Development and validation of specific anthropometric equations to determine the body density of Brazilian Army military women

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ABSTRACT

The purpose of this study was to develop and validate specific anthropometric equations to determine the body density of Brazilian Army military women. All anthropometric variables were collected from females 18-45 years old, living in Rio de Janeiro. One hundred military women were distributed into two groups: the regression group (n = 80), used for the development of the equations proposed in this study, and the validation group (n = 20), used for the validation of the developed equations. Ten skinfolds, ten perimeters, three diameters, body mass (BM), height and density (D) by means of hydrostatic weighing were measured. For the purpose of developing the equations, stepwise regression was performed; for validation, Pearson linear correlation coefficient ($p \leq 0.05$), constant error (CE), technical error (TE) and standard error of the estimate (SEE) were calculated. The subjects showed the following characteristics: regression group (n = 80), aged 30.54 ± 6.53 years, height 165.05 ± 5.95 cm, body mass 58.71 ± 6.68 kg and body density 1.045620 ± 0.00876 g/ml; validation group (n = 20), aged 31.08 ± 6.84 years, height 164.21 ± 5.49 cm, body mass 58.88 ± 7.88 kg and body density 1.043877 ± 0.01117 g/ml. After the regression analysis and the subsequent choice criteria, 10 equations showing an R between 0.681 and 0.822, as well as a SEE between 0.00516 and 0.00652 g/ml were developed. These equations were validated[1,2] by means of variables such as skinfolds, perimeters and diameters to estimate D of Brazilian Army military women aged 18-45 years.

Key words: Brazilian army females. Anthropometry. Body density. Regression equations. Validation.

INTRODUCTION

The military career requires a minimum physical condition from its professionals for the development of specific military functions in times of peace and war[3], bringing to women who selected the military career the need to maintain good health conditions and the physical fitness constantly.

The body composition has been used as parameters for several segments of the physical activity, health and professional performance and its correct calculation is vital.

The Brazilian Army, despite being one of the most ancient institutions of our country, only recently has admitted women as part of its staff. With the inclusion of the female segment, the interest for its body composition is increasing, having in mind the peculiarities of the missions performed, which has the MC as a delimitating factor or not[3].

Due to the relevance of areas of employment, the correct utilization of the measure techniques and formulas for the calculation of the components considered as vital becomes necessary.

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Informations associated to the body composition are vital on the orientation of programs for the body weight control[4] and they become even more important when related to what we have as the most valuable good: our health[5].

One of the parameters required by the Military Physical Training Handbook (C20-20), used in the Brazilian Army in order to standardize the physical activity of soldiers, is the amount of body fat[3]. However, there is a great difficulty by the military women to keep an acceptable fat percentage for the military standards due to the lack of an adequate measuring of this parameter, once practically no studies on the topic have been published, since the majority of methods used were developed from specific populations other than the subjects of this study.

Currently, the body mass value (MC), as a whole, is no longer used as reference, once people with the same body area, body mass, height, age and gender may present tissues with different amounts of fat. Thus, a precise and discerning evaluation of how much the proportion of each component means becomes necessary.

Some sophisticated laboratory methods have been currently used to assess the body fat[6], among them the body total electric conductivity[7], the ultrasound and the infrared ray scanner.

Besides the methods above mentioned, we can also find double-energy radiological absorptiometry (DEXA), electrical bio-impedance, the densitometry, pletismography, hydrometry, spectrometry, ultrasonography, computerized tomography, magnetic resonance, neutrons activation, infrared rays interactancia, anthropometry, creatinine excretion index, serum creatinine, photonic absorption, radiography and urinary 3-metil-histidine[8].

Despite the availability of a variety of precise and modern methods, their use is not recommended to evaluate a large number of people because they use expensive equipments, spend relevant time and require highly qualified professionals[6].

The search for simple and economic techniques has made several professionals to search for a less expensive practical solution in the anthropometrical methods that approve the skinfolds measures, muscular perimeters and bone diameters, performed out of the laboratories[9].

The anthropometrical information is valuable with regard to the prediction and estimation of the several body components in the growth, development and aging[10].

There are several advantages on the use of the anthropometrical method[9], among them: the good relation of the anthropometrical measures with the body density obtained through laboratorial methods; the use of low cost equipments; the facility and agility on the data collecting and the fact that the method is non-invasive.

The hydrostatic weighing (PH) has still been considered as the more accepted non-invasive laboratorial method for studies of the body composition[11], and that, even after all adaptations the original method has suffered, is still considered as the standard procedure in many laboratories with applications on the physical fitness, nutrition and weight control.

In order to estimate the body density (D) and the fat percentage (%G), thus fragmenting the body composition, prediction equations should be used so that, from the anthropometrical measures, the body mass (MC) in values of fat mass (MG) and the lean body mass (MCM) can be calculated.

It is believed that the tendency of the body composition research in Brazil is to question, to develop and to find the equations that should be used for the estimation of D of the Brazilian population[12]. It is worthy emphasizing that Petroski, in 1995, validated several equations developed abroad, for both genders.

There are two types of prediction equations for fragmenting of the body composition: the generalized and the specific equations[8].

The generalized equations are developed using large heterogeneous samples of age, body fat and physical fitness, as the equations from Petroski, developed in 1995[12]. Specific equations are equations developed from homogeneous populations, as those from Guedes, developed in 1985[4], those from Carvalho and Pires Neto in 1998[13] and those from Rodrigues Añes and Pires Neto, developed in 1998[14].

The main advantage of a specific equation, when applied to its origin population, is the accuracy[8]. We cannot say so when a specific equation is used for subjects with characteristics different from their origin population.

Thus, this study aimed to develop and to validate specific equations to determine the body density of Brazilian Army military women, living in Rio de Janeiro, from anthropometrical variables.

METHODS

The sample comprised 100 Brazilian Army military women, regardless the hierarchy, from the city of Rio de Janeiro (RJ) divided into two groups: one called regression group (RG), composed of 80 military women evaluated (80% from sample), being the data from this group used for the development of the equations, and the other called validation group, composed of 20 military women evaluated (20% from sample), being the data from this group used to validate the developed equations[15].

The present study has considered the Norms for the Research Performance in Human Beings, Resolution 196/96 from the Health National Council of 10/10/1996 and has been approved by the Ethics Committee – UCB – RJ.

All participants signed up a Informed consent Form and the Military Organization that they belong to has received an information term.

All subjects were voluntary with good health and followed the inclusion-exclusion criteria.

The data collecting was performed in the following order:

1) Anamnesis;

2) Body mass and height measure;

3) Thickness measure of the following skinfolds[16,17]: chest (PE), biceps (BI), triceps (TR), subscapular (SE), medial axillary (AXM), oblique supra iliac (SIO), supra spinal (SESP), vertical abdominal (ABV), medial thigh (CXM) and medial calf (PAM);

4) Measure of the following body perimeters (P)[16,17]: neck (PPESC), forearm (PANB), relaxed arm (PBREL), contracted arm (PBCON), thorax (PTRX), waistline (PCINT), umbilical abdominal (PABU), hip (PQUAD), thigh (PCOXA) and calf (PPAN);

5) Measure of three bone diameters[16,17]: femoral biepicondilian (DBF), umeral biepicondilian (DBU) and biestiloidal (DBI);

6) Body density measure through hydrostatic weighing, in which subjects were measured barefoot wearing bathing suit adequate for the swimming practice[6];

The material and procedures used in this study were the following[8,9,16,17]: body density calculation (D) – from a conventional formula MC/volume, the value of D was determined through the following equation[6]:

$$D\ (g/ml) = \frac{MC}{[\,(MC - PS)/Da\,] - (VR + 100)}$$

where: D = body density

MC = body mass in kg

PS = MC with body submersed in water in kg

Da = water density

VR = residual volume in liters

0,1 = gastrointestinal gas constant (100 ml)

Residual volume (VR) – the VR was measured by estimative[18], considering the age and height:

Women: VR = 0.009 (age, years) + 0.032 (height, cm) – 3.9.

Fat percentage (%G) – the %G was determined through the equation: %G = (495/D) – 450[19].

Fat mass (MG, kg) – the MG was obtained by multiplying the body mass by the fat percentage fraction[9]: MG = MC (100/%G).

Lean body mass (MCM, kg) – the MCM was estimated by subtracting MG from the body mass[9]: MCM = MC – MG.

The equipment used for the hydrostatic weighing was a 120 x 120 cm squared tank with 190 cm of height, bricklaying-built and covered with wall tile inside with 30 cm thickness. The front part of the tank has a 30 mm thick laminated glass window label *Blindex* of rectangular shape with 50 cm of width and 60 cm height for the visual communication between appraiser and appraised[20].

The tank was kept with water at 150 cm height and the temperature was maintained at 36°C.

A chair constructed of PVC tubes was fastened to a load cell with display IDSI label *Filizola* with capacity of 50 kg and accuracy of 10 g[20].

A 4 kg diver belt was fastened around the subject's waistline in order to guarantee stability during the weighing[21]. The belt weight was subtracted from the submerse MC, performing the load cell tare before the beginning of weighings.

For the bone diameters measure, a caliper rule label *Mitutoyo*, made in Japan, was used and adapted with 15 cm stems with accuracy of 0.01 mm.

For the body mass measure, a digital balance label *Filizola*, made in Brazil, was used, with capacity of 150 kg and accuracy of 100 g.

For the skinfolds measures, a *Lange* compass, manufactured by the Cambridge Scientific Industries with scale of 1 mm and constant pressure of 10 g/mm^2 in all openings was used.

For the perimeters measures, a 0.5 cm width made in Brazil metallic tape measure, with accuracy of 0.1 cm, sold by the Sanny company was used.

Firstly, the data collected were analyzed through the descriptive statistics to establish both GR and GV profiles[9]. In a second moment, the Pearson correlation was used to determine the relation between D determined through the hydrostatic weighing and the anthropometrical measures (mass, height, skinfolds, perimeters and diameters) as well as the chronological age[22]. In a third moment, a series of sums of skinfolds, perimeters and diameters, associated or not to other variables, were performed to determine how the sums improved the correlation with density directly measured through the hydrostatic weighing[12].

The stepwise regression analysis was used to develop the specific equations for the density estimation[22]. The dependent variable (criterion) was the value of D hydrostatically determined and the independent variables (predictors) were the anthropometrical measures, combinations and sums of variables that reached the highest correlation[23].

The regression analysis was performed in the following stages:

1) For skinfolds, perimeters and diameters separately;

2) With the skinfolds and their square, perimeters and their square, diameters and their square;

3) The same procedure, but associated to age, body mass and height;

4) Combining skinfolds and perimeters, skinfolds and diameters and perimeters and diameters, all associated to age, mass and height;

5) All variables together;

6) Using the combination of skinfolds and perimeters that obtained the highest R when treated individually;

7) Using several combinations of skinfolds, perimeters and diameters with high R and lower number of variables with the respective square and yet, summing up age, mass and height to verify whether or not R increased;

8) Using mixed combinations of skinfolds, perimeters and diameters to verify the increase of R;

9) Combining the mixed sums with age, mass and height;

10) The terms quadratic and logarithmic were included in the different sums.

The validation of the developed equations was performed through the utilization of a sample corresponding to 20% of the number of measured and randomly selected individuals (validation sample) and that did not participate on the development of the equations[15].

The validation analyses[1,9] were performed through the determination of the following calculations: multiple correlation (R > 0.80), paired *t*-test ($t < t$ critical and $p < 0.05$), constant error (EC), total error (ET) and estimative standard error[24] (EPE) (EPE < 0.0080).

The selection of models was performed according to the following criteria:

1) Variables partial significance;
2) Lowest EPE;
3) Highest multiple correlation coefficient;
4) Model being practical;
5) Lower number of independent variables.

RESULTS

For the development of this study, 100 Brazilian Army military women were used, living in Rio de Janeiro, divided into two groups: the regression group (n = 80) and the validation group (n = 20)[15].

The descriptive values of age, height, total body mass (MCT), body density (D) and fat percentage (%G) are presented on table 1.

TABLE 1
Descriptive values of the regression and validation groups

	N	Minimum	Maximum	$\bar{x} \pm s$
	Regression group			
Age (years)	80	18.92	45.25	30.54 ± 6.53
Height (cm)	80	152.10	184.90	165.05 ± 5.95
MC (kg)	80	48.10	79.00	58.71 ± 6.68
D (g/ml)	80	1.027583	1.063440	1.045620 ± 0.00876
%Fat (%G)	80	15.47	31.71	23.44 ± 3.97
	Validation group			
Age (years)	20	19.42	42.58	31.08 ± 6.84
Height (cm)	20	156.50	173.00	164.21 ± 5.49
MC (kg)	20	49.20	81.70	58.88 ± 7.88
D (g/ml)	20	1.026236	1.062773	1.043877 ± 0.01117
%Fat (%G)	20	15.76	32.35	24.25 ± 5.07

With the objective of developing specific equations for the determination of the body density of the Brazilian Army military women from anthropometrical variables, 10 skinfolds, 10 perimeters and three diameters were measured and correlated to the body density in order to be included as independent variables in the equations developed by this study. The anthropometrical measures descriptive values of the regression group are presented on table 2.

TABLE 2
Descriptive anthropometrical values of the regression and validation groups

	Regression group (n = 80)			Validation group (n = 20)		
Skinfolds (mm)	**Min**	**Max**	**$\bar{x} \pm s$**	**Min**	**Max**	**$\bar{x} \pm s$**
PE	4.00	26.50	12.09 ± 4.5	5.00	26.00	11.90 ± 6.07
BI	2.80	21.00	9.19 ± 3.6	4.50	18.50	9.72 ± 4.03
TR	12.00	38.50	20.06 ± 4.7	8.10	32.00	19.44 ± 5.74
SE	7.00	34.00	14.38 ± 5.1	7.00	42.00	14.86 ± 7.72
AXM	5.00	23.50	10.32 ± 3.9	4.50	31.00	10.94 ± 6.99
SIO	6.20	39.00	21.56 ± 6.7	3.50	45.50	19.28 ± 8.97
SES	5.50	25.10	13.17 ± 4.3	7.10	22.00	12.17 ± 4.03
ABV	7.10	33.00	19.61 ± 5.4	9.50	33.50	19.03 ± 6.16
CXM	12.40	46.00	27.70 ± 6.4	13.00	51.00	28.46 ± 8.65
PAM	9.50	37.00	17.54 ± 5.4	11.00	31.00	19.34 ± 5.29
Perimeters (cm)						
PPESC	28.60	35.50	31.39 ± 1.6	29.20	34.90	31.65 ± 1.78
PPAN	20.50	26.40	23.12 ± 1.2	21.30	26.00	23.50 ± 1.41
PBREL	22.60	31.60	26.42 ± 1.9	23.90	33.20	26.70 ± 2.30
PBCON	23.50	32.40	27.10 ± 1.9	24.90	31.30	27.38 ± 1.71
PTORAX	66.60	85.00	74.56 ± 4.1	62.90	88.80	75.23 ± 6.17
PCINT	61.80	79.60	69.72 ± 4.5	62.10	88.00	70.87 ± 6.22
PABD	34.70	98.40	77.51 ± 7.7	63.50	101.50	77.52 ± 7.99
PQUAD	88.60	112.90	97.00 ± 5.0	92.50	113.50	97.13 ± 4.80
PCOXA	49.60	68.10	56.15 ± 3.7	51.20	63.60	55.99 ± 3.50
PPAN	30.80	39.40	35.22 ± 2.0	32.10	40.00	35.55 ± 2.13
Diameters (cm)						
DBF	8.20	11.10	8.92 ± 0.5	8.14	10.00	8.99 ± 0.44
DBU	5.30	6.85	5.90 ± 0.3	5.40	6.50	5.98 ± 0.30
DBI	4.30	5.50	4.84 ± 0.2	4.40	5.45	4.92 ± 0.31

TABLE 3
Values of correlation and significance of anthropometrical variables with D

Sums	D	
	R	**sig**
(BI + TR)	–0.681	0.000
(PANB + PTORAX + PCINT)	–0.443	0.000
(PCINT + PABD)	–0.448	0.000
(PTORAX + PANB + PABD + PCINT)	–0.469	0.000
$(PTORAX + PANB + PABD + PCINT)^2$	–0.475	0.000
(PCINT + PPESC)	–0.445	0.000

For the selection of the independent variables analyzed by regression, the variables correlation was firstly tested individually, then to test the same variables squared and after, the combination between all variables, together with age, height and body mass.

After the variables individual correlation test, the multiple correlation test (R) was performed through the stepwise regression, firstly to verify which variables were selected to participate on the equations, after, to know which were these variables, the option backward regression was used to verify which were the highest R and with which variables combination.

It is worthy emphasizing that, when variables are combined individually, the results of the correlations with high R uses a large number of variables, making the equations assembly infeasible, once the equations would have high R, low EPE and the equations would be impossible due to the excessive number of calculations to be performed for the estimation of the body composition. For doing so, the backward regression was performed in order to have an orientation of how sums of variables could be set up in order to enter the equation as a single variable.

Despite the combinations using skinfolds, perimeters and diameters had obtained high R, its utilization contradicted one of the

TABLE 4
R and EPE values of equations developed in this study

D (g/ml) Equations	No	R	EPE
D = 1.0 – 0.000748 (BI + TR) + 0.002538 (PANB) + 0.0007667 (PTORAX) – 0.00000995 (PCINT)^2	E1	0.798	0.00542
D = 1.058 – 0.000763 (BI + TR) + 0.002948 (PANB) – 0.000836 (PCINT)	E2	0.780	0.00593
D = 1.022 – 0.000676 (BI + TR) + 0.000005533 (PTORAX)^2 – 0.0000104 (PCINT)^2 + 0.00004012 (PANB)^2 + 0.008641 (DBI)	E3	0.822	0.00516
D = 1.03 – 0.0007 (BI + TR) – 0.00000603 (PCINT)^2 + 0.00005083 (PANB)^2 + 0.007819 (DBI)	E4	0.802	0.00537
D = 1.045 + 0.002079 (PPESC) – 0.00112 (PCINT) – 0.000736 (PCOXA) + 0.01142 (DBI)	E5	0.710	0.00633
D = 1.058 + 0.002142 (PPESC) + 0.00004764 (PNAB)^2 – 0.0011 (PCOXA) – 0.00000885 (PCINT)^2	E6	0.689	0.00652
D = 1.040 – 0.000611 (BI + TR) – 0.000269 (PCINT + PABD) + 0.01303 (DBI)	E7	0.784	0.00555
D = 1.095 – 0.000676 (BI + TR) – 0.000198 (PCINT + PABD)	E8	0.720	0.00616
D = 1.069 – 0.000796 (BI + TR)	E9	0.681	0.00645
D = 1.081 – 0.000649 (BI + TR) – 0.000000380 (BI + TR)^2 – 0.00000326 (PCINT)^2	E10	0.711	0.00628

TABLE 5
Validation of equations for the body density estimation

Eq.	$\bar{x} \pm s$	R (prob)	t (prob)	EC (g/ml)	ET (g/ml)	EPE (g/ml)
PH$\bar{x}$ = 1.043877 ± 0.011173						
E1	1.045826 ± 0.0096	0.799 (0.000)	–1.291 (0.212)	–0.00129	0.0000235	0.00542
E2	1.046023 ± 0.0104	0.804 (0.000)	–1.414 (0.173)	–0.00190	0.0000235	0.00593
E3	1.045940 ± 0.0097	0.751 (0.000)	–1.230 (0.234)	–0.00206	0.0000289	0.00516
E4	1.045725 ± 0.0104	0.773 (0.000)	–1.131 (0.272)	–0.00185	0.0000277	0.00537
E5	1.045073 ± 0.0073	0.595 (0.006)	–0.594 (0.560)	–0.00253	0.0000432	0.00633
E6	1.045300 ± 0.0083	0.635 (0.003)	–0.731 (0.474)	–0.00194	0.0000379	0.00652
E7	1.046387 ± 0.0088	0.731 (0.000)	–1.468 (0.159)	–0.00251	0.0000309	0.00555
E8	1.045489 ± 0.0084	0.790 (0.000)	–1.050 (0.307)	–0.00203	0.0000248	0.00616
E9	1.045681 ± 0.0076	0.793 (0.000)	–1.167 (0.258)	–0.00191	0.0000250	0.00645
E10	1.045247 ± 0.0087	0.799 (0.000)	–0.910 (0.374)	–0.00135	0.0000229	0.00628

objectives of this study, that was the assembly of more practical and simple equations for the estimative of the body density. Thus, with the result of the backward regression, one could have an orientation of which variables could be summed up to, once again, be applied to the regression and to verify the increase on the value of R. However, as the number of variables to be summed up was still large, making the equations less practical, the best combinations were tested once again with smaller number of variables, associating the results of the stepwise regression with the backward regression and once again applying the regression in order to verify which is the smallest number of variables that would originate the highest values of R and, from this point on, to use the sum of these variables in the regression in order to verify whether or not the correlation would decrease, so that we could assemble equations with a satisfactory value of R, low EPE value and with smaller number of variables, what certainly would originate more practical equations.

On table 3, some sums that had been selected due to the smaller number of variables are presented; in other words, sums more simple that present significant correlation $p \leq 0.01$ with D. Several sums were analyzed and, as they do not present significant correlation or had a larger number of variables involved, were excluded as variables at the moment of the equations assembly.

After selecting which variables should be analyzed for the equations assembly, the stepwise regression was used with different variables combinations, more and more to obtain a high value of R and lower values of EPE.

For the equations assembly, combinations of skinfolds and perimeters, diameters, ID, EST and MC; skinfolds, perimeters and diameters; skinfolds and perimeters; perimeters and diameters; skinfolds and diameters; only perimeters and only skinfolds were tested.

In order to come to the variables combinations that could be used in the equations developed in this study, the stepwise regression was used, firstly using the most significant variables for the equations assembly; in other words, the groups of variables that were selected in the stepwise regression and the combinations appearing with smaller number of variables and maintaining the value of R considerably high.

With the reduction on the number of variables, it became easier to combine them for the verification of which groups could be selected for the equations assembly of this study and, from this point on, the combinations that would be effectively used in the equations assembly started being selected, finally coming to the equations developed in this study and presented on table 4.

After the reduction on the number of variables, previously mentioned, the criteria for selecting the equations developed in this study (table 4) were the following: firstly, the equations with the largest number of variables were excluded, once they would become complicated or not practical; secondly, the equations with close or similar values were also excluded; thirdly, the equations that required many measures by the users, as an example, the equations with the sum of two or three perimeters, were also excluded, once despite having high R and low EPE, they were unpractical; fourthly the equations only presenting skinfolds, skinfolds and perimeters, skinfolds and diameters, perimeters and diameters and only perimeters were kept and from this point on, to select the models with smaller number of variables, with R relatively high (above 0.70) and EPE relatively low (below 0.007); finally, the values of D of all equations for the subjects from the regression group were calculated and, among the equations that presented no significant difference with the average of D obtained through PH, the 10 more simple were selected.

To accomplish the objectives of this study, equations that could be easily used were assembled (table 4), but another important step was to validate the equations developed through the validation group (GV), which was randomly removed from the population of this study, not participating on the equations assembly. The descriptive values of this group were presented on table 2 and the validation results are presented on table 5.

Considering the values of the validation results, it was verified that the linear correlations performed were all considered significant ($p \leq 0.05$).

When the differences between the values of D measured through the hydrostatic weighing and through the equations developed were analyzed, it was observed that no equation presented significant difference ($p \leq 0.05$) between the averages of the D measured and the D estimated.

As we analyze the average differences found for D measured through PH and the D estimated by the equations developed ($EC = D_{measured} - D_{estimated}$), values extremely low are observed.

Finally, the extremely low values of ET and the values of EPE considered as excellent (E1, E3, E4 and E7 for EPE < 0.0055) and satisfactory (E2, E5, E6, E8, E9 and E10 for EPE < 0.0070), validate the equations developed[1] in this study to estimate the D for the Brazilian Army military women aged between 18 and 45 years.

CONCLUSIONS AND RECOMMENDATIONS

This study had as objective to develop and to validate specific equations for the determination of the body density of military women aged between 18 and 45 years, living in Rio de Janeiro, from anthropometrical variables.

Thus, 100 military women participated on this study, divided into two groups: regression group (n = 80), used for the development of the equations proposed by this study, and the validation group (n = 20), used for the validation of the equations developed.

After the performance of this study, one came to the following conclusions:

– It was possible to develop and to validate specific equations for the determination of the body density of military women, living in Rio de Janeiro, from anthropometrical variables (skinfolds, perimeters and diameters).

– The Brazilian Army military women presented the following average anthropometrical characteristics: age 30.65 ± 6.56 years, height 164.88 ± 5.84 cm, MC 58.74 ± 6.90 kg and %G 23.60 ± 4.19 %.

– After the performance of the hydrostatic weighing, the body density of subjects from this study was determined, which was 1.045272 ± 0.00926 g/ml.

– A significant correlation ($p \leq 0.05$) was observed between the values of D measured through the hydrostatic weighing technique and the several combinations of sums of anthropometrical measures (skinfolds, perimeters and diameters).

– 10 equations were developed for the estimation of the body density of military women, living in Rio de Janeiro, using as variables the skinfolds, perimeters and diameters, which were characterized by the simplicity and method being practical.

– A significant correlation ($p \leq 0.05$) was observed between the values of D measured through the hydrostatic weighing technique and the values of D estimated through the equations developed.

– The equations developed in this study are valid for the estimation of values of D of military women found within limits of two standard deviations in the variables reported and aged between 18 and 45 years.

New studies should be performed aiming at the validation of the equations developed in this study for other group of Brazilian women.

When one searches the accuracy of the equations developed and these equations are used by experienced appraisers with specialized equipments, it is recommended that, for the estimation of values of D, equations with skinfolds, perimeters and diameters be used, in other words, the equation (E2):

$$D = 1.058 - 0.000763\,(BI + TR) + 0.002948\,(PANB) - 0.000836\,(PCINT)$$

If it is considered that the lack of experience of the appraiser for the attainment of the skinfold measure may influence negatively on the result of values of D, thus summing up one more error to the result, it is recommended that, despite the higher accuracy of equations that used skinfolds, perimeter, diameter and skinfolds and perimeter, the equation that uses only perimeters, in other words, the equation (E6) be used by the inexperienced appraisers:

$$D = 1.058 + 0.002142\,(PPESC) + 0.00004764\,(PANB)^2 - 0.0011\,(PCOXA) - 0.00000885\,(PCINT)^2,$$

Especially due the fact that high cost equipments for the skinfold measure are not required and also that measures are simple to be obtained and are already validated, it is recommended that this equation be used on the Military Organizations with female segment with the same characteristics as the subjects from this study.

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