P < 0.001$); measurements made 2.5 cm lateral to the mid-point were thicker than at the mid-point ($P < 0.001$).

Variation in the size of bite led to systematic differences in skinfold thickness. A deep bite yielded significantly thicker skinfold measurements ($0.02 < P < 0.05$) while a superficial bite yielded thinner skinfold measurements ($0.1 < P < 0.05$) than did the normal bite. No systematic difference in skinfold thickness was found when skinfold measurements were made with the skinfold held by the fingers or released.

It is concluded that a lack of precision in identification of the triceps mid-point may lead to large random variation in skinfold thickness between subjects and to systematic differences between observers. Likewise differences in depth of bite may have a similar effect. Attention to accurate location of the triceps mid-point and standardization of depth of bite should reduce the variability of the measurement.

REFERENCE

- EDWARDS, D. A. W., HAMMOND, W. H., HEALY, M. J. R., TANNER, J. M., and WHITEHOUSE, R. H. (1955). Design and accuracy of calipers for measuring subcutaneous tissue thickness. *Brit. J. Nutr.*, **9**, 133.