# Estimation of subcutaneous fat in men – Part 2: Comparison of caliper and ultrasound measuring

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## Abstract

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**Purpose**
1. To measure whole body subcutaneous fat in men
2. To compare caliper and ultrasound measuring

**Methods**:
In 25 men, aged 23 to 75 (46±14) years, total body subcutaneous fat ("WBSF") was measured using a skin fold calliper and an ultrasound measuring equipment. In each person, 116 square sectors with a mean area of 10 square cm were marked on the skin. Subcutaneous fat of each square sector was repeatedly measured using a calliper. The method in detail is described elsewhere.

**Results**
Mean body weight of the subjects was 88 ± 15 kg. Whole body subcutaneous fat was 9,11 ± 4,03 kg (10.4% of whole body mass). The variance of measurements was -2.4 kg to + 2.5 kg. Referred to a significance level of 5% only 3 of 25 pairs of variates exceeded a deviation of more than -1.95 kg to + 1.87 kg.

**Conclusions**:
In 25 men subcutaneous fat was estimated using a calliper vs. an ultrasound method. No substantial differences were found between these measurements. This indicates that subcutaneous calipometry may be done using one or the other method, prerequisite no extremely thin or thick subcutaneous layer is present.

**Key words:**
subcutaneous fat, calipometry, ultrasound

## Introduction

The most common simple methods to measure whole body subcutaneous fat are skin fold calipometry and ultrasound [5, 10, 11, 14, 15, 17]. It is an obvious drawback of skin fold calipometry that a number of factors may affect the results, e.g. very thin or thick subcutaneous layers, the way of pulling up the skin, and the use of the calliper itself. Ultrasound measures skin and subcutaneous layers directly, although the differentiation between the layers does not always work automatically and substantial practice of the observer is needed to obtain feasible results.

In combination with whole body fat measurement, whole body subcutaneous fat measurement may be a clinically relevant parameter to estimate intra abdominal fat [10, 11, 15], which is a major risk for cardio vascular diseases like hypertension, insulin resistance and diabetes, coronary artery disease and stroke. Until now, no easy handling tool of whole body subcutaneous fat (WBSF) measurement hase come to our knowledge. Recently equations to calculate WBSF from only 3 points have been published by our own group (21). Until today, WBSF is measured in clinical settings by modified computer tomography, which is accompanied by inadequate radiation load or MRI [1].

The amount and distribution of body fat is apparently a major factor of cardio-vascular risk in children and adolescents and makes the measurement of body composition an important diagnostic tool [4, 9, 12, 13]. Skinfold fat measurements until now do not provide any information about total body subcutaneous fat nor about the distribution of the fat. In contrast, the use of skinfold techniques may cause misleading results of whole body fat since large amounts of abdominal fat will not be represented by any site of subcutaneous fat measurement.

Some more or less indirect attempts have been made to measure WBSF [5, 8, 14, 16, 17, 18], including simple anthropometric variables [3, 14], but extremely high variations around true values make these methods unacceptable for clinical use. So up to date skinfold and ultrasound subcutaneous fat measures of special body points are the accepted method to estimate whole body fat content. In this study we compare the results of skinfold and ultrasound measuring as options for direct estimation of WBSF with whole body mapping or by 3-point subcutaneous fat measurement [15].

## Methods

Measurements of subcutaneous fat were performed in 25 healthy men (mean age 46±14 years; mean weight 88±15 kg; Table 1,2).
Skin fold measurements (Holtain Skinfold Caliper) and ultrasound measurements (Bodymetrix BX 2000) were performed in 116 square fields, each about 10 $cm^2$. All square fields were marked on the body and measurements were taken in the middle of each field. Each measurement was repeated threefold and mean values were calculated. To compare calliper and ultrasound measurements Bland Altman plots [6] were calculated. The portioning of the body in detail is given in Table 3 (for further details of the methods see Part 1). In addition comparative skinfold and ultrasound measurements were performed for a number of standard body points used for the estimation of whole body fat from subcutaneous fat measurements [15, 22].

**Table 1. Age and anthropometric data of the subjects**

| | means ± SD | range |
|---|---|---|
| **Age (years)** | 45,72 ± 17,2 | 23 - 75 |
| **height (cm)** | 178 ± 5,91 | 167 - 189 |
| **weight (kg)** | 88,01 ± 15,18 | 62,8 - 122,8 |
| **BMI (kg/m²)** | 27,84 ± 4,92 | 21,73 - 38,75 |
| **waist/hip ratio** | 1,01 ± 0,06 | 0,91 - 1,16 |

**Table 2. Age and anthropometric data of the subjects in dependency of age ranges**

| | 20 - 29 Jahre | 30 - 39 Jahre | 40 - 49 Jahre | 50 - 59 Jahre | 60 - 75 Jahre |
|---|---|---|---|---|---|
| **Alter (Jahre)** | 24,4 ± 0,89 | 33,0 ± 2,34 | 45,2 ± 1,30 | 56,2 ± 3,83 | 69,8 ± 5,71 |
| **Gewicht (kg)** | 72,9 ± 6,83 | 96,32 ± 19,23 | 91,50 ± 4,65 | 83,04 ± 13,04 | 96,26 ± 16,50 |
| **BMI (kg/m²)** | 23,54 ± 2,20 | 30,29 ± 6,16 | 26,77 ± 1,81 | 27,67 ± 4,00 | 30,75 ± 6,36 |
| **WHR** | 0,95 ± 0,03 | 1,01 ± 0,05 | 1,01 ± 0,04 | 1,03 ± 0,04 | 1,06 ± 0,08 |

**Table 3. Body mapping, points of subcutaneous fat measurement.**

| part of the body | subdivision | fields´ numbers |
|---|---|---|
| **upper arm** | biceps / ventral upper arm | 1,2,3 (left / right) |
| **lower arm** | lateral / medial | 4,5,6 (left / right) |
| **abdomen and chest** | lateral<br>medial | 11 – 15 (left / right)<br>16 – 20 (left / right) |
| **cervix** | dorsal<br>anterolateral | 21 (left / right)<br>22 (left / right) |
| **back** | lateral<br>medial | 23 – 28 (left / right)<br>29 – 34 (left / right) |
| **thigh** | extensor lateral<br>extensor medial<br>adductors<br>hamstrings lateral<br>hamstrings medial | 37, 38, 39 (left / right)<br>40, 41, 42 (left / right)<br>43, 44, 45 (left / right)<br>46, 47, 48 (left / right)<br>49, 50, 51 (left / right) |
| **fossa poplitea** | | 52 (left / right) |
| **lower leg** | m. tibialis<br>gastrocnemius lateral<br>gastrocnemius medial | 53, 54 (left / right)<br>55, 56 (left / right)<br>57, 58 (left / right) |

## Results

The correlation coefficients of subcutaneous fat measurements using skinfold and ultrasound measurement are given in Table 4. In Fig. 1 the differences between ultrasound and skinfold measurements are displayed. Values are given in kg whole body subcutaneous fat as estimated from whole body mapping (x-axis: ultrasound values are set as reference values).

**Table 4. Correlation coefficients of skinfold vs ultrasound measurements.**

| | total | 20-29 years | 30-39 years | 40-49 years | 50-59 years | 60-75 years |
|---|---|---|---|---|---|---|
| **number** | 25 | 5 | 5 | 5 | 5 | 5 |
| **correlation (Pearson)** | 0,936* | 0,407 | 0,980* | -0,253 | 0,665 | 0,985* |
| **significance** | < 0,0001 | 0,497 | < 0,003 | 0,681 | 0,221 | < 0,002 |

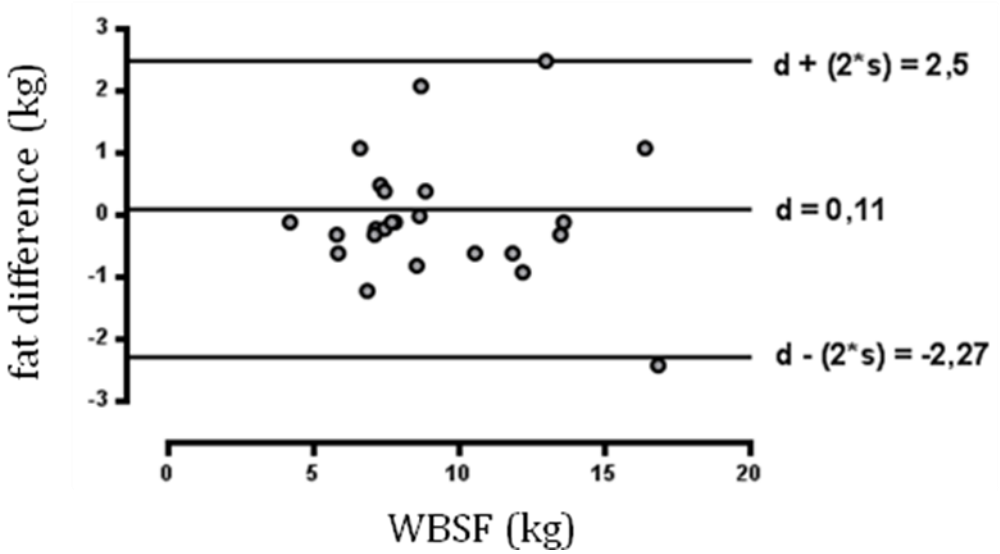


**Figure 1. Bland-Altman plot of WBSF calculated from ultrasound vs. calipometry whole body mapping data (means of all subjects)**

Fig. 1 shows that there is no relevant mean difference between the measurements and only a small variation in the range of 1 kg. Further comparative measurements were performed using standard skinfold points for the estimation of whole body fat [15, 22] vs. ultrasound measurements. The intra-method correlation of ultrasound measurements comparing the 3- and 7-point equation or the 3- and 9- point equation show good correlations (r = 0.987 p<0.001 and r=0.814 p<0.001 respectively). The corresponding intra-method results for the skin-fold estimations were similar (r = 0.987 p<0.001 and r=0.889 p<0.001 respectively).

The inter-method comparison revealed similar results (ultrasound vs. skinfold methods; 3-point method r=0.919 p<0.001; 7 point method r=0.951 p<0.001).

## Discussion

There is a large number of publications dealing with the question how to measure whole body fat content or visceral fat [e.g. 1, 2, 3, 8, 10, 11, 13, 15, 17, 19 and many others]. No method how to estimate whole body subcutaneous fat (WBSF) has come to our knowledge. Though MRI would provide this option, availability and the necessity for a whole body scan would restrict this method for only few indications. In 1995 Bonora et al. [3] have made an attempt to estimate human visceral and subcutaneous abdominal fat from anthropometric data, but the variation from MRI were too high. So until today subcutaneous fat measurement only serves to estimate whole body fat according to approximations derived from e.g. body density measurements [11] or DXA-Scan [10]. Our own approach of whole body skin mapping as described in Part 1 of this paper is new according to our literature research. Since mapping was performed using both skinfold and ultrasound methods it was of major interest whether both methods would reveal similar results.

The results of this study suggest that no relevant mean differences exist between skinfold and ultrasonic measurements of subcutaneous fat. As displayed in the Bland-Altman graph (Fig. 1) there is only a very small variance of about 2 kg and almost all points are within the range of variance. Looking at this we confirm the results of Müller et al. 2013 and Selkow et al. 2011 [17, 18], though these authors saw an advantage of the ultrasound measurement. We think either method may be used in dependency of the availability of the equipment. According to our experience both methods need a good time of training, both methods have a number of possible bugs [17, 18]. Further to our experience the skinfold calliper has advantages for thin skin such as in sportspeople, whereas the ultrasound device shows a much better handling and probably better results when used in overweight and adipositas.

**Conclusions**

Subcutaneous fat measurements for measurement of whole body subcutaneous fat may be done with either skinfold calliper or ultrasound measuring equipment.

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