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A Comparison of the Body Composition Estimated by Densitometry and Total Body Potassium Measurement in Trained and Untrained Subjects

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Summary. For the study of the body composition in vivo many methods are available. Two more elaborate methods are densitometry and K-40 measurement. During a period of training changes in body composition occur, viz. a decrease in the fatmass (FM) and an increase in the fatfree mass (FFM). The body composition (FM and FFM) of 15 trained and 20 untrained subjects was investigated applying the two above mentioned methods.

The body composition estimated from body density differs clearly from the body composition estimated from body potassium measurement in trained as well as in untrained subjects.

One of the explanations for this discrepancy could be, that between individuals the K-content of the FFM varies greately. One of the factors causing a difference in the K-content of the FFM could be the training level; in the trained subjects a mean value of 69.0 mEq per kg FFM and in the untrained subjects of 61.6 mEq per kg FFM could be calculated.

Key words: Body Composition — Body Density — Body Potassium — Training.

For the assessment of the amount of body fat in the human body different methods are available. When the body weight and the percentage of body fat are known the fatfree mass (FFM) can be calculated. Two extensively applied laboratory methods for determining the body composition are the densitometry and the measurement of the body potassium. In several investigations a change in body composition during a period of training has been shown. The changes commonly observed during a period of training are a decrease in the amount of body fat (FM) and an increase in the FFM (Dempsey, 1964; Leusink, 1972; Parizkova, 1959; Sprynarova *et al.*, 1956; Thompson *et al.*, 1956; Thompson, 1959).

The present paper compares the results of measuring the FFM and the FM by two different methods in one group of untrained and one of trained subjects. The results of the two methods to be compared were the densitometry and the K-40 method.

Methods

As trained subjects acted 15 well-trained male hockey-players; as untrained subjects 20 apparently healthy men were investigated (medical students, laboratory personnel). The mean values (and standard deviations) for age ,height and weight are listed in Table 1.

Table 1

		Trained (n = 15) M ± S.D.	Untrained (n = 20) M ± S.D.
Age	yr	21 ± 4	25 ± 5
Height	m	1.81 ± 0.04	1.79 ± 0.06
Weight	kg	69.1 ± 7.0	68.8 ± 6.4

Methods of Estimating FFM and FM

Densitometry. The density (D) of the subjects was measured by weighing underwater with the simultaneous measuring of the residual volume in the lungs and the airways with the He-dilution technique. Fat content (%F-dens) of the body weight was calculated according to the formula of Brožek *et al.* (1963).

$$\%\text{F-dens} = \left[\frac{4.570}{D} - 4.142\right] \times 100 \quad (D \text{ in g} \cdot \text{cm}^{-3}) .$$

The FFM-dens and FM-dens were calculated from body weight and %F-dens.

K-40 Measurement. Total body K-40 was measured with a mobile whole-body radioactivity monitor. K-40 in the human body was measured for 60 min. After calculating total body potassium from the K-40 measured the formula of Forbes *et al.* (1961) was used to calculate the FFM-K-40.

$$\text{FFM-K-40} = \frac{\text{measured mEq K}}{68.1}$$

The FM-K-40 and the %F-K-40 were calculated from body weight and FFM-K-40.

Results

The results of the investigations of body composition are shown in Table 2.

Only in 11 of the 15 trained subjects the FFM-K-40 and %F-K-40 could be calculated, in 4 trained subjects the calculated FFM-K-40 was heavier than the body weight itself. Comparing the weights of the FFM-dens and the FFM-K-40 of the 11 trained subjects no significant differences could be shown (t-test for paired observations). Also the %F and the FM of the 11 trained subjects as estimated with two methods did not differ significant.

It was striking that the body composition in the untrained subjects estimated with the two methods gave quite different results. The mean weight of the FFM-dens of the untrained subjects (59.7 ± 5.9 kg) was

Table 2

		The body composition of trained and untrained subjects as estimated with two different methods		
		Trained ($n = 15$) M ± S.D.		Untrained ($n = 20$) M ± S.D.
Weight	kg	69.1 ± 7.0		68.8 ± 6.4
Density	$g \cdot cm^{-3}$	1.080 ± 0.007		1.070 ± 0.012
%F-dens	%	8.9 ± 2.6		13.0 ± 4.6
FFM-dens	kg	62.9 ± 6.2		59.7 ± 5.9
FM-dens	kg	6.2 ± 2.1		9.1 ± 3.2
K	g	170 ± 24		144 ± 12
	mEq	4348 ± 614		3683 ± 307
%F-K-40	%	7.8 ± 8.1	($n = 11$)	20.3 ± 5.0
FFM-K-40	kg	64.8 ± 9.1	($n = 11$)	54.3 ± 4.3
FM-K-40	kg	5.7 ± 5.6	($n = 11$)	14.5 ± 4.6

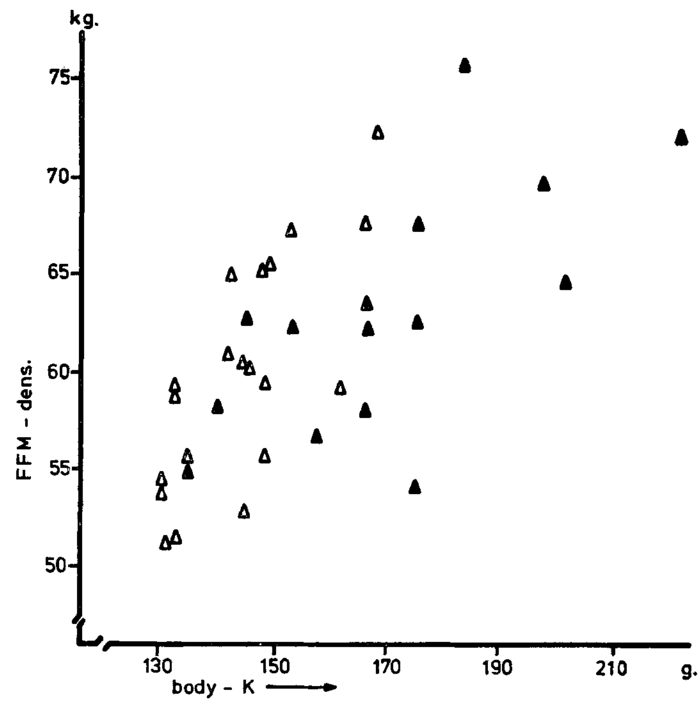

Fig. 1. Relation between the FFM-dens and body-K in trained and untrained subjects. ▵ Untrained subjects ($n = 20$) $r = 0.74$ ($P < 0.001$), ▴ trained subjects ($n = 15$) $r = 0.66$ ($P < 0.01$)

significantly higher than the FFM-K-40 (54.3 ± 4.3 kg; difference $P < 0.001$). Also the differences in the mean FM and the $^0/_0$F as estimated with the two methods were highly significant.

In Fig. 1 the relationship between the FFM-dens and the amount of body-K is shown. Both in the trained and in the untrained subjects a significant correlation betwen FFM-dens and body-K was shown.

For reasons to be discussed also the K-content of the FFM-dens was calculated in the two groups. The results are given in Table 3.

Table 3

	K-content of the FFM as estimated from the body density	
	Trained ($n = 15$) M ± S.D.	Untrained ($n = 20$) M ± S.D.
K-content of the FFM-dens		
$g \cdot kg^{-1}$	2.70 ± 0.29	2.41 ± 0.17
$mEq \cdot kg^{-1}$	69.0 ± 7.4	61.6 ± 4.5

The K-content of the FFM-dens of the trained subjects was significantly higher ($P < 0.001$; *t*-test for unpaired observations) than the value in the untrained subjects.

Discussion

The two methods for estimating the body composition gave uncomparable results. In 4 trained subjects the FFM-K-40 could not be calculated according to the formula of Forbes *et al.* (1961). In the untrained subjects significant differences in body composition, as estimated with densitometry and K-40 measurement, were found.

In literature several times discrepancies in body composition as measured with different methods were found. Myhre *et al.* (1966) estimated the $^0/_0$F of males and females in different age groups by K-40 measurements and densitometry. Although the estimated values of body fat derived from both methods were highly correlated ($r = 0.87$), the K-40 method yielded significantly higher $^0/_0$F estimates for each age sample considered. Significantly different results in estimating the $^0/_0$F or the FFM of young male and female subjects by two different methods were reported by Young *et al.* (1961) and Steinkamp *et al.* (1965).

A possible explanation for the different results of the two methods used could be attributed to the formula of Forbes *et al.* (1961). The factor 68.1 mEq per kg FFM as proposed by Forbes was the mean value of the

K-content of the FFM found in 4 cadaveranalyses (66.5, 66.6, 72.2 and 66.8 mEq per kg FFM resp.).

More recent data suggest sex differences and a decrease in the K-content of the FFM with increasing age (Anderson, 1963; Cheek, 1968).

In order to estimate the fat content of a human body from the density measured different formulae are used. The formula described by Rathbun *et al.* (1945), Siri (1953) and Brožek *et al.* (1963) are widely used. These three formulae are based upon a two-component model (FM and FFM); it is assumed that the density of the two components is the same in every person. In spite of the fact that the original data, as used by the above mentioned authors, differ completely, approximately the same values for the respective densities of FM and FFM were calculated. This means that the variation introduced by the use of these different formulae for calculating the $^0/_0$F of subjects with densities between 1.040 and 1.090 g · cm^3 is relatively small (between 0.5 and 3.0$^0/_0$). Thus we assume that with densitometry the best approximation of the FFM has been obtained.

Because of the uncertainity of the constancy of the K-content of the FFM it is useful to calculate the K-content of the FFM-dens in our subjects.

In trained and untrained subjects we found significant differences in the K-content of the FFM. Woodward *et al.* (1956) and Allen *et al.* (1960) recorded mean values of 63 and 63.3 KmEq per kg FFM resp. in their (probably untrained) subjects.

From the results of an investigation of body composition of well trained subjects by Novak *et al.* (1968) we could calculate a value of 69.1 mEq per kg FFM.

Comparing our results with these observations it is strongly suggested that training influences the K-content of the FFM. Our value of 69.0 mEq K per kg FFM in the trained group agrees very well with the value calculated from the data of Novak. Also the value for the K-content of the FFM of our untrained subjects, 61.6 mEq per kg FFM, agrees with the above mentioned data from literature.

A possible explanation for these different findings in trained and untrained subjects might be related to other well-known effects of training viz. a higher aerobic capacity (maximal O_2-uptake per min), a better capillarization of the skeletal muscle and muscle hypertrophy. Considering the fact that about 60$^0/_0$ of the body potassium is located in the muscles a higher K-content of the FFM in the trained subjects might have been caused by an increase of the amount of K per kg muscle or by an increase of the total amount of muscle without affecting the K-content. Possibly both factors are involved. Besides hypertrophy also the better O_2 supply of skeletal muscles of trained subjects both at work and at rest might have a K-sparing effect in these muscles.

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