Medicina Sportiva
Med Sport 13 (3): 151-154, 2009
DOI: 10.2478/v10036-009-0028-z

VALIDITY OF MEASURING BODY FAT USING THE SKINFOLD METHOD

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Abstract

Introduction: The aim of this study is to verify the external criterion validity of measuring body composition by skinfold method and to compare the obtained results with the results gained using the DEXA method.

Material and methods: The investigated group consisted of 74 individuals (45 males and 29 females) whose average age was 20.2 ± 0.90 and 19.5 ± 0.73 respectively. The DEXA and skinfold methods and methodologies according to Pařízková, Matiegka, Drinkwater and Ross were applied to measure body composition. The correlation coefficient between the skinfold methods and criterion was considered the ratio of the stated validity. A level of statistical significance of all used parameters was tested using the $\alpha = 0.05$ level.

Results: The acquired values of the Pearson correlation were r = 0.781 (females - according to Pařízková) and r = 0.815 (females - according to Matiegka), r = 0.678 (females – according to Drinkwater and Ross) and r = 0.876 (males - according to Pařízková), r = 0.921 (males - according to Matiegka),r = 0.765 (males – according to Drinkwater and Ross). Standard error of estimate $d_{max} = \pm 2\ s_{y/x}$ was found to be ± 3.54 to 4.50% for females, and ± 2.88 to 4.86% for males.

Conclusion: The standard error of criterion estimate shows discrepancies in the estimation acquired by the reference method (DEXA method) through observed methodologies. These methodologies do not allow acceptable estimation of measuring by means of DEXA and their results are not equivalent in this respect.

Keywords: *body composition, skinfold method, accuracy of measurements, coefficient of correlation, standard error of estimate*

Introduction

Body composition represents one of the most important components of health-based abilities as it indicates nutrition and health condition of each individual (1-4). The parameters concerning body composition in the field of physical education and sports training are monitored during most functional examinations of sportsmen (5, 6). The most frequently monitored parameter is fat value (fat fraction) or its distribution in all body segments. Research sources describe a negative influence on a medical condition of an individual when having high as well as low fat values. The high level of fat is generally linked to obesity leading to a number of medical complications (e.g. orthopedic dysfunctions, respiratory difficulties, metabolism problems, cardiovascular illnesses). In the area of exercising and sports a high fat value leads to lowering sporting abilities and performance while a too low value may bring many health risks in the form of various dysfunctions as a certain amount of fat is necessary to maintain basic physiological functions. (7, 8).

Body composition is always determined by estimation; this estimate is obtained by using various methods, laboratory or field ones. Laboratory methods are demanding from the point of view of technical equipment, special operational skills and also financial means. The results measured by these methods are however more valid; therefore, these methods are considered as reference methods to the field ones (7, 9, 10). One of these laboratory methods is DEXA which uses the difference in the absorption of two pulse level x-ray by soft tissue and bones (7). This method is currently widely used, not only to measure bone mineral density, but also to measure body composition. Some authors consider this method as "gold standard" (8, 11, 12), similarly to the hydrostatic weight method. DEXA is used as a reference method in case hydrostatic weighing is not available. The Czech Republic is one of the examples where the usage of hydrostatic weighing as a reference method is impossible due to its unavailability.

One of the field methods is, besides the BIA method, also the estimation of body composition by means of anthropometric methods. This concerns measuring accurately defined skin creases with calipers and calculations obtained using a wide spectrum of predicative equations, enabling to estimate the fat fraction, or other parameters based on which it is possible to calculate other body fractions (e.g.

according to Durnin and Womersley, according to Deurenberg and Westrate, Lohman, Thorland, and others) (8, 10). The indisputable advantage of anthropometric methods is that they are not financially demanding and do not depend on body hydration as the bioelectrical impedance method (13). In order to obtain reliable data, the person carrying out the measurements is required to have sufficient experience in measuring (14).

If the DEXA method is regarded as one of the reference methods (15, 16), then its results can serve as a criterion to estimate external criterion validity which is one of the conditions of standardization of utilized methods, and therefore verification of their credibility. Consequently, a lot of authors dedicate themselves to this subject matter (17-20). Our paper deals with the skinfold method as per the methodologies by Pařízková, Matiegka, and by Drinkwater and Ross (8). These methodologies are used most frequently in the Czech Republic due to the existence of equations to calculate body fat that are created based on the Czech, formerly Czechoslovak, population (for this reason, in our opinion, they are suitable for other population of Central Europe). The equations are verified by a wide population sample of various age groups. The other difference, when compared to other methodologies, is the creation of equations to calculate body fat that are based on measurements on a number of body segments.

The aim of this study is to utilize the DEXA method as a criterion for the estimation of the external criterion validity of the results of the body fat measurement, using the skinfold method: methodologies by Pařízková, Matiegka, Drinkwater and Ross.

Material and methods

The selected group consisted of students of physical education and sports at the Pedagogical Faculty of Ostrava University. These are individuals with regular sports activity resulting from their curriculum of physical education and sports and from their sports activities as such. Based on this fact it is possible to utilize the obtained data in further diagnostics (which we dedicate ourselves to) of individuals practicing various sports disciplines. The number of students was 74 (45 males, 29 females - Caucasians), the average age was 20.2 (males) ± 0.90 and 19.5 (females) ± 0.73. The differences in average values of age between males and females were not significant (table 1). The age difference assessment was conducted by the t-test for independent groups. A third generation Denzitometer Holgic QDR was used to find out the body composition by means of the DEXA method. For skinfold measurements, calipers, manufactured by Best, (calipers are pushed during measuring by the 2N pressure, the measurement scale is 0 – 80 mm, skinfolds are measured with accuracy of ± 0.5 cm, which is based on the measuring devices construction and used measuring methodology) and 3 methodologies, were used. The Matiegka's methodology involves the following measurements: 6 skinfolds (biceps, forearm – medial, maximum girth of forearm, thigh - halfway between trochanter and tibiale, calf - posterior in maximum girth of calf muscle, abdominal, chest - at height of 10th rib), body height, body weight, circumferences (of arm, forearm, thigh - mid, calf - maximum), width dimensions (epicondyles of humerus and femur, wrist and ankle). The Drinkwater and Ross's methodology, which uses phantom values and standard deviations of these characteristics, is a modification of the Matiegka's methodology. The Pařízková's methodology involves measuring 10 skinfolds (face - below the temple, neck - below the chin, above the hyoidal axis, chest - axial line above pectoralis major, chest - at height of 10th rib, triceps, subscapsular, abdominal, suprailiac, thigh - above patella, calf - 5cm below fossa poplitea. The measurement of individual anthropometric parameters and calculations of body fat were realized exactly as per the instructions of the original source (8). The final result of the percentage of the body fat presence was conducted by the computer program ANTROPO, built to do these calculations. All measurements of body fat were carried out always in the morning. Each individual was measured within one day (one after another). The caliperation was realised by the same, experienced member of staff.

As a ratio of external criterion validity, a correlation coefficient between the results obtained by DEXA and the results observed by the skinfold method were used. The accuracy of criterion estimation measurements was assessed on the basis of the approximate error of estimate $d_{max} = \pm 2\, s_{y/x}$. The statistical processing was done by means of the statistics program SPSS 16.0. All statistical tests were carried out at the level of significance of $\alpha = 0.05$.

The study protocol was approved by the Ethics and Research Committee of the University of Ostrava. All participants signed a consent form.

Table 1. *Characteristics of the tested probands age*

	n	M	SD	F	Sig.	t	Sig *
Male	45	20.2	.90	.579	.449	-1.769	.081
Female	29	19.5	.73				

n – frequency M – mean SD - standard deviation F – F test Sig.- F test significance t – t-test value Sig.*- t-test significance

Results

Tables 2 and 3 show basic descriptive characteristics, given in percentage, of fat measured by all utilized methods in case of both females and males.

Table 2. *Basic characteristics of measurement of body fat – females (n = 29)*

	DEXA % BF	Pařízková % BF	Matiegka % BF	Drw-Ross % BF
M	24.81	23.71	30.46	19.11
SD	3.36	3.30	5.40	2.08

BF – body fat M – mean SD - standard deviation

Table 3. *Basic characteristics of measurement of body fat - males (n = 45)*

	DEXA % BF	Pařízková % BF	Matiegka % BF	Drw-Ross % BF
M	12.71	14.92	16.63	13.22
SD	4.18	3.26	6.25	2.39

BF – body fat M – mean SD - standard deviation

External criterion validity of all methodologies is shown in Tables 4 and 5.

Table 4. *Coefficient of correlation and accuracy of body fat values estimation, acquired by utilized methods in comparison with the DEXA method - females (n=29)*

	Pařízková	Matiegka	Drw-Ross
r	.781	.815	.678
$S_{y/x}$ (% BF)	1.91	1.77	2.25
d_{max} (% BF)	3.82	3.54	4.50

r – Pearson correlation $s_{y/x}$ (SEE) – standard error of estimate d_{max} – ± 2 $s_{y/x}$

In spite of the fact that the average % value of body fat according to Matiegka is not very close to the average value obtained by DEXA (see Table 2), the criterion estimation obtained by this methodology is more accurate than by the other methodologies. When using this methodology, the standard error of estimate is the lowest and the coefficient of correlation is the highest, exceeding the value of 0.8. The Drinkwater and Ross methodology is the least accurate as the standard error of estimate is the highest and the coefficient of correlation is the lowest.

Table 5. *Coefficient of correlation and accuracy of body fat values estimation, acquired by utilized methods in comparison with the DEXA method - males (n=45)*

	Pařízková	Matiegka	Drw-Ross
r	.876	.921	.765
$s_{y/x}$ (% BF)	1.78	1.44	2.38
d_{max} (% BF)	3.56	2.88	4.76

r – Pearson correlation, $s_{y/x}$ (SEE) – standard error of estimate, d_{max} – ± 2 $s_{y/x}$

The results of males and females are similar. The Matiegka's methodology seems to be the most appropriate. The correlation coefficient exceeds the value of 0.9 and the standard error of estimate is only 2.88 % BF.

Discussion

On the basis of the calculated Pearson correlation value and the standard error of estimate, we can consider the Matiegka's methodology to be the most accurate. The Pearson correlation value was 0.815 (females) and 0.921 (males). This explains more than 66% of dispersion (females) and almost 85% of dispersion (males). However, the d_{max} values are high: ± 3.54% for the fat component in females and ± 2.88 for the fat component in males. This error appears to be significant in relation to the changes in body composition which need to be recorded. The obtained range of values concerning the criterion estimation can result in the wrong placement of a person into a group when using the standard percentage of the fat component (21, 11), which may subsequently mean incorrect deduction of health risks. This deviation is also considered as significant by other researchers in the field of sports. In individual sports disciplines the sportsmen's range of the fat component in percentage is said to be most frequently between 2 and 5 % (22-24). The values of the standard error in the criterion estimation indicate the difference in assessing the fat component between individual methods (DEXA and skinfold methods) and their mutual non-interchangeability. The Pařízková's methodology is the closest to the Matiegka's methodology, there are only small differences. The values obtained using the Drinkwater and Ross methodology are remarkably different. To compare our results with the results of other authors is quite difficult as the authors working with similar issues use different methodologies and work with different numbers of skinfolds, different types of calipers and equations to calculate the percentage of fat. It is most frequently calculated from three skin crease types (triceps, subscapular, abdominal) after Lohman (25) using Lange calipers. In spite of this fact, these authors, who worked with groups of sportsmen, obtained similar results. The calculated SEE values were about 1.72 % of BF (26-31), which can be considered as comparable to our values.

It is clear that our results could have been influenced by both selected example of respondents and diagnosed individuals. The sample group consisted of physical education students whose BF is more homogenous compared to the average population. We should be aware of this fact especially with extreme values of BF.

In spite of the fairly high value of the Pearson correlation it is necessary to state that due to the findings obtained by means of the DEXA method and methodologies of the skinfold method it is not possible to estimate the values of DEXA from the skinfold method measurements with sufficient accuracy. The accuracy of the criterion estimation is affected by a high value of standard error (d_{max}). The values of the standard error when using the skinfolds method have a similar size as standard errors when comparing the BIA method (which also belongs among field methods) with the DEXA method. The standard error showed between ± 2.38 % and 4.42 % of BF depending on gender and modes of measurement used (32). Considering the range of the investigated group and the character of observed individuals, we suggest being careful with generalization of the presented results, especially of those concerning individuals with borderline values of the percentage of BF.

The results presented in this study show the differences between the results gathered by means of different methodologies for the estimation of percentage of BF in body composition. Substitution of the results obtained by different methodologies is not possible. It is recommended to repeat measurements using the same method every time.

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Received: May 31, 2009
Accepted: August 25, 2009
Published: September 04, 2009

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A – Study Design	C – Statistical Analysis	E – Manuscript Preparation	G – Funds Collection