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Body composition and somatotype in overweight and obese women pre- and post-circuit training or jogging

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ABSTRACT

Purposes: To compare different assessment methods of the body composition in overweight and sedentary obese women submitted to two months of circuit training (CIRC) or Jogging (JOGG) and to associate the physical performance to the muscular index calculated using two methods. **Methods:** Groups: CIRC, n = 14, body mass index (BDI, kg/m^2) = 32 ± 8 (mean ± SD; age = 34 ± 10 years; and JOGG, n = 12, BMI = 30 ± 3; age = 38 ± 11. Training: 60 min. x 3d/week in the first month, and 60 min. x 4d/week in the second month. Assessment of the body composition: anthropometry(1,2), bio-impedance(3), and somatotype(4). It was performed one maximal repetition test (1-MR) to the bench press, leg press and low-seated rowing exercises. **Results:** The mass, the BMI, the body fat percentage by the anthropometry and bio-impedance, and the endomorphy were significantly reduced in both groups. The mesomorphy had a decrease, and the ectomorphy increased in the JOGG. The bio-impedance slim and muscular mass did not change in both groups. The muscular circumference of the arm (MCA) had a significant increase in the CIRC. The result of the bio-impedance fat percentage and the anthropometry were the same and significantly correlated. The endomorphy was significantly correlated to the anthropometry fat percentage, and to the mesomorphy to the slim mass anthropometry. The ectomorphy was not correlated to the slim mass of the anthropometry. **Conclusion:** The somatotype had a good result to assess the phenotypical changes in obese women submitted to the training. Nevertheless, the endomorphy presented the best concordance, and the ectomorphy had the worst one compared to other methods. The results of the somatotype suggest that the CIRC attained the best result into this group. The bio-impedance and the anthropometry produced similar results to assess the body composition.

Keywords: Endomorphy. Mesomorphy. Ectomorphy. Bio-impedance. 1-MR.

INTRODUCTION

The morphologic classification of men has a scientific and general interest since the times of Hypocrates, that is, around 400 b.C. The major part of the first methods was not satisfactory, dividing the population from two to five different categories. It was not easy to separate one from another, since few persons had a clear idea to which group they belonged to(5). In 1921, Matiegka proposed the first systematic anthropometric human classification through the quantification of the body tissues of a sampling composed by barbers, butchers, smiths, and gymnastic instructors.

Later, other physical descriptions were elaborated and it was denominated somatotype by Sheldon and colleagues in 1940, Parnell in 1954, and that classification was reviewed and modified by Heath and Carter in 1967(6). The somatotype consists in three components: the endomorphy, which is the greasy component; the mesmorphy, which is related to the muscular component and presents the solidity and "square" body aspect, and the ectomorphy in which it predominates the linearity and the fragility of the body(7).

An important concept to the fitness and aesthetics, similar to the weight-lifting sportive modality is the symmetry and proportionality added to the muscular definition(8). The fat percentage or the body mass index (BMI, kg/m^2) calculations, for instance, do not define the body fat or the slim mass distribution, and this does not allow define the above mentioned concepts. The somatotype is a form measurement instead of the size, presuming that adults with different body sizes are geometrically similar, that is, symmetrical and proportional, and they are best fitted to assume such role(6).

The somatotype is a description composed by the individual's physique, and it is defined by a set of components(9). Nevertheless, it was observed that the circumference of the athletes' thigh compared to the control individuals had a higher increase than that predicted by the body's geometrical similarity proportional to the mass(6). Furthermore, generally, the endurance athlete has an increased body density, appendiceal muscular mass and reduced cutaneous folds compared to non-athlete individuals with the same weight. The physical aerobic activities have a predominant effect on the fat catabolism with little muscular improvement(7,10). Therefore, the result of different interventions can be a specific body improvement that reflects not only the global increase or decrease in a proportional and geometrically distributed way.

On the other hand, the body composition is capable to perform the evolution assessment aside from the slim and fat mass. Resisted exercises stimulate the muscular improvement(11), confounding the reduction of the body fat in the body mass appraisal. The general anthropometric formulas to calculate the body composition are more comprising, and those for specific populations are more accurate(12). However, Pollock *et al.*(1,13) have developed equations for both genders with age adjustments, and it is used in big populations with a quite high accuracy index. Other studies have shown the significant relationship between generic equations and the result of the doubled scanning X-Ray (DEXA)(14,15). The bio-impedance has also shown a good relationship to estimate the slim body mass comparing to the hydrostatic weighing(3).

Therefore, the main goals this paper is contemplating were: 1) to verify the effects of the circuit training (CIRC) or jogging (JOGG) on the body composition, assessed by the bio-impedance and anthropometry; 2) to compare the somatotype as to the changes measured by other methods; 3) to observe if the somatotype could reflect the phenotype evolution considering the effects on the fat mass, the muscular improvement and the consequences on the body's fragility.

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METHODS

Volunteers: The study started with forty-three 25 to 57 BMI women, no records of metabolic diseases except the own obesity, no orthopedic limitations, sedentary, and clinically examined by a physician. Next, they were randomly divided in two groups, and after some discontinuances, it remained in the study the following data: CIRC, n = 14, BMI = 32 ± 8 (mean ± SD); age = 34 ± 10 years; and, JOGG, n = 12, BMI = 30 ± 3; age = 38 ± 11. As the groups had a random formation, there was a certain difference on their age and BMI.

It was 60 min x 3 d/week training in the first month, and 60 min. x 4 d/week training in the second month. The CIRC consisted of fifteen 30sec. resisted exercise stations intercalated by 30 sec. jogging/trotting repeated for 40-45 min. The jogging was a 45 min. walking, and the remaining 15 min. were used in the warm up and cooling in both groups. The nutritional guidance was to consume similar daily caloric amounts than in the energetic resting expenditures, measured through indirect calorimetry containing 20% proteins, 20% fat, and 60% carbohydrates. Every volunteer signed a free and clarified consent term approved by the Human Research Ethics Committee from the second institution listed in the first page of this paper.

Anthropometric assessment: Every anthropometric assessment was made using the conventional techniques described by Pollock *et al.*(13). It was evaluated the total body mass (kg) and the height (cm) by means of a type ID 1500 Electronic platform scale Fillizola® (São Paulo, SP, Brazil) with 0.1 kg and 0.5 cm accuracy, respectively.

To measure the cutaneous folds, it was used a Lange® 10 g/mm^2 constant pressure on the contact surface, 1 mm accuracy and 0-65 mm scale adipometer (Beta Technology Inc., Santa Cruz, CA, USA) with. The recorded value was the mean taken from three consecutive measurements. The body density was calculated by the three cutaneous fold equations for women, corrected by their age(1):

$$1)\quad DC = 1,0994921 - (0,0009929 \times X) + (0,0000023 \times X^2) - (0,0001392 \times Y)$$

where: **DC** = body density (g/ml); **X** = sum of the triceps cutaneous, suprailiac and thigh folds in mm; **Y** = age in years.

The percentage of fat was attained from the DC calculation(2):

$$2)\quad \%G = [(4,95 / DC) - 4,5] \times 100$$

where: **%G** = fat percentage calculated from the anthropometric variables; **DC** = body density (see 1 above).

The fat body mass can be attained from the following formula:

$$3)\quad MG = (M \times G) / 100$$

where: **MG** = fat body mass (kg) calculated from anthropometric variables; **M** = body mass (kg); **G** = fat percentage by the anthropometry (see 2 above).

The slim mass was attained by the subtraction of the fat mass from the total mass.

Circumferences (cm): extended arm, forearm, wrist, neck, waist, abdomen, hip, thigh and calf. It was used a flexible inextensible metallic tape with 0.1 cm accuracy, according to conventional techniques(13).

The muscular circumference of the arm and thigh were calculated by the following formula:

$$4)\quad CMB \text{ ou } CMC = A - (B \times \pi)$$

where: **CMB** or **CMC** = muscular circumference of the arm and thigh, respectively (cm); **A** = circumference of the arm or the thigh (cm); **B** = cutaneous fold from the triceps or the thigh (cm).

The muscular area of the arm was calculated by an equation developed through multi-varied analysis of the variance, having as golden standard the computerized tomography(16):

$$5)\quad AMB = 1,403 \times CMB$$

where: **AMB** = muscular area of the arm (cm^2); **CMB** = muscular circumference of the arm (cm) (see 4 above).

The body muscular mass was calculated from anthropometric measurements, according to the following equation modified from Martin *et al.*(17):

$$6)\quad MMu = [E \times (0,0553 \times A^2 + 0,0987 \times B^2 + 0,0331 \times C^2) - 2445] \times 1000$$

where: **MMu** = muscular mass (kg); **E** = height (cm); **A** = muscular circumference of the thigh (cm).

$$7)\quad A = CC - \pi \times PCC;$$

where, **CC** = circumference of the thigh (cm); **PCC** = cutaneous fold of the thigh (cm); **B** = maximal circumference of the forearm (cm), and; **C** = muscular circumference of the calf (cm).

$$8)\quad C = CP - \pi \times PCP;$$

where, **CP** = circumference of the calf (cm); and **PCP** = cutaneous fold of the calf (cm).

This is an equation intended to be used for men, and it was found no equation aiming this variable for women. It might be some error in the appraisal due to differences between genders. Nevertheless, the intra-individual comparison as to the effects of the physical activity on the muscular mass must remain valid.

Bone diameter assessed (cm): humeral biepicondyle having the elbow in a 90° angle flexion and the pachymeter's shafts in a 45° angle related to the joint; and the femoral bicondyle assessed in the seated positioning at a 90° angle in the knee joint with the equipment in a 45° angle.

The somatotype was calculated from the anthropometry using the below shown formulas adapted from Heath and Carter(4) by Brito *et al.*(18):

$$9)\quad Endo = -0,7897977038 + 0,1506850093 \times (\Sigma PC \times 10) - 7,24011 \times 10^{(-4)} \times (\Sigma PC \times 10)^2 + 2,02696 \times 10^{(-7)} \times (\Sigma PC \times 10)^3 + 1,50939 \times 10^{(-8)} \times (\Sigma PC \times 10)^4 - 4,42939 \times 10^{(-11)} \times (\Sigma PC \times 10)^5$$

where: **Endo** = endomorphic component of the somatotype; **ΣPC** = sum of the triceps, subscapular, and suprailiac cutaneous folds.

$$10)\quad Meso = 4 + (4,961390196 + 6,866194747 \times BEU \times 4,796637252 \times BCF + 1,490130181 \times (CB - PCT / 10) + 1,274233697 \times (CP - PCPan / 10) - 104,961949677 \times E) / 8$$

where: **Meso** = mesomorphic component of the somatotype; **BEU** = humeral biepicondyle diameter (cm); **BCF** = bicondyle femoral diameter (cm); **CB** = circumference of the arm (cm); **PCT** = cutaneous fold of the triceps (cm); **CP** = circumference of the calf (cm); **PCP** = cutaneous fold of the calf (cm); **E** = height (m).

$$11)\quad Ecto = 73,2043628 \times (E / M^{1/3}) - 28,56$$

where: **Ecto** = ectomorphic component of the somatotype; **E** = height (m); **M** = body mass (kg).

Note: if the result of the above formula is < 0, the value of the ectomorphy is 0.5; in the event the result is ≥ 0, the value of the ectomorphy is the result attained by the formula.

Bio-impedance: The bio-impedance was performed using a Quantum BIA-101Q device (RJL Systems, Inc. Clinton: MI, USA) with a 50 kHz frequency in alternate 4-electrodes current. To determine the slim mass, it was used a formula validated by Segal *et al.*(3):

$$12)\quad MMbia = 0,0011E^2 - 0,021R + 0,232M - 0,068I + 14,595$$

where: **MMbia** = slim mass attained by the bio-impedance (kg); **E** = height (m); **R** = resistance (Ω); **M** = body mass (kg); **I** = age (years).

One maximal repetition test (1-MR): Following the previous described methodology(10): the volunteers were guided and assisted by Physical Education professionals. Test 1: straight supine (triceps, shoulders, and chest); Test 2: leg press (thighs and gluteus); Test 3: seated-pulley down rowing (biceps, shoulders, and back).

Statistical analysis: The normality was tested through Kolmogorov and Smirnov. To the correlations, it used the Pearson or Spearman methods to the normality or not, respectively. The beginning (M1) and end (M2) of the study were compared through the paired t-test or the Wilcoxon test, whenever there was or not normality, respectively. The variance between groups (Δ; M2-M1) it was assessed through the non-paired t-test or Mann-Whitney test, whenever there was or not normality, respectively. The results are the mean and the standard deviation, and to the correlations, the individual data with the central bias line. The statistical conclusions were performed at 5% significance with a 95% reliance interval(19).

RESULTS

There were seventeen discontinuances due to: non-compliance to the interventions (n = 7), difficulties in the training schedules (n = 3), disease in the family (n = 1), fall (n = 1), depression and/or anxiety (n = 5).

The results of the body composition by the anthropometry and bio-impedance, the BMI and somatotype are presented on table 1. There was a reduction in the body fat in both groups, the CIRC has increased the muscularity and the JOGG has increased the fragility.

TABLE 1
Anthropometric assessment and bio-impedance

Variables	*CIRC			*JOGG			
	Beginning	End	P	Beginning	End	P	PΔ
Anthropometry							
N	14			12			
M	89 ± 20	84 ± 18	0.001	75 ± 11	70 ± 11	0.001	0.701
IMC	33 ± 8	32 ± 8	0.001	28 ± 1	26 ± 1	0.001	0.415
%Gantro	44 ± 6	38 ± 7	0.001	40 ± 5	33 ± 5	0.001	0.115
MMu	40 ± 7	41 ± 6	0.389	39 ± 6	38 ± 7	0.256	0.196
Somatotype							
N	14			12			
Endo	10 ± 1	8 ± 1	0.001	9 ± 1	7 ± 1	0.001	0.574
Meso	7 ± 2	6 ± 2	0.139	5 ± 1	5 ± 1	0.005	0.069
Ecto	0.6 ± 0.4	0.6 ± 0.5	0.575	0.4 ± 0.2	1.5 ± 0.4	0.015	0.131
Bio-impedance							
N	8			9			
MMbia	53 ± 5	52 ± 5	0.055	46 ± 7	45 ± 7	0.055	0.884
MGbia	45 ± 15	41 ± 15	0.004	29 ± 6	24 ± 6	0.002	0.815
%Gbia	45 ± 6	43 ± 6	0.004	38 ± 2	34 ± 3	0.002	0.139

The values are mean ± SD. *CIRC = circuit training group, and CAM = jogging training group. P = statistical result M1xM2 (intra-groups); PΔ = variations between groups (intergroups) (Δ = M2-M1 for each group). M = body mass (kg); IMC = body mass index (kg/m^2); %Gantro = fat percentage through the anthropometry; MMu = muscular mass calculated through the anthropometry (kg)(17); Endo = endomorphic component of the somatotype; Meso = mesomorphic component of the somatotype; Ecto = ectomorphic component of the somatotype(4); MMbia = slim mass calculated through the bio-impedance (kg); MGbia = fat mass calculated through the bio-impedance (kg); %Gbia = fat percentage calculated through the bio-impedance(3).

The MCA and the muscular area of the arm had a significant increase in the CIRC (p = 0.023 both). The muscular circumference of the thigh did not present any difference in both groups (p > 0.05). The MCA deltas and the muscular circumference of the thigh were not different between both groups (p > 0.05). The mean 1-MR for the three exercises had a significant increase between M1 and M2 to the CIRC (58 ± 25 kg x 65 ± 26 kg, p < 0.0001), and to the JOGG (48 ± 22 kg x 53 ± 21 kg, p < 0.0001).

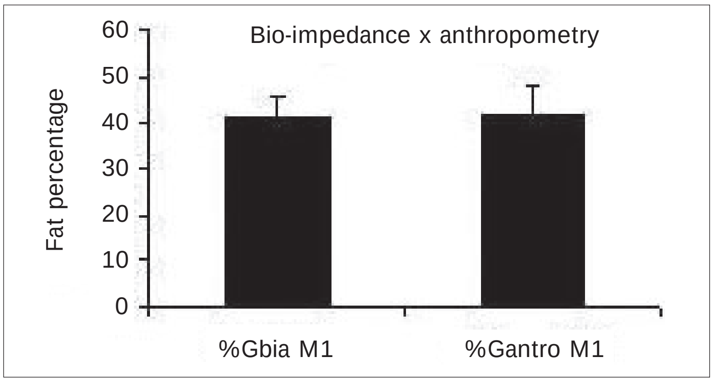

***Fig. 1** – Comparison between the fat percentage calculated through the bio-impedance (%Gbia)(3) and anthropometric variables (%Gantro)(1,2) before the interventions (M1) according to the methodology described. Results are the mean ± standard deviation; N = 43; P = 0.356.*

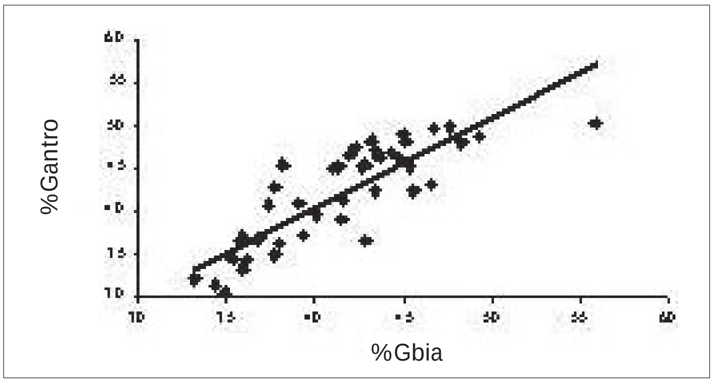

***Fig. 2** – Pearson linear correlation between the fat percentage attained through the bio-impedance (%Gbia)(3) and the anthropometric variables (%Gantro)(1,2), before the interventions (M1), according to the methodology described. Statistics: n = 43; r = 0.83; r^2 = 0.69; P < 0.0001.*

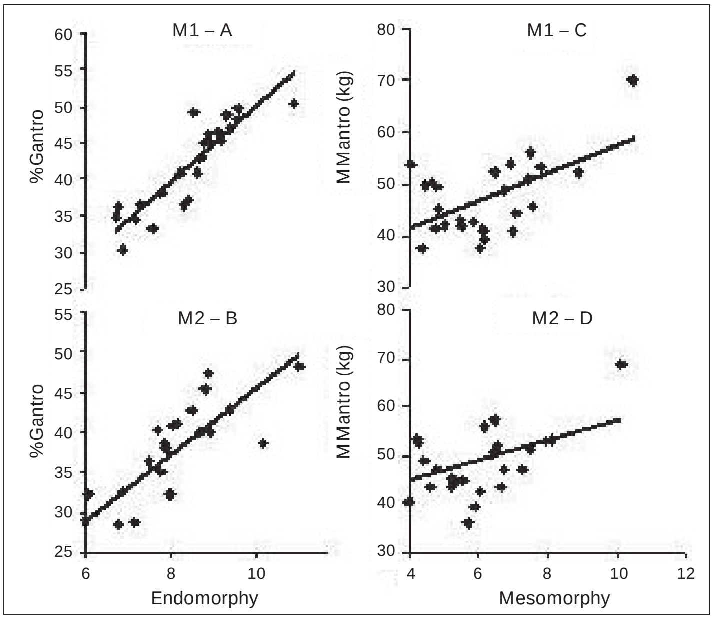

***Fig. 3** – Pearson's linear correlation between the endomorphic and mesomorphic components of the somatotype(18) the fat percentage (%Gantro), and the slim mass (MMantro)(1,2) respectively, calculated through the anthropometry, according to the methodology described. The endomorphy was significantly correlated to the %Gantro before (M1-A) and after (M2-B) the interventions (N = 26, P < 0.0001 in both). The mesomorphy was significantly correlated to the MMantro before (M1-C) and after (M2-D) the interventions (N = 26, P = 0.003 and P = 0.032 respectively).*

In order to compare the correspondence of the somatotype components to the other variables, the groups were treated as they were one sole group. The means of the fat percentage of the bio-impedance and anthropometry in M1 were not different among them, and they were significantly correlated (figures 1 and 2, respectively).

The endomorphy was significantly correlated to the fat percentage of the anthropometry in both moments, and the mesomorphy was correlated to the anthropometry slim mass (fig. 3 A, B, C, D). The ectomorphy was not correlated to the anthropometry slim mass in no moment ($p > 0.05$).

The mesomorphy variations and the anthropometry slim mass were not correlated to the Δ of the sum of the 1-MR ($p > 0.05$). There was no difference between groups to the sum of the 1-MR ($p > 0.05$).

DISCUSSION

It is suggested that the separate treatment of the somatotype components confounds the result, leading to non-significant interpretations. However, it is impossible to make a direct analysis of the alterations between plotted points in a 3-dimensional space(20). In order to test these assertions, we have tried to verify both approaches to assess the alterations caused by the exercise protocols.

In general, the interventions caused a reduction in the body fat in those assessed women, and this was indicated by every method used in this study.

In an individual analysis, the somatotype components, the results suggest that the CIRC group became stronger and the JOGG groups became more fragile. This is reinforced by the increase in the MCA and in the muscular area of the arm only in the CIRC. Nevertheless, the other muscularity indicators (muscular circumference of the thigh, slim mass of the bio-impedance and muscular mass) were not modified in any group.

The conjunct analysis of the somatotype of its three components has shown that both groups walked towards the mesomorphoendomorpho category, where the first and second components are equal or are not more than a half unit different, and the third one is lower(18), but they did not begin to change their category. However, this suggests a reduction in the fat component and an increase in the muscular component. This is characteristic of the somatotype, that can show a "type" alteration in the physic, and not only in the quantification and proportion of the fat and slim tissues. Maybe a longer interventional time could evidence those alterations as to the strength and "robustness" in favor of the CIRC to the variables that had not any alteration. Nevertheless, these set of results do not allow assert that the CIRC became stronger and the JOGG became more fragile, since this may be a limitation in interpreting the somatotype components isolate.

Similar to what happened in the present study, other studies also found a good(21) or moderate(5) relationship of the endomorphy and the body fat in both genders. As to the sports, those representatives with more endomorphic expressivity were the channel swimmers, the football players, the golf players, and those with the lowest amount of that component were the long-distance runners, wrestling fighters, and weight lifters of the lighter categories(22) and physi-culturists(8), suggesting that such component has an important correspondence to the body fat.

The mesomorphy and the slim mass were not correlated to the strength increase observed, and the neuromuscular factors might have been more important to the strength gain in this phase than the muscular hypertrophy *per se*(7). Although the muscular mass has pointed towards the direction of the mesomorphic results, with an approximate 1 kg increase in the CIRC and a decrease in the JOGG, these were not significant. At last, the increase in the ectomorphy in the JOGG might have occurred mainly due to the reduction in the body mass, once from all variables to calculate that component, this is the only skilled for adult individuals.

Similar to what was observed in this study, Wilmore(5) found a weak correlation of the mesomorphy and the slim mass, and the shared variance (r^2) was 2.6% and 16.8% for women and men, respectively. The strength is related to the slim mass and consequently to the mesomorphy(4). Therefore, the increase in the strength estimated by the sum of the 1-MR justifies such relationship in the CIRC, but not to the JOGG, that has reduced the mesomorphy. Still, it was observed that the relationship of the mesomorphy to the slim mass and the body density is gender-dependent. In a study involving men and women, Susanne *et al.*(21) found a positive correlation between the muscular improvement and the body density only in the first ones. However, Carter(22) observed that the mesomorphy was a characteristic generally found in athletes, and the women that had the highest expression of that component were the gymnasts and among weigh-lifters.

The lack of a mesomorphic relationship with the 1-MR tests may in part have been due to the relatively short endurance of the protocol, and partially because women do not respond well to such component.

On the other hand, the increase in the ectomorphy only in the JOGG might have been due to the type of the activity performed by the groups. The CIRC group practiced resisted activities related to the muscular hypertrophy(10). In the sports, individuals involved in the endurance training, such as weight-lifters(22) and physic-culturists(8) presented higher mesomorphic values and lower ectomorphic values. The endurance activities such as the marathon, presents an inverse bias(22).

It was observed that the ectomorphy was positively related to the skeletal factor and negatively related to the muscular factor and the body fat. However, the ectomorphy was not an independent factor in both genders(21). Another study has observed that the ectomorphy was higher in main Italian volleyball league players compared to the secondary league. Still, the secondary league players were more mesomorphic than those of the main league. The main league players were taller and presented a higher height/weight relationship in both genders, and lower values as to the cutaneous folds compared to the secondary league(23). This must have influenced the higher ectomorphic expression, but not necessarily indicating that they were more fragile, being reinforced even by the best sportive performance found in the main league. Therefore, it is necessary to interpret these results very carefully.

Many studies have been performed with athletes, and this limits the comparison with non-athlete individuals.

The anthropometry is subject to several types of errors to be used as accurate measurements due to a lack of an adequate training and non-appropriate equations. In a recent study, it was observed that the anthropometric measurements has underestimated about 29% of the fat, and overestimated 4-5% of the muscular area of the arm upon the comparison on the computerized tomography(16). However, the fat percentage estimated through the anthropometry was positively correlated in the present study, and did not present any difference between means compared in the bio-impedance. Still, in another study with type-2 diabetic old women conducted by our group, the result had equal statistical means and it was highly correlated to the results attained in the DEXA(14). The cutaneous folds were capable to perform an adequate prediction on the total body fat as well as the trunk fat in children compared to the DEXA(15). Therefore, the equations used in this study(1,13) seem to perform a quite well role as to the general use in different populations.

Summarizing, it seems that all the body classification systems used in this study presented some limitations. However, every method used pointed out for a reduction in the body fat in both groups.

As to the somatotype, its different components presented different results compared to other methods: a) the endomorphy seemed to be well-correlated to the body fat; b) the mesomorphy had a fragile relationship to the slim and muscular mass; and, c) the ectomorphy is not an independent factor, and it must be interpreted along with other data. The strength improvement in those women did not depend only on the muscular improvement, suggesting that other factors, such as neuromuscular factors should participate in that process. At last, the anthropometry using a generic equation to estimate the body composition presented similar results than the bio-impedance did.

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