

RAPID COMMUNICATION

A NEW METHOD FOR ESTIMATION OF BODY COMPOSITION IN THE LIVE RAT¹

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Abstract. Measurement of total body electrical conductivity (TOBEC) has been used to estimate lean and fat content of meat based on the principle that electrical conductivity of lean tissue is far greater than that of fat. This approach was used to estimate body composition of live rats. An instrument designed for commercial analysis of ground meat (DjMe 100) was used to measure TOBEC in 30 male Sprague-Dawley rats (197-433 g). Individual TOBEC values were obtained in 20 seconds and repeated twice for each rat. The animals were then killed with ether, hair was shaved, lungs collapsed and body density measured hydrostatically. Carcasses were homogenized and analyzed for fat, nitrogen, and water. A high correlation was found between TOBEC and lean body mass by densitometry ($r = .97$) and between TOBEC and fat-free mass derived from direct carcass analysis ($r = .97$). Rats weighing up to 450 g could be accommodated in this particular instrument. Measurement of TOBEC should prove useful in estimating body composition and monitoring its changes in live rats and other small laboratory animals.

Estimation in laboratory animals of body composition and its changes in response to a variety of experimental manipulations has been hampered by lack of feasible noninvasive and nondestructive procedures, and by the difficult and time-consuming task of undertaking total carcass analysis.

Densitometric techniques were used as early as 1930, when Kohlrausch employed hydrostatic weighing to estimate nutritionally-induced changes in body composition of dogs (1). The Archimedian principle of weighing the body under water, while providing accurate measurement of body volume, still requires estimates of air in the lungs and respiratory passages and gastrointestinal tract at the time of weighing. While such estimates can be made reliably in man, they are very difficult to accomplish in the live animal (2).

Currently, direct chemical methods are the most accurate source of information regarding body composition of laboratory animals. Aliquot samples of the carcass are used for direct measurement of body fat (3), body nitrogen (4), and water. However, this approach involves killing

the animal, thus making it impossible to monitor progressive changes in the body composition of individual animals under various experimental conditions.

In the present report we describe a new method for the *in vivo* estimation of body composition of small rodents by means of measurement of total body electrical conductivity (TOBEC). The TOBEC values were compared with those obtained by densitometry and carcass analysis.

Materials and Methods. A DjMe 100 Ground Meat Fat Tester (DICKEY-john Corp., Auburn, Ill.) was used to estimate body composition in live rats. This method, which is based on the widely differing electrical conductivities of lean tissue and body fat (5), is related to an earlier described technique, bioelectrical impedance analysis (BIA), used by investigators to estimate total body water (6) and several body fluid compartments (7). Although both TOBEC and BIA utilize a similar approach; namely, measurement of electrical impedance, BIA requires a suitable arrangement of current-injecting and voltage-detecting electrodes to be placed at various body sites. In contrast, TOBEC uses an elec-

tromagnetic coil surrounding the measurement chamber to induce a current throughout the body, thereby obviating the need for electrode placement and facilitating standardization.

The TOBEC instrument can determine in a nondestructive fashion the total electrical conductivity of the animal's body or of a ground meat sample with a fat content ranging from 2 to 80%. The difference between the impedance measured when the animal is inside the electromagnetic field and when the chamber is empty is an index of the total electrical conductivity of the body, which in turn is proportional to the animal's lean body mass. The TOBEC index is displayed digitally in 20 seconds following placement of the animal within the sample container. The machine can be adjusted readily to read out either in % lean or in % fat.

Total body electrical conductivity values of 30 healthy male Sprague-Dawley rats fed *ad libitum* (weight range 197 g to 433 g) were measured by means of the DjMe instrument. Prior to TOBEC measurement, the animals were anesthetized lightly with ether and then placed in the instrument. TOBEC values were obtained within a 20-second period in triplicate for each animal. The animals were then killed with an overdose of ether, their lungs collapsed and their fur thoroughly shaved. Body density was measured by weighing the animals under water by means of a simple device designed in our laboratory, which consists of a standard digital scale (Mettler) placed over a large container of water. A hanging wire basket attached to a rod atop the scale is suspended in the water and tared. The basket containing the animal is then weighed. Body density was calculated by applying the following formula, corrected for the temperature of the water: $D = MA/MA - MW$, where MA represents the weight in ambient air and MW the weight under water. Lean body mass (LBM) was calculated from the densitometric data by means of Siri's equation (8).

The carcasses together with their water-cleansed intestines were autoclaved for two hours and homogenized in water in an ultrasonic disintegrator (Polytron, Brinkman Instruments Co., Westbury, N.Y.). Aliquots from the homogenates were then analyzed for fat

(Folch), protein (micro-Kjeldahl) and water (by drying at 60° C to a constant weight). Linear regression techniques were applied to the data (9).

Results. The reliability of the TOBEC method was excellent. The reliability coefficient for the mean for three trials was 0.994 and 0.983 for a single trial. TOBEC measurements obtained in the 30 live animals had an excellent correlation with LBM values derived from densitometry as shown in Fig. 1. The TOBEC values also were correlated with those of fat-free mass derived from carcass analysis (Fig. 2). In addition, an excellent correlation was found between total protein derived from the measurement of total body nitrogen and TOBEC (Fig. 3) and between total body water and TOBEC (Fig. 4).

Discussion. Early studies of the use of TOBEC to estimate body composition in human subjects have been encouraging (10,11). This study demonstrates that it is possible to obtain a meaningful estimate of body composition in the live rat by means of rapid measurement of TOBEC. The results show a high correlation between TOBEC readings and LBM derived from densitometry ($r = 0.97$; $SEE = 13.60$) and between TOBEC values and those of fat-free mass derived from chemical analysis of the carcass ($r = 0.97$; $SEE = 14.16$). Equally good correlations were obtained between TOBEC and total protein values ($r = .95$; $SEE = 5.05$) and between TOBEC and total body water ($r = .98$; $SEE = 10.66$) obtained

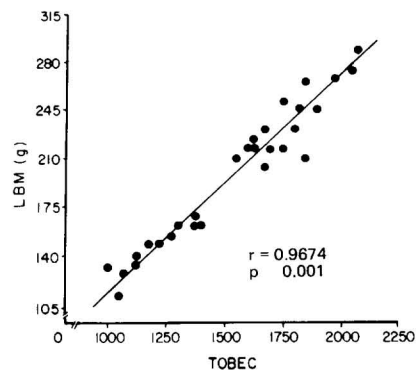


Fig. 1. Correlation in 30 Sprague-Dawley rats between lean body mass (LBM) derived from densitometry and total body electrical conductivity (TOBEC).

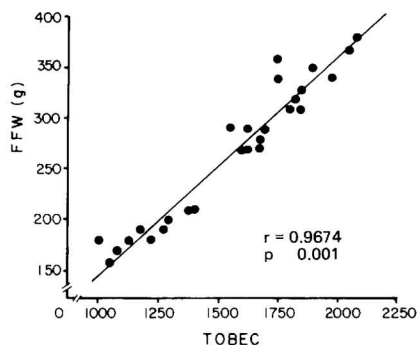


Fig. 2. Correlation in 30 Sprague-Dawley rats between fat-free weight (FFW) derived from chemical analysis and total body electrical conductivity (TOBEC).

by carcass analysis. It is well known that measurements of body composition by indirect methods are subject to errors resulting not only from the particular method used but also from biological variability (12,13). The excellent correlation of results obtained by TOBEC and those obtained by densitometry or carcass analysis are encouraging. The high reliability of TOBEC measurement and the relative accuracy in predicting chemically derived LBM from TOBEC may become an acceptable alternative method for assessment of body composition. Indeed, measurement of TOBEC should prove to be especially useful in monitoring body composition in the live animal, as it changes in

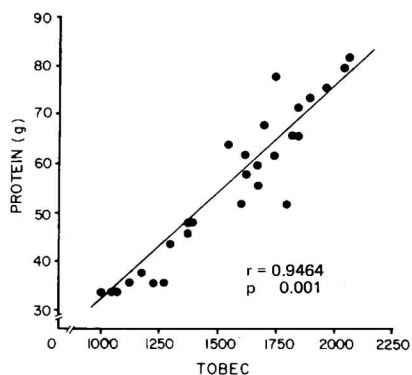


Fig. 3. Correlation in 30 Sprague-Dawley rats between total body protein derived from chemical analysis and total body electrical conductivity (TOBEC).

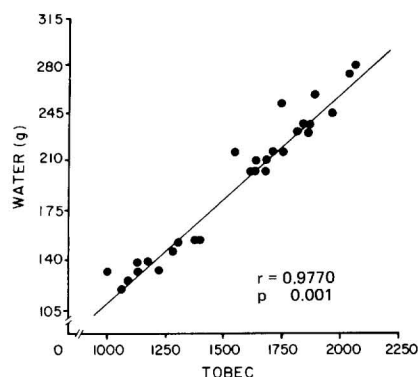


Fig. 4. Correlation in 30 Sprague-Dawley rats between total body water derived from drying carcass homogenates to constant weight and total body electrical conductivity (TOBEC).

response to a variety of experimental manipulations such as starvation, dehydration and derangements of acid-base balance. Finally, the ability of the method to predict chemically determined body composition in rats of widely varying size and fatness (e.g. obese Zucker rats) needs to be tested.

The use of rodent-shaped electrolyte-filled phantoms, made from inert material, should prove useful in the calibration of the instrument. The present DjMe 100 can accommodate rats up to 450 g of body weight; thus, new generations of TOBEC instruments will be needed to permit assessment of body composition in rats varying widely in size and weight.

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