Skinfolds Thickness and Body Surface Area Evaluated with Anthropometry and its Relation with Body Fat

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ABSTRACT:

PURPOSE: To describe the utility of the product of skinfold thickness measured by anthropometry and body surface area (BSA) in relation with body fat (% and mass) in varsity athletes.

METHODS: 10 skinfold thicknesses were assessed in 97 varsity athletes (50 males [age 21.5 ±2.0 y, weight 72.0 ±10.9 kg, height 175.7 ±6.7 cm, BMI 23.3 ±3.0 kg/m2], 47 females [20.8 ±1.9 y, 60.1 ±10.2 kg, 164.7 ±7.3 cm, 22.1 ±2.9 kg/m2]). Body fat mass and percentage was assessed by DXA whole body scanning. Body surface area was calculated with two anthropometric equations (DuBois, Biering), additionally Behnke's body building factor was calculated. We performed the Pearson correlation test for body fat mass and body fat percentage with each skinfold thickness, the sum of 10 skinfolds (10SKF), the sum of 8 skinfolds (8SKF) and the product of multiplying 10SKF or 8SKF with either a) DuBois BSA, b) Biering BSA, c) Behnke's factor.

RESULTS: There was a higher correlation with body fat mass than with body fat percentage when the skinfolds were multiplied by BSA, this correlation was higher in males than females. In males, triceps skinfold thickness had a high correlation with body fat percentage and axilla with body mass.

CONCLUSIONS: The product of 10SKF (or 8KSF) multiplied by BSA had high correlation coefficients with body fat mass. We propose using the sum of skinfolds (both 10 and 8) and multiplying it by BSA as an adiposity indicator in varsity athletes. There is still need to test if this strategy is useful for monitoring changes in body fat.

INTRODUCTION

In 1921 Matiegka[1] proposed a strategy for estimating adipose tissue mass by calculating the half of the calculated average of some skinfolds thickness and multiplying it by body surface area (BSA). Behnke[2] and Tanner[3] used this strategy measuring the subcutaneous adipose tissue with X-ray images. Later Katch[4] used a modified strategy for obtaining body fat percentage (%BF) and compared the results with a densitometric method. The purpose of this work was to explore the validity these strategies with modern body composition methods as dual energy X-ray absorptiometry (DXA).

METHODS

Subjects

We evaluated 88 varsity athletes (49 males [age 21.5 ±2.0 y, weight 72.0 ±10.9 kg, height 175.7 ±6.7 cm, BMI 23.3 ±3.0 kg/m^2], 39 females [20.8 ±1.9 y, 60.1 ±10.2 kg, 164.7 ±7.3 cm, 22.1 ±2.9 kg/m^2]).

Body composition

A whole body scan was performed with a DXA Hologic Discovery QDR 4500 and analyzed with the software version 12.2.1. The equipment was calibrated following the manufacturer instructions. Subjects were asked to attend with at least 2 hours of fasting.

Anthropometry

Anthropometry and DXA were evaluated within the same day or week. Eight skinfolds thickness (8SKF, triceps, biceps, subscapular, suprailiac, supraspinal, abdominal, thigh and calf) were assessed following the International Society for the Advancement of Kinanthropometry[5] (ISAK) proposed method, and we added axillar and pectoral skinfolds (10SKF) following the Lohman[6] technique.

Body Surface Area (BSA)

The BSA was estimated using two equations (DuBois[7] and Biering[8]) and the "Body building factor" (BBF) proposed by Behnke[2], the equations are the follow:

$$BSA_{Dubois}(m^2) = \frac{71.84 \times BM^{0.425} \times HT^{0.725}}{10000} \qquad BSA_{Biering}(m^2) = \frac{10.9 \times BM^{2/3} \times 100}{10000}$$

$$BBF_{Behnke} = \sqrt{BW/HT(dm)}$$

BM = Body mass (kg)
HT = Height (cm)
HT (dm) = Height expressed in decimeters

Statistical analysis

We performed the Pearson correlation test and calculate the coefficient of determination (R^2) for body fat mass and %BF with each skinfold thickness, the sum of 8 (8SKF) and 10 skinfolds (10SKF) and the product of multiplying 8SKF or 10SKF by DuBois BSA, Biering BSA and Behnke's equations.

RESULTS

A summary of anthropometric and body composition data can be found in Table 1. The coefficient of determination for the sum of skinfolds and product of different BSA calculated with 8SKF and 10SKF are shown in Table 2.

The highest R^2 for body fat (kg) was obtained with SKF*Biering and for %BF was sum of skinfolds for both males and females (Table 2).

Table1. Anthropometric and body composition data

	Males			Females		
	$\bar{X}$	SD	Range	$\bar{X}$	SD	Range
Age (years)	21.5	2.0	17.4—26.7	20.9	1.9	15.5—25.6
Weight (kg)	71.5	10.0	53.0—93.7	59.2	8.9	44—82.1
Height (cm)	175.9	6.7	161.0—192.0	164.7	7.3	146.8—176.7
BMI (kg/m^2)	23.2	2.9	18.3—29.9	22.1	2.9	16.8—27.6
BBF	2.0	0.1	1.8—2.3	1.9	0.1	1.7—2.2
BSA Biering (m^2)	1.9	0.2	1.5—2.2	1.7	0.2	1.3—2.1
BSA Dubois (m^2)	1.9	0.1	1.6—2.2	1.6	0.1	1.3—2.0
8SKF (mm)	86.5	43.9	38.6—211.9	104.9	25.3	60.6—167.4
10SKF (mm)	106.6	55.6	46.2—256.9	123.8	30.8	70.5—213.4
BMC (kg)	2.8	0.4	1.9—4.0	2.4	0.4	1.3—3.2
Body fat (kg)	12.3	5.3	5.5—25.8	15.3	4.7	8.2—29.7
Body fat (%)	17.0	5.6	9.5—32.6	26.6	4.7	15.9—36.6
Fat-Free mass (kg)	58.0	6.7	44.2—71.3	43.3	5.0	30.6—53.7

8SKF: eight skinfolds sum; 10SKF: ten skinfolds sum; BBF: Body building factor; BMC: Bone mineral content; BMI: Body mass index; BSA: Body surface area.

Table 2. Coefficients of determination for body fat and body fat percentage with skinfolds and the BSA and skinfolds product

		Body fat			
		Females		Males	
		Kg	%	Kg	%
SKF	10SKF	0.779	0.731	0.844	0.813
	8SKF	0.760	0.729	0.839	0.819
SKF*Behnke	10SKF	0.850	0.720	0.859	0.796
	8SKF	0.841	0.724	0.857	0.802
SKF*Biering	10SKF	0.883	0.701	0.864	0.777
	8SKF	0.881	0.709	0.865	0.785
SKF*DuBois	10SKF	0.873	0.697	0.862	0.777
	8SKF	0.870	0.705	0.864	0.786

8SKF: eight skinfolds sum; 10SKF: ten skinfolds sum; SKF: sum of skinfolds.

CONCLUSIONS

The product of 10SKF (or 8KSF) multiplied by BSA showed high coefficients of determination with body fat mass. The relationship was higher for body fat than for %BF. This suggests that the skinfolds are better to estimate body fat mass than %BF as has been commonly used.

We propose using the sum of skinfolds (both 10 and 8) and multiplying it by BSA as an adiposity indicator in varsity athletes. There is still need to test if this strategy is useful for monitoring changes in body fat.

REFERENCES

[1]Matiegka, J. (1921). The testing of physical fitness. American Journal of Physical Anthropology, 4, 223-230.

[2]Behnke, A. R., & Wilmore, J. H. (1974). Evaluation and regulation of body build and composition. Prentice Hall.

[3]Tanner, J. M. (1964). The Physique of the Olympic Athlete.... Rome, 1960. George Allen and Unwin Limited.

[4]Katch, F. I., Behnke, A. R., & Katch, V. L. (1979). Estimation of body fat from skinfolds and surface area. Human Biology, 411-424.

[5]Stewart, A., et al. (2011). International Standards for Anthropometric Assessment. International Society for the Advancement of Kinanthropometry.

[6]Lohmann, T. G., Roche, A. F., & Martorell, R. (1988). Anthropometric Standardization Reference Manual. Human Kinetics Books, Champaign, Ill

[7]DuBois, D., DuBois, E. F. (1916). A formula to estimate the approximate surface area if height and weight be known. Arch Intern Med;17:863 - 71.

[8]Biering (1930) cited in Comas, J. 1960 Manual of Physical Anthropology. Thomas, Springfield