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CORRECTION OF THE WEIGHT OF THE MAIN BODY COMPONENTS IN THE ANTHROPOMETRIC FRACTIONATION OF THE BODY MASS

ABSTRACT. — The paper describes a method for the correction of mass fractions calculated according to the method developed by Drinkwater and Ross using for the correction the error between the actual and calculated body mass. The sum of the corrected fraction masses is identical with the measured mass. The % of the fractions masses with regards to the total body mass is equal as it was before the correction. The error of the total body mass after the correction is O.

KEY WORDS: Body Mass Fractions — Statistics — Correction of the Error.

The authors describe in their paper a method suitable for application in the correction of the weight of the main body components in the fractionation of the body mass due to the error resulting from the actual and computed value of the body weight. Following the completion of the correction the value of the final error is then equal to zero. The correction is applied in the computational techniques developed by Drinkwater and Ross (1980).

On estimating various questions related to the training process, search for talented sportsmen and their participation in special training processes, etc., it is necessary to have a deep knowledge of the body composition, i.e. of particular body franctions (fat, muscles, bones and residuum).

In practice various methods are used allowing the quantitative determination of the main body components (lean body mass and depoted body fat). One of these methods is the determination of the specific body weight based on underwater weighing, the so called hydrostatic weighing. The density is computed by the Brožek's method and for computing the % of fat the methods developed by Keys and Brožek, Pařízková (1973) are used. These methods were used also by several other authors, e.g. by Zrubák (1970), Piechaczek (1976) and others. Another method used for determining the body density is based on the dilution of helium according to Siri (Novák, 1979). In other methods for determining of body fat and lean body mass the amount of the total body fluid is determined — i.e. hydrometry is applied (Novák, 1979). These methods are based on the dilution of a deuterium isotope and of a radioactive isotope of tritium. The method of determining the body composition by means of the amount of body potassium (Novák, 1979) or heavy water, Novotný (1979) is similar. The X-ray graphic method aplied for measuring the thickness of the particular layers (bones, muscles, fat) in the upper limbs was used by Tanner (1964) who tested Olympic athletes. A very accurate picture of the body composition could be obtained by using a tomograph. On the other hand the use of echograph on ultrasonic principle does not expose the tested persons to harmful radiation effects.

As regards the claims on the tested persons, operating personnel and technical outfit the most suitable methods proved to be those based on the mathematical evaluation of the anthropometric measures. A method suitable for anthropometric fractionation of the body mass wass published by Matiegka (1921). The formulae for the computation of the three independent fractions (fat, muscles, bones) and of the remaining fraction (residuum) have been modified and the constants made accurate on the base of the hitherto gained experience.

Many authors, e.g. Wilmore and Behnke (1970), Pařízková (1973), (1972), Šprynarová and Pařízková (1971) and others used various anthropometric measures in studying the body composition. The determination of the body fat through densitometric and anthropometric methods was described by Piechaczek (1976).

The alternative method used by Drinkwater and Ross (1) is characterized by a more exact computational method based exclusively on phantom anthropometric measures without using man-made constants in the correction of the weight. The method is applicable regardless of sex.

In the computation of the particular body fractions the following anthropomertic measures were used:

1. *Fat mass* — triceps skinfold, thigh skinfold, calf skinfold, subcapular skinfold, suprailiac skinfold (measured according to Borms et al. (1979).

2. *Muscle mass* — girth of arm⁺, forearm, chest⁺, thigh⁺, and calf⁺.

The ⁺— designated measures are corrected for the computation by the corresponding skinfold according to the relation

$$G_k = G^+ - \frac{\pi . s}{10}$$

G_k = corrected measure
G^+ = original measure
s = skinfold measure

The quantities (variables) appearing together in the relation stated are in *table 1.*

TABLE 1. *Simultaneously appearing values in girth dimensions correction*

G+ girth	s skinfold
Arm	Triceps
Chest	Subscapular
Thigh	Thigh
Calf	Calf

3. *Bone mass* — biepicondylar breadth of humerus and femur, girth of wrist and ankle.

4. *Residum mass* — biacromial breadth, biiliocristal breath, breadth and depth of the chest.

From the measured anthropometric dimensions the proportional z-score is computed from the relation

$$z = \frac{1}{s}\left[v\left(\frac{170.18}{h}\right)^d - P\right]$$

v — anthropometric dimension
d — exponent
d = 1 length meassuments
d = 2 surface meassurements
d = 3 volume meassurements
h — height of the tested person
P — phantom value for concrete anthropometric dimension
s — standard deviation for the phantom value *P*

In the computation of the fractions also the average *z*-score $\bar{z}$ for each group of the variables is further computed

$$\bar{z} = \frac{1}{n}\sum_1^n z$$

and then from the averages of $\bar{z}$ we obtain the mass of the fractions for the corresponding group by using the relation

$$M_F = \frac{\bar{z} . s + P}{\left(\frac{170,18}{h}\right)^3}$$

P — phantom value of the searched fraction mass
s — standard deviation for the phantom value of the *P*-fraction

TABLE 2. *The phantom values for the particular fractions*

Fraction	Mass P [kg]	s. d. s [kg]
Fat	12.13	3.25
Muscle	25.55	2.99
Bone	10.49	1.57
Residuum	16.41	1.90
Total body mass	64.58	8.60

The phantom values of P and s for the particular fractions are seen in the *table 2.* The total body mass M_c is the sum of the masses of the particular fractions

$$M_c = \sum M_F = M_T + M_S + M_K + M_R$$

From the computed mass M_c and the meassured mass *M* we can calculate the error

$$E = \frac{M_c - M}{M} . 100 \quad \%$$

The computation of the fraction mass according to Drinkwater and Ross (1980) is suggested for the population of both sexes. When performing measurement on extreme populations a considerable systematic error may occur, especially if we measure a group of top sportsmen. We can distinguish the different body composition of top sportsmen, e.g. basketball players, weight-lifters and gymnasts at first sight.

For the correction of a systematic error we consider a linear model

$$M_c = M + m_s + m_{Fn}$$

m_s — systematic error
m_{Fn} — random error of the fractions

In the correction of the systematic error we assume the sum of random errors to be 0. $\sum m_{Fn} = 0$ and then it holds for the systematic error that

$$m_s = M_c - M$$

The correction of the systematic error with regards to the mass of the particular fractions is divided in proportion to the fractions mass after the correction of M_{Fk}

$$M_F = M_{Fk} + m_s \frac{M_{Fk}}{M}$$

By modifying this relation we obtain for fraction mass after correction

$$M_{Fk} = \frac{M_F}{1 + \frac{E}{100}}$$

For the sum of the corrected fractions mass it will then hold that

$$\sum M_{Fk} = M$$

DISCUSSION

The described method of error correction warrants that the measured and computed body mass be identical. The correction of the mass of the particular fractions represents a linear transformation so that even after the correction the % body composition remains equal. The estimation of the size of the random errors of the particular fractions in vivo is problematic.

As an example let us quote the results obtained from the computation and correction of the fractions mass when the tested person was a Czechoslovak top cyclist-sprinter. The measured body mass was M = 71.95 kg. On the basis of mass fractions calculation following parameters were stated:

fat mass	$M_T =$ 5.12 kg
muscle mass	$M_S =$ 32.35 kg
bone mass	$M_K =$ 11.70 kg
residuum mass	$M_R =$ 17.68 kg

thus the sum for the calculated mass was $M_c = 66.85$ kg. From the measured and calculated mass we obtain the error $E = -7.08$ %. On the basis of this error we then calculate the corrected mass of the particular fractions:

corrected fat mass	$M_{Tk} =$ 5.51 kg	7.66 %
corrected muscle mass	$M_{sk} =$ 34.82 kg	48.39 %
corrected bone mass	$M_{Kk} =$ 12.59 kg	17.50 %
corrected residuum mass	$M_{Rk} =$ 19.03 kg	26.45 %

The sum of the corrected mass is identical with the measured mass, i.e. the value of the error in the result is 0.

An extensive bibliographic review of this problem offers the work of Deutsch and Ross (1978).

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