Technical Note

Skinfold thicknesses: is there a need to be very precise in their location?

BY J. V. G. A. DURNIN[1], H. DE BRUIN[2] AND G. I. J. FEUNEKES[2]

[1]*Department of Human Nutrition, University of Glasgow, Yorkhill Hospitals, Glasgow G3 8SJ*
[2]*Department of Human Nutrition, Agricultural University, Wageningen, The Netherlands*

(*Received 10 April 1996 – Revised 23 May 1996 – Accepted 5 June 1996*)

Skinfold thicknesses represent a comparatively simple and reasonably accurate assessment of body fatness which is an important part of the estimation of nutritional state. However, much emphasis is placed on the necessity to be very precise in the exact position of the skinfold being measured and there is frequently concern, also, about the variability of the measurement by different observers using different types of caliper. Fifty-three women and forty-five men had four skinfolds (biceps, triceps, supra-iliac and subscapular) measured first at the standard sites (Tanner, 1953; Edwards *et al.* 1955), and then at deliberately chosen sites about 20 mm distant from the 'correct' ones. The effect on the estimation of body fatness by this manoeuvre resulted in a difference of usually less then 1 % and, at a maximum, 3 %. In the light of the uncertainty of the basic assumptions which are made in extrapolating from skinfolds (or indeed densitometry, total body water, total body K, and others) to body fatness, these technical errors assume comparatively little importance.

Skinfold thickness: Location: Fatness

In the description of almost any nutritional investigation in human subjects, some elementary information on the physical characteristics of the experimental subjects needs to be included. One important characteristic is the relative fatness of the individuals and some assessment of this should be provided as a part-indicator of nutritional status.

One of the commonest methods of assessing fatness in human beings, especially in field investigations, is by the use of skinfold thicknesses using either the equations of Durnin & Womersley (1974) or Jackson & Pollock (1978).

There is considerable scope for error in the use of any of the several methods for estimating fatness, quite apart from faulty technique, including factors such as the constancy of the subcutaneous : internal adipose tissue ratio, of the water and K proportion of the fat-free mass (FFM), of the relationships of body density to fat and FFM, etc. The basic assumptions are therefore a considerable source of discrepancy and, because of this, it is possible that skinfolds may provide the most valid estimate of fatness (McNeill *et al.* 1991).

However, an inhibiting factor in using skinfolds appears to be the common impression that (1) the technique itself is difficult, (2) there is much variability in the results obtained by different observers, (3) there are differences in the measurements due to variations in type of caliper used, and (4) important differences may occur because of small variations in deciding on the exact site to be measured. There are several reports of studies which have demonstrated little justification for concern with regard to the first three of these possible sources of variation.

Since Tanner (1953) first described the Harpenden skinfold caliper it has been widely used and various aspects which might lead to error have been examined. Observer variability has been studied by Edwards *et al.* (1955), Burkinshaw *et al.* (1973), Womersley & Durnin (1973), Durnin *et al.* (1985), and Fuller *et al.* (1991). In all of these studies observer differences account for 2–3 % or less in the estimated percentage fat. Differences due to which side of the body was taken for the measurements were examined by Womersley & Durnin (1973), and Durnin *et al.* (1985), and the influence of the type of caliper used was assessed by Imbimbo *et al.* (1968), and by Womersley & Durnin (1973). In none of these cases was the error due to side of body or instrument likely to lead to an error in percentage fat of more than 2–3 % and it was usually much less.

The present study was designed to try and determine whether picking up the skinfolds at sites which were slightly different from the recommended ones would influence the results, which was the fourth area of concern listed above.

METHODS

A group of ninety-eight adults (fifty-three women and forty-five men) formed the experimental sample. Skinfolds were measured at the standard biceps, triceps, supra-iliac and subscapular sites on the right side of the body (Weiner & Lourie, 1969). The skinfold was picked up firmly between thumb and forefinger and pulled away slightly from the underlying tissue. At the moment that the caliper jaws were applied to the skinfold, the thumb and forefinger were removed and a reading was taken after 2 or 3 s. The measurement was done three times at each site and recorded to the nearest 0·2 mm.

As well as measuring these skinfolds at the standard sites, the following variations were also done.

Biceps: mid-arm, i.e. at the level of the triceps skinfold, and not, therefore, exactly over the mid-point of the belly of the biceps muscle.

Triceps: at points 20 mm above, 20 mm below, and 20 mm to the right of the standard reference site.

Sub-scapular: 20 mm below the reference location, and also immediately superficial to the tip of the scapula instead of immediately below this.

Supra-iliac: 20 mm above the reference location just above the iliac crest, and also taken as a vertical and as a horizontal skinfold and 20 mm anterior to this location at an angle of 45°.

The data for the men and women were analysed separately. For each site, the skinfold at the reference or standard location was compared with the skinfolds at the deviant locations by paired *t* tests, using the Bonferroni multiple comparisons approach. Fatness values estimated from combinations of the reference locations and deviant sites were compared with fatness values estimated from the four reference sites using the equations of Durnin & Womersley (1974).

RESULTS AND DISCUSSION

Table 1 gives some of the physical characteristics of the two groups of experimental subjects. In Table 2 the mean skinfolds at the four reference locations are given, together with those at the deviant sites. The first value under the four sites is the mean of the skinfolds measured correctly at each reference site. There then follows, for each site (i.e. biceps, triceps, etc.), the mean value obtained for the separate deviant sites. There were significant differences at six of these sites for both men and women; the importance of these differences will be discussed later.

Table 1. *Age, weight, height, BMI, sum of four reference skinfolds and percentage body fat of male and female subjects*

(Mean values, standard deviations and ranges)

	Females (*n* 53)			Males (*n* 45)		
	Mean	SD	Range	Mean	SD	Range
Age (years)	22·7	5·3	17·0–38·0	29·0	10·6	18·0–66·0
Wt (kg)	57·2	7·3	43·0–70·0	70·1	7·7	54·5–87·0
Ht (m)	1·66	0·08	1·46–1·83	1·76	0·09	1·53–1·96
BMI (kg/m^2)	21·0	2·2	17·0–26·0	23·0	2·8	19·0–28·0
Sum of four skinfolds (mm)	46·2	13·2	26·5–76·5	41·4	15·0	18·3–80·7
Body fat (%)	25·2	3·8	17·9–32·1	17·5	4·8	10·1–29·4

Table 2. *Biceps, triceps, subscapular and supra-iliac skinfold thicknesses (mm) at reference and deviating locations for females and males*

(Mean values and standard deviations)

	Females (*n* 53)		Males (*n* 45)	
	Mean	SD	Mean	SD
Biceps				
Reference	6·7	2·6	4·6	2·1
Mid-arm	6·1***	2·3	4·3***	1·6
Triceps				
Reference	14·4	4·2	9·4	3·7
20 mm higher	14·9***	4·2	10·4***	4·2
20 mm lower	14·5	4·4	8·9***	3·4
20 mm to the right	17·8***	4·9	10·7***	4·3
Subscapular				
Reference	12·0	3·3	12·0	4·0
20 mm lower	12·5*	3·4	12·4	4·3
On the tip	11·6*	2·9	11·3***	3·8
Supra-iliac				
Reference	13·1	5·6	15·3	7·3
20 mm higher	12·7	5·0	15·8	7·0
Horizontally	13·4	5·0†	15·1	6·9
20 mm to the spine at 45°	10·7***	5·0	11·9***	6·4

Mean values were significantly different from the reference values: *$P < 0·025$,***$P < 0·001$.
† *n* 52.

Table 3 gives for men and women the difference between the value for 'percentage body fat as a function of body mass' obtained by using the four reference sites and also from three reference sites and a fourth deviant site. For seven out of the nine possible differences this was equivalent to less than 0·2 % fatness in the women; in the men, six out of nine showed a difference of less than 0·2 % fatness. The maximum difference was less than 2 % with the exception of the supra-iliac site taken at an angle of 45° to the vertical. Although several of these mean differences were very highly significant, the actual extent of the difference was of very minor importance for most purposes for which this method is likely to be used.

An estimation was also made of the effect of making measurements at two out of the four sites at positions deviating from the reference technique. In all, twenty-nine different combinations were examined. There were significant differences between the value of the

Table 3. *Difference between body fat (%) calculated from the sum of four reference skinfolds and body fat (%) calculated from the sum of three reference skinfolds and one skinfold at a deviating location for females and males*

(Mean difference values, standard deviations and ranges)

	Mean difference % fatness	SD	Range
Females (*n* 53, 25·2% body fat)			
Biceps mid-arm	0·2**	0·2	−0·5–0·9
Triceps 20 mm higher	−0·2*	0·4	−1·1–0·7
Triceps 20 mm lower	−0·0	0·3	−0·8–0·6
Triceps 20 mm to right	−1·0**	0·4	−1·8–0·1
Subscapular 20 mm lower	−0·1*	0·4	−0·8–0·8
Subscapular on tip	0·1	0·4	−0·7–1·3
Supra-iliac 20mm higher	0·1	0·3	−1·2–1·9
Supra-iliac horizontally	−0·2†	0·7	−1·9–1·6
Supra-iliac 20 mm to spine at 45°	0·8**	0·7	−1·1–2·5
Males (*n* 45, 17·5% body fat)			
Biceps mid-arm	0·1*	0·2	−0·3–0·7
Triceps 20 mm higher	−0·3**	0·4	−1·2–0·7
Triceps 20 mm lower	−0·1**	0·2	−0·3–0·7
Triceps 20 mm to right	−0·4**	0·3	−0·9–0·3
Subscapular 20 mm lower	−0·1	0·3	−1·0–0·5
Subscapular on tip	0·2**	0·3	−0·4–0·9
Supra-iliac 20 mm higher	−0·2	0·6	−1·8–0·9
Supra-iliac horizontally	0·0	0·5	−1·5–1·1
Supra-iliac 20 mm to spine at 45°	1·1**	0·6	−0·4–3·1

Mean differences were statistically significant: $*P < 0·025$, $**P < 0·01$.
† *n* 52.

mean percentage fatness calculated from the four reference skinfolds and from two reference and two deviant skinfolds in seventeen out of the twenty-nine, but this reached only 1·15 and 1·18 % fatness in the two greatest differences, between 0·5 and 1 % fatness in eight 'deviant' calculations, and between zero and 0·5 % fatness in the remaining nineteen combinations. The maximum difference was never greater than 3 % fatness, and was less than 2 % in fourteen out of the twenty-nine combinations.

CONCLUSION

The present study was concerned with assessing the effect of making a gross misjudgement of the exact position of the skinfold to be measured. Using the equations of Durnin & Womersley (1974) the percentage fatness of an individual from four skinfolds (biceps, triceps, supra-iliac and subscapular) picked up at the standard reference sites was then contrasted with one obtained by deliberately making a considerable error in the position of one of the sites, and also, as a separate exercise, in the position of two sites out of the four. Although many of these comparisons were significantly different from each other, the actual amount of the difference was comparatively small and of little practical importance. With one deviant skinfold the mean percentage fatness of a group of fifty-three women differed by, in seven out of nine cases, less than 0·2 % fatness, and in a group of forty-five men by less than 0·3 % fatness in seven out of the nine possible comparisons. The maximum difference within each set of comparisons (e.g. with a deviant biceps or a deviant subscapular with the other three skinfolds having been picked up correctly) was equivalent to 2·5 % fatness for an individual woman and 3 % for an individual man.

In the case of two out of the four skinfolds being deviant, in only two out of the twenty-nine possible comparisons did this lead to a difference of as much as 1·2 % fatness in the women and in only three comparisons in the group of forty-five men was it as much as 1·3 % fatness. The maximum difference for an individual woman was 2·7 % fatness and for an individual man was 3·1 % fatness.

When we consider, first of all, the relatively small magnitude of these differences and, second, the imprecision of the quantitative bases from which percentage fatness is calculated from skinfolds (Durnin, 1995) (although most other techniques are open to even greater criticism; Womersley & Durnin, 1973; Durnin & Womersley, 1974; McNeill *et al.* 1991; Fuller *et al.* 1992; Jebb *et al.* 1993), the degree of error caused by picking up the wrong skinfold is really of minimal importance.

Of course, single or multiple skinfolds by themselves are sometimes used to examine any local effect of a treatment. Deviant error in this case might assume greater importance and would have to be assessed using different criteria. The present paper is concerned with errors in estimating total body fat percentage or FFM.

This work was partly funded by a grant from the Nestlé Foundation.

REFERENCES

Burkinshaw, L., Jones, P. R. M. & Krupowicz, D. W. (1973). Observer error in skinfold thickness measurement. *Human Biology* **45**, 273–279.

Durnin, J. V. G. A. (1995). Appropriate technology in body composition. *Asia Pacific Journal of Clinical Nutrition* **4**, 1–5.

Durnin, J. V. G. A., McKay, F. C. & Webster, C. I. (1985). *A New Method of Assessing Fatness and Desirable Weight, for Use in the Armed Services. A Survey of 9000 Adults in the UK. Report to Ministry of Defence.* London: Ministry of Defence.

Durnin, J. V. G. A. & Womersley, J. (1974). Body fat assessed from total body density and its estimation from skinfold thickness: measurements on 481 men and women aged from 16 to 72 years. *British Journal of Nutrition* **32**, 77–97.

Edwards, D. A. W., Hammond W. H., Healy, M. J. R., Tanner, J. M. & Whitehouse, R. H. (1955). Design and accuracy of calipers for measuring subcutaneous tissue thickness. *British Journal of Nutrition* **9**, 133–143.

Fuller, N. J., Jebb, S. A., Goldberg, G. R., Pullicino, E., Adams, C., Cole, T. J. & Elia, M. (1991). Inter-observer variability in the measurement of body composition. *European Journal of Clinical Nutrition* **45**, 43–49.

Fuller, N. J., Jebb, S. A., Laskey, M. A., Coward, W. A. & Elia, M. (1992). A four-component model for the assessment of body composition: comparison with alternative methods, and evaluation of the density and hydration of fat-free mass. *Clinical Science* **82** 687–693.

Imbimbo, B., Fidanza, A. A., Caputo, V. & Moro, C. O. (1968). Valutazione comparativa di tre differenti plicometri. (A comparative evaluation of three different skinfold values). *Quaderni della Nutrizione* **28**, 332–340.

Jackson, A. S. & Pollock, M. L. (1978). Generalized equations for predicting body density in men. *British Journal of Nutrition* **40**, 497–504.

Jebb, S. A., Murgatroyd, P. R., Goldberg, G. R., Prentice, A. M. & Coward, W. A. (1993). In vivo measurement of changes in body composition: description of methods and their validation against 12-d continuous whole-body calorimetry. *American Journal of Clinical Nutrition* **58**, 455–462.

McNeill, G., Fowler, P. A., Maughan, R. J., McGaw, B. A., Fuller, M. F., Gvozdanovic, D. & Gvozdanovic, S. (1991). Body fat in lean and over-weight women estimated by six methods. *British Journal of Nutrition* **65**, 95–103.

Tanner, J. M. (1953). Growth of the human at the time of adolescence. *Lectures in the Scientific Basis of Medicine* **1**, 308–363.

Weiner, J. S. & Lourie, J. A. (1969). *Practical Human Biology*. London: Academic Press.

Womersley, J. & Durnin, J. V. G. A. (1973). The assessment of obesity from measurements of skinfold thickness, limb circumferences, height and weight. In *Regulation of the Adipose Tissue Mass*, pp. 234 –237 [J. Vague and J. Boyer, editors]. Amsterdam: Excerpta Medica.