Resting metabolism of post-menopause women submitted to a training program with weights (hypertrophy)

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ABSTRACT

The study had as objective to evaluate the resting energy expenditure (REE) of post-menopause women submitted to a training program with weights. Thirty women, age between 45 and 70 years (FSH > 40 mIUmL), separated in two groups (TG: training n = 15 and CG: control n = 15) were studied. The body mass index (kg/m²) was calculated and the body fat percentage and the muscular mass were determined through bioelectric impedance (BIA). The REE was obtained through indirect calorimetry (respiratory O_2 and CO_2) and calculated by the Weir equation. The measurement occurred after 12 hours of fasting, during 30 minutes under controlled temperature and humidity. The TG participated of the training program with weights during 16 weeks, in the frequency of three times per week. The analyzed data by the t-Student, Mann-Whitney and ANOVA tests ($p < 0.05$) demonstrated that the TG had body mass increased in the 1.8 kg mean, muscular mass in 2.0 kg and the REE presented increase of 8.4% in relation to the CG. In conclusion, the training with weights increased muscular mass and REE. Therefore, this kind of exercise is recommended part of strategy to revert muscular and metabolic losses derived from aging and/or menopause.

Keywords: Menopause. Exercise. Resting energy expenditure.

INTRODUCTION

Several physiological alterations which occur in women during aging increase with menopause. Among them, the main are: representative decrease of female sexual hormones; increase of adiposity; reduction of muscular mass and decrease of resting energy expenditure. Consequently, there is a reduction of mobility and balance as well as an increase of risk of falls, decreasing hence, life quality as age progresses[1-2].

It is possible that the decrease of the metabolically active lean tissue reduces the energetic needs in resting and that this fact associated with the decrease of physical activity with no proportional reduction in caloric ingestion, causes an accumulation of body fat[3-4].

On the other hand, many studies have shown the importance of weight training in physical fitness programs, once they stimulate the increase of muscular mass which increases the resting energy expenditure due to the straight relationship which exists among these factors[5].

Physical exercise, which includes muscular strengthening exercises, could minimize the risks and even revert losses faced with aging, especially at menopause[6-7]. Within this context, the aim of the present study was to evaluate the effect of weight training over the resting energy expenditure of post-menopause women.

MATERIAL

Subjects: Thirty post-menopause women, age 45-70 years, with over one year of menstruation interruption (FSH values higher than 40 mIU/mL), and sedentary, followed by the Center of Metabolism in Exercise and Nutrition (CeMENutri) and by the Climacterium and Menopause Nursing Room of the Clinics Hospital, Medicine School of Botucatu – ENESP, were part of the study group. All of them were informed about the study's proposal as well as the procedures to be performed and signed a free and clarified consent form according to Resolution Nº 196 from 10 October, 1996 of the Ethics in Research Committee (CEP) of the Medicine School – UNESP – Botucatu. The favorable answer from the CEP was given on April 05, 2004. All subjects went through a medical triage in order to verify the inclusion criteria in the study. Therefore, women who underwent hormonal replacement therapy; were smokers; made use of alcohol; performed physical exercises; made use of vitamin supplements and/or minerals or had any type of endocrine-metabolic, gynecological and/or osteo-articular diseases which could hamper weight exercises practice were excluded. They were separated in two groups: (**TG:** Training and **CG:** Control). There was no diet prescription and the women were instructed to continue their eating habits.

Weight training protocol: It was prescribed and supervised by physical education professors and had the duration of 16 weeks, in which the 4 first weeks were scheduled for physical fitness leveling. All loads were individually measured for each exercise in the end of the first 4 weeks, through a 1RM test[8]. The progression for the determined aim was gradual until it reached 3 sets of 8-12 maximal repetitions with 60-80%[9], keeping the intensity/volume ratio steady, that is, the higher the volume, the lower the intensity and vice-versa. These loads suffered periodical readjustments with the purpose to generate progressive overload and training break of the homeostasis.

The training protocol was adapted to women above 45 years of age, involving weight exercises aiming hypertrophy, with a program of 3 weekly sessions. Ten exercises were performed: 2 for the chest, 2 for the back, 3 for the thighs, 1 for the biceps and 1 for the triceps. The exception was the abdomen with 1 exercise including 3 sets of 30 repetitions. The exercises were performed in the following order: leg press, knee extension, knee flexion, bench press, peck deck, row, high pull, triceps pulley, biceps curls and abdominal.

The recovery interval was of 2 minutes, both between sets and exercises. One minute rest between sets was given in the exception. Moreover, the women were oriented to perform the eccen-

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tric action in 2 seconds and the concentric action in 1 second. The breathing was controlled so that expiration should be performed in the concentric action and inspiration in the eccentric action of the exercise with the purpose to avoid apnea.

Body composition evaluation: Body mass was evaluated (kg) using a platform type anthropometric scale (Filizola®, Brazil), with 0.1 kg precision and capacity of up to 150 kg., and height (m) through a 0.1 cm precision portable anthropometer (SEKA®) which was attached to the wall. Both measurements were conducted according too procedures described by Gordon *et al.*[10]. The body mass index (BMI) was calculated through the body mass (kg)/height (m) ratio[2] and classified according to standardization of the World Health Organization[11]. The measurement of the waist circumference (WC) was also checked with inextensible measuring tape[12].

Muscular mass – MM (kg) and body fat percentage were measured through bioelectric impendence – BIA (BIODYNAMICS model 450), according to equations proposed by Janssen[13] and Segal[14] respectively. Afterwards, the percentage of the muscular mass – MM (%) in relation to the body mass was calculated.

Laboratory evaluation: In the beginning of the study, the follicle stimulating hormone (FSH)[15], was dosed by the automatic analyzer Elecsys® 2010 (Roche Diagnostics®, Mannheim, Germany) in order to confirm menopause and specific kit for immune essay through electrochemiluminescence in solid phase.

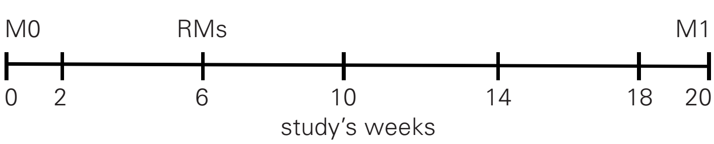
Resting energy expenditure evaluation (REE): The participants were previously instructed about the evaluation. They should not perform physical exercises, ingest coffee, black tea or alcohol 24 hours prior to the test, and, in the morning of the evaluation day, they should be at 12-hour fasting. The individuals were in dorsal decubitus position on a stretcher in a thermo-neutral environment 23-24°C and 40-60% of relative air humidity. They should remain quiet, comfortable (avoiding movement) and not sleeping. The oxygen intake was obtained (O_2) and the carbon dioxide gas production (CO_2) continuously for 30 seconds. The 10 first minutes were discarded for the calculation in order to guarantee higher data homogeneity. The resting energy expenditure (REE) was calculated through the equation proposed by Weir[16] by open circuit indirect calorimetry through the mixing-chamber system, in a Quinton equipment (QMC).

$$\mathbf{GER = [(3.941 * O_2) + (1.106 * CO_2) - (2.17*0,0083)] * 1440}$$

Were: The O_2 (liters/minute) and exhaled carbon dioxide CO_2 (liters/minute)**.**

During the entire measurement of the REE the heart rate was monitored (HR) through Polar frequencymeter (model A1) obtaining thus the interval mean. The RQ – respiratory quotient was calculated by dividing the produced carbon oxide gas (CO_2) by the intaken oxygen (O_2)**,** in order to know the resting energy substrate.

Study's framework: The study had total duration of 20 weeks (M0-M1), divided as following: the two anterior and the two posterior weeks served for the evaluations, the weight exercises protocol (M0-M1) had the duration of 16 weeks. The evaluation of the maximal load by 1RM test was exception, once it was performed in the end of the 4 weeks of the training protocol.



Statistical analysis: T-Student test was used for data analysis in the comparison between the training (TG) and control (CG) groups, considering variables with normal distribution, and the Mann Whitney test, in the lack of normality[17]. The comparisons of the groups in the two moments of the study (M0 – initial and M1 – final) were performed from the variance analysis technique for the model of repeated measures in two independent groups[17]. The ratio between muscular mass and the resting energy expenditure (REE) was obtained through linear regression. All discussions occurred with 5% of significance level.

RESULTS

No statistically significant difference ($p > 0.05$) was found in the comparison between groups at the initial moment of the study (M0), showing thus homogeneity (table 1). The women of both groups were classified as sarcopenic, with abdominal and sarcopenic adiposity. Moreover, all of them had follicle stimulating hormone levels (FSH) higher than 40 mIU/mL, showing post-menopause state.

TABLE 1
Comparison of the physical and clinical characteristics expressed in mean and standard deviation, of the women of the training (TG) and control (CT) groups at the initial moment (MO) of the study

Variables	TG (n = 15)	CG (n = 15)
Age (years)	57.5 ± 8.5	59.9 ± 6.6
Body Mass Index BMI (kg/m²)	27.8 ± 5.1	27.2 ± 3.9
Waist circumference (cm)	91.9 ± 11.9	90.4 ± 8.7
Menopause time (years)	7.2 ± 3.8	9.1 ± 4.8
Follicle stimulating hormone – FSH (mIU/mL)	82.6 ± 31.6	117.0 ± 43.7

* Significant difference between groups when $p \leq 0.05$.

As well as in the general characteristics at the initial moment (M0) of the study, none significant difference was found in the indicators of the body composition, when the training (TG) and control (CG) groups were compared. However, during the study (M0-M1), there was significant increase ($p \leq 0.05$) for the variables: body mass (1.8 kg corresponding to 2.6%), muscular mass (2.0 kg corresponding to 10.6%) for the training group (TG), with no alterations in the body fat buildups and distribution (figure 1).

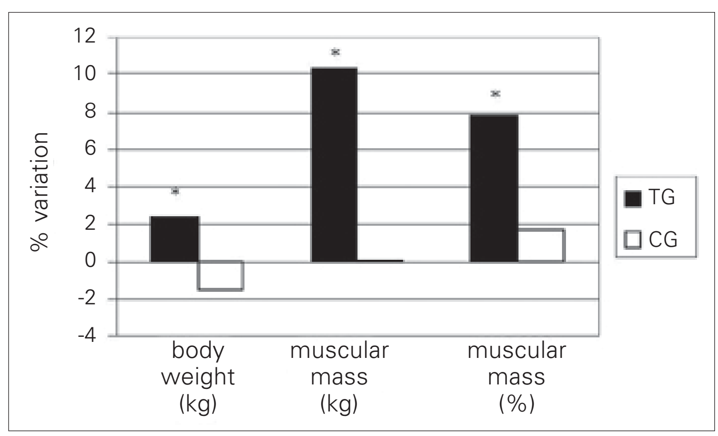


***Figure 1** – Comparison between the variation percentage of the body composition indicators of the training group (TG) and control group (CT) during the time (M0-M1)*
* significant difference between groups ($p < 0.05$)

Figure 2 shows increase of 110 kcal (8.4%) in resting energy expenditure (REE) of the training group (TG) and reduction of this component at around 70 kcal (4.9%) in the control group (CG), with significant difference ($p \leq 0.05$) in the comparison between groups during the time (M0-M1). Nevertheless, no significant difference was observed in heart rate (HR) and in the oxidation of energy substrates represented by the respiratory quotient (RQ).

The linear regression between the resting energy expenditure (REE) and the muscular mass is presented in figure 3. The association was positive and significant ($R^2 = 0.55$ and $p \leq 0.05$).

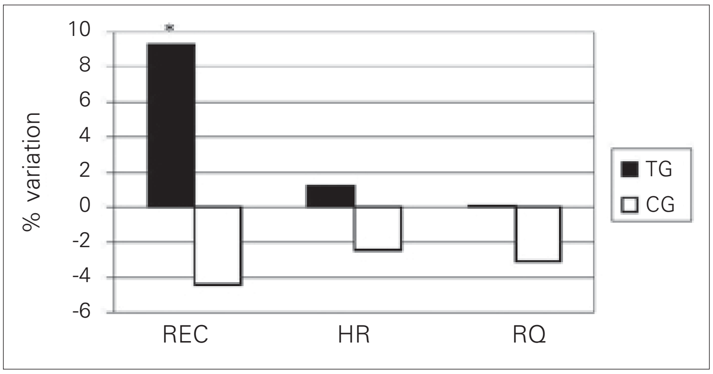


Figure 2 *– Comparison of the variation percentage of the resting energetic cost (REC), of the heart rate (HR) and respiratory quotient (RQ), between the training group (TG) and control group (CG) during the time (M0-M1)*
* significant difference between groups ($p < 0.05$)
REC (resting energetic cost – kcal/24h), HR (heart rate – bpm), RQ (respiratory quotient)

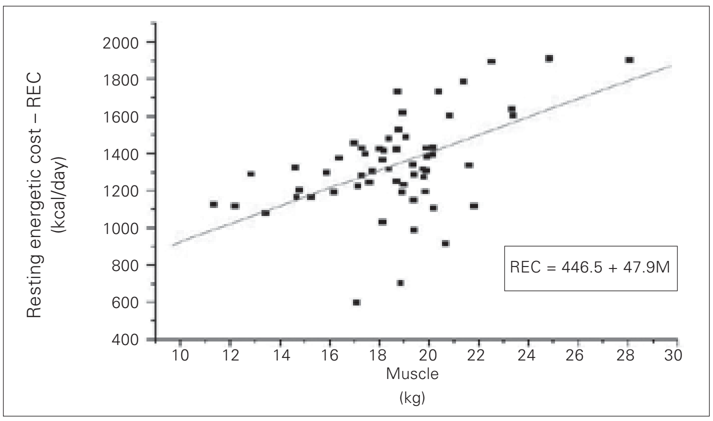


Figure 3 *– Relation between the resting energetic cost (REC) and muscular mass (muscle-kg) of post-menopause women*
Where: REC = Resting energetic cost, M = muscle, $R^2 = 0.55$, $p < 0.0001$

DISCUSSION

Muscular mass loss (senile sarcopenia) is one of the changes derived from the hormonal alterations which occur with aging[18]. Nonetheless, the mechanisms of the female sexual hormones action over the muscular mass, if existing, are still obscure[19].

The women of this study, both of the training (TG) and the control groups (CG), were considered sarcopenic at the initial moment (M0). Muscular mass percentage values were below the recommendation of 28% for women[20], presenting 27.8 ± 3.6% and 27.3 ± 2.9% of body mass in the training and control groups, respectively. However, in the group submitted to the 16 weeks of weight training, reclassification of the percentage of muscular mass was observed (for 30.0 ± 3.7% of body mass).

Weight training, among other factors, has been mentioned as having increased lean body mass and even decreased body fat[21]. Evans[22] emphasizes that the processes through which this training stimulates muscular hypertrophy are not well-established yet. Lifting weight requires that the muscle produces strength (concentric-eccentric). This muscular work has been prescribed for producing structural damage which can stimulate the muscular protein metabolism increase. This muscular damage triggers a myriad of metabolic events similar to the acute phase of the inflammatory response, which includes: activation of the complement system; mobilization of neutrophiles; increase of interleucine-1 (IL-1) flow, accumulation of muscular macrophage and increase of the muscular protein synthesis and degradation.

Weight training can be effective for adults and older subjects' health once it changes, among other components, the energy expenditure which results from the combined influence of expended energy with exercise, increase in resting energy expenditure as well as increase of metabolic demand[23]. Although the energy expenditure during the weight exercises session was not big (about 150 to 200 kcal per session)[24], during the recovery period (post-exercise), the oxygen consumption increased, generating higher energy expenditure, known as EPOC (excess post-exercise oxygen consumption)[25].

In this study, after 16 weeks of weight training an increase in the resting energy expenditure (REE) of 110 kcal/day (8.4%) was observed for the training group (TG); a value statistically higher ($p \leq 0.05$) in comparison with the control group (CG), which presented reduction of 70 kcal/day (4.9%) during the time (M0-M1).

There is evidence that the resting energy expenditure increase may be estimated by the increase of approximately 100 to 150 kcal/day in the daily energy expenditure[26]. Studies suggest an increase of 6.8 to 7.7% in the resting energy expenditure after 12 to 16 weeks of weight training in adults and older individuals[27-28]. Ballor and Poehlman[29] observed in meta-analysis that the resting energy expenditure seems to be proportional to the metabolic active tissue. It is believed that for each kilogram of lean mass an increase of around 50 kcal in the daily energy expenditure occurs, and that in sedentary individuals the muscular mass is one of the main determinants of the resting energy expenditure[30-31].

Evidence on these findings were identified in this study which shows a positive ($R^2 = 0.55$) and significant ($p \leq 0.05$) relationship between muscular mass and the resting energy expenditure (REE). However, the explanations for the increase in the total and resting energy expenditure can also be related, besides the muscular mass increase, to the exercise intensity, to the increase in the metabolic activity of the lean tissue as well as to the increase in the basal concentrations of noradrenaline[23,27].

Continuous exercise practice promotes adaptations in the metabolism of fats which enable the trained body to choose the use of this substrate as energy source, over carbohydrates[26]. Nevertheless, the extension of this effect for the resting conditions is still controversial.

Respiratory quotient values (RQ) enable the evaluation of the use of the energy substrates by the body in different situations such as in resting and exercise. In this study, the values of the RQ were similar, in average 0.82 both in the training (TG) and control groups (CG), and no significant change ($p > 0.05$) in this concern was evidenced after the 16 weeks of weight training.

In the study by Nadai *et al.*[32], aerobic training alone was not sufficient to promote changes in the body fat and muscular mass of post-menopause women. Nonetheless, when the training intensity was increased by the addition of weight exercises, a reduction in the general adiposity associated with the increase of muscular mass was seen. However, long periods of training seem to be necessary, around 25 weeks, in order to see it happening[33].

It is believed that the maintenance of muscular mass may help to avoid the decrease of the metabolic rate, keep the maintenance of the body weight as well as prevent visceral adiposity[34]. In this context, weight training seems to be effective and safe, and should be therefore, prescribed as auxiliary in physical exercise trainings which aim to control the body weight of adult and older individuals[23].

CONCLUSION

Post-menopause, sedentary women, when submitted to a 16-week weight training protocol aiming hypertrophy, showed: modifications in the indicators of the body composition related with increase of the lean mass (muscular and fat-free mass), with no modifications in adiposity; increase of the resting energy expenditure positively related with the muscular mass, with no significant alteration of the respiratory quotient (types of oxidized energy substrates). Therefore, weight training is suggested as an economical and safe choice for the improvement of these women since it reverts, or at least, attenuates organic and metabolic consequences menopause-related. It also rescues functional abilities and promotes life quality. Moreover, the control of food ingestion and longer training time may be needed in order to intensify results such as muscular mass increase and even reduction of body adiposity.

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