ESTIMATION OF THE METABOLIC EQUIVALENT (MET) OF AN EXERCISE PROTOCOL BASED ON INDIRECT CALORIMETRY

EXERCISE AND SPORTS SCIENCES

ORIGINAL ARTICLE

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ABSTRACT

Objective: This study aimed to determine the energy expenditure (EE) in terms of caloric cost and metabolic equivalents (METs) of two sessions of an exercise protocol. Methods: Fifteen subjects (51.0 ± 5.5years) performed the exercise sessions (80min), which were composed by (warming, walking and flexibility exercises; Session A) and (warming, walking and local muscular endurance exercises; Session B). Heart hate (HR) was measured during each part of the sessions. In laboratory environment, maximal oxygen consumption (VO_{2max}) and oxygen uptake in rest and exercise conditions (using mean HR obtained in classes) were measured on different days, using indirect calorimetry. Exercise METs were obtained by dividing VO_2 in exercise ($mL.kg^{-1}.min^{-1}$) by VO_2 in rest ($mL.kg^{-1}.min^{-1}$). The EE of the exercises was calculated by the formula: MET x Weight(kg) x Time(min)/60. The results were analyzed by ANOVA with Tuckey post hoc test ($p < 0.05$). Results: One MET for this group was 2.7 ± 0.1$mL.kg^{-1}.min^{-1}$. The mean METs of exercises were 4,7 ± 0,8 (warming), 5,8 ± 0,9 (walking) and 3,6 ± 0,7 (flexibility) on session A, and 4,6 ± 1,2 (warming), 5,6 ± 1,0 (walking) and 4.8 ± 1,0 (local muscular endurance exercises) on Session B. The training sessions showed similar energy cost (A: 398 ± 86.72 kcal and B: 404 ± 38.85 kcal; $p > 0,05$). None of activities were classified into vigorous intensity (> 7 METs). There were no differences on VO_2 between walking (15,6 ± 2,8 or 15,4 ± 2,6 $mL.kg^{-1}.min^{-1}$) and local muscular endurance exercises (13,2 ± 2,9 $mL.kg^{-1}.min^{-1}$), although both were higher ($p > 0.05$) than flexibility exercises (10.1 ± 2.2 $mL.kg^{-1}.min^{-1}$). Conclusion: The proposed protocol achieves the physical activity needed by healthy adults to improve and maintain health, by their structure, moderate intensity, duration, frequency and caloric expenditure.

Keywords: exercise, energy expenditure, MET.

INTRODUCTION

Regular physical activity plays an important role in the body weight control[1] and in the prevention of countless non-transmissible chronic diseases[2]. However, some variables should be assessed and manipulated in order to boost the benefits of physical activity, variables as intensity and duration of performed activities.

The accurate determination of the physical activity intensity which is also expressed in relation to the energy expenditure (EE), has become crucial in epidemiological studies[1,3-6]. The exercise intensity is usually determined by the percentage of the VO_2max or of the maximum heart rate, scale of perceived exertion and metabolic equivalent (MET)[7].

The metabolic equivalent (MET), multiple of the baseline metabolic rate, is equivalent to the energy needed by an individual to remain at rest, represented in the literature by the oxygen consumption (VO_2) of approximately 3.5 ml/kg/min[8,9]. When the energy expenditure is expressed in METs, the number of times by which the rest metabolism was multiplied during an activity is represented[8-10]. For example, cycling at four METs implies in caloric expenditure four times higher than what it is at rest[11].

The American College of Sport Medicine suggests that the MET unit is used as a method to indicate and compare the absolute intensity and energy expenditure of different physical activities. Therefore, the MET concept is applied in the general guidelines to the population concerning energy expenditure of the activities; thus, MET is a measurement of exertion intensity[12,13].

In the compendium of physical activities[9,14] translated to Portuguese [11], the different activities are classified concerning the energy expenditure and metabolic equivalent. However, until the present moment, we have not found in the literature any study which quantified these variables in a traditional physical training protocol.

Thus, this study had the aim to determine the energy expenditure in terms of caloric expenditure and metabolic equivalent of two physical exercise sessions performed in a traditional physical training protocol.

METHODS

Subjects

15 (12 women and three men) moderately trained participants of a university extension program with individual supervised physical exercises and eating counseling, conducted by the Center of Metabolism in Exercise and Nutrition (CeMENutri) of the Medicine School – UNESP – Botucatu, were selected.

The study was carried out within the standards required by the Declaration of Helsinki (1975), modified in 1983 and approved by the ethics in research committee of the Medicine School of Botucatu (# 112/protocol 209/2003).

The adult individuals (age range of 40 to 60 years) were selected. Normal menstrual cycles was a pre-requisite for inclusion in the experiment. Vegetarians, renal, digestie and metabolic diseases patients, who made use of hormones or similar medication and drugs which interfere in the normal metabolism, besides corticoids, ,HMG-CoA reductase inhibitors (beta-hydroxy-beta-methyl-glutaryl CoA) or statins, diuretics and individuals with osteoarticular problems which made exercise practice impossible, were excluded.

Physical exercise protocol

The physical exercises protocol was conducted by Physical Education professional from the Center of Metabolism in Exercise and Nutrition (CeMENutri) of the Medicine School of UNESP in Botucatu. It included aerobic, local muscular resistance and flexibility exercises, in five weekly sessions with duration of 80 min/session, where session A was performed on Mondays, Wednesdays and Fridays and session B on Tuesdays and Thursdays.

Session A was composed of 20 minutes of warm-up, 40 minutes of walking and 20 minutes of flexibility exercises. Session B was composed of 20 minutes of warm-up, 30 minutes of walking and 30 minutes of local muscular resistance exercises. The target zone for walking was set between 70 and 80% of maximum heart rate (220 – age). The local muscular resistance activities (Session B) consisted of two sets of 10-15 repetitions, where load was progressively adjusted according to the group's adaptation. Nine exercises for muscle groups were performed, namely: chest, latissimus dorsi muscle, shoulder, biceps, triceps, quadriceps, thigh posterior, abductors and abdominals.

The exercises proposed for flexibility and balance should be performed for at least 30 seconds for the main joints: neck, elbow, shoulder, wrist, hip, knee and ankle.

During the articular warm-up, recreational and/or stretching activities were performed.

Anthropometric evaluation

Body weight and height were measured according to the procedures described by Heyward and Stolarczyk[15]. Body weight and height were evaluated with the use of an anthropometric scale (Filizola, Brazil) with precision of 0.1 kg for weight and 0.1 cm for height. The body mass index (BMI) was calculated from the weight and height measures through the body weight quotient (kg)/height^2 (m).

In order to estimate the fat-free mass (FFM) and fat percentage values, the bioelectric impedance test (Byodinamics) was used according to the procedures described by Lukaski *et al.*[16]. The formula used for the fat-free mass calculation was proposed by Gray *et al.*[17].

The nutritional diagnosis was performed using the classification proposed by the World Health Organization (2002) and the Latin American Consensus in Obesity (1998).

Metabolic rate, heart rate and metabolic equivalent at rest (MET)

The individuals remained at dorsal decubitus on the stretcher for tem minutes for the test performance. After that period, the evaluation was performed for 30 consecutive minutes. The individuals were at 12-hour fast and without physical exercises in the 24 hours preceding the evaluation. Room temperature and relative humidity were kept between 21 and 23°C and 40 and 60%, respectively, in all the tests performed.

In order to determine the metabolic rate at rest (MRR) and the metabolic equivalent at rest (MET), the oxygen consumption volume (VO_2) and the produced carbonic gas volume (VCO_2) were continuously measured in an one-circuit ergospirometric system (QMC™ 90 model Metabolic Cart, Quinton®, Bothell, USA) using indirect calorimetry. Energy expenditure at rest was calculated with the formula proposed by DeWeir mentioned by Branson[18]:

$$\mathbf{MRR = (3.9 \times VO_2(L/min)) + (1.1 \times VCO_2(L/min)) \times 1.440}$$

The mean of the oxygen consumption at rest (VO_2 rest) during the 30 minutes of the test was calculated. This value was considered the metabolic equivalent art rest (MET). The heart rate at rest was measured in a heart rate monitor (Polar® Edge NV) during the 30 minutes of the test. The mean value of all the measurements was calculated.

Evaluation of maximum aerobic power (VO_{2max}) and maximum MET

Maximum aerobic power (VO_{2max}) was evaluated in the ergospirometry on treadmill (inclination of 1%), with initial velocity of 4.5 km/h and increase of 0.5 km at each minute until voluntary exhaustion or when one of the following criteria was reached: increase in the VO_2 lower than 2 $ml.kg^{-1}.min^{-1}$ for the increase in the exercise intensity (plateau); expiratory exchange ratio higher than 1,1; maximum heart rate expected for the age was reached, calculated by the formula (220 – age). Prior to the beginning of the test, the individuals performed three minutes of warm-up at the 3.1 km/h velocity. Heart rate (HR) was monitored in the electrocardiogram. The respiratory parameters were measured in an open-circuit ergospirometric system using the Mix-Chamber Technique. MET was determined at the end of the test (MET maximum) by the ratio:

$$\mathbf{MET\ maximum = VO_{2max}\ (ml.kg^{-1}.min^{-1})/VO_2\ rest\ (ml.kg^{-1}.min^{-1})}$$

Cardiorespiratory fitness of the individuals was determined using the classification proposed by the American Heart Association mentioned by Marins and Gianichi[19].

Calculation of the metabolic equivalent (MET) and calorie expenditure of the exercises

HR measurements during training sessions A and B were monitored through the heart rate monitor (Polar® Edge NV) and recorded. It was possible to determine the mean HR of each part of the training sessions (warm-up, walking, LMR and flexibility/balance) with these data. They were later sent to the ergospirometry laboratory. At the laboratory, the individuals performed 30 continuous minutes of walk on treadmill at the same mean frequency reached during the parts of the exercise sessions, to precisely determine in the ergospirometry the oxygen consumption in each part of the sessions.

The evaluation of the intensity (MET and % of VO_{2max}) and the energy expenditure (kcal) was performed in each part of the class.

In order to calculate the MET value in each part of the class, the following formula was used:

$$\mathbf{MET\ exercise = VO_2\ in\ the\ HR\ of\ the\ class\ (ml.kg^{-1}.min^{-1})/\ VO_2\ rest\ (ml.kg^{-1}.min^{-1})}$$

Concerning intensity, according to the model proposed by Pate *et al.*[18] the METs are classified in: < 3 METs – light activity; 3 to 6 METs – moderate activity; > 6 METs – vigorous activity.

Caloric expenditure of the exercises which compose each part of sessions A and B was calculated with the formula:

kcal = (MET of activity x body weight(kg)/60) x Time of the activity (min)

DATA ANALYSIS

Data were expressed in mean and standard deviation (± SD). The comparison between exercises in each part of the class was done with one-way ANOVA with Tukey post hoc. The significance level accepted was $p < 0.05$. The statistical treatment was performed by the BioEstat 5.0 software (Brazil).

RESULTS

The data expressed on table 1 reveal that mean and women are classified as overweighed and obese, according to BMI and fat percentage data, respectively. ,

Table 2 evidences that the mean values of oxygen relative consumption ($ml.kg^{-1}.min^{-1}$) classified the individuals of both sexes within good status concerning the expectation for the age. The VO_2 at rest equivalent to 1 MET (2.7 $ml.kg^{-1}.min^{-1}$ for men and women) was lower than the one described in the literature (3.5 $ml.kg^{-1}.min^{-1}$). In the test of aerobic power, men and women increased the oxygen consumption 8.7 and 10.3 times compared to at rest (MET_{max}).

Table 3 presents the values of metabolic and equivalent and total energy expenditure of the sessions and of the exercises which compose the different parts of the class. There was no significant difference in the total of energy spent between sessions A (398 kcal) and B (404 kcal). The oxygen consumption (15.6 ± 2.8 $ml.kg^{-1}.min^{-1}$) of the walking and local muscular resistance exercises was not different from each other. However, both were statistically higher than the ones obtained in the warm-up and flexibility/balance exercises ($p < 0.05$).

Table 1. Age mean and standard deviation and anthropometric data of the participants according to sex.

	Women (n = 12) (Mean ± SD)	Men (n = 3) (Mean ± SD)
Age (years)	44.0 ± 3.3	51.0 ± 5.5
Height (m)	1.6 ± 0.06	1.8 ± 0.04
Weight (kg)	72.8 ± 13.7	95.0 ± 3.1
BMI (kg/m2)	28.3 ± 4.6	28.8 ± 1.1
Abdominal circ. (cm)	94.1 ± 10.2	103.8 ± 3.5
Fat (%)	40.2 ± 4.4	28.1 ± 4.8

BMI – body mass index; Abdominal circ. – abdominal circumference.

Table 2. Metabolic, respiratory and energy expenditure variables mean and standard deviation of the participants according to sex.

Metabolic variables	Women (n = 12) (Mean ± SD)	Men (n = 3) (Mean ± SD)
VO_{2max} ($l.min^{-1}$)	2.3 ± 0.2	3.9 ± 0.5
VO_{2max} ($ml.kg^{-1}.min^{-1}$)	33.4 ± 4.7	41.2 ± 4.8
VO_2Rest ($l.min^{-1}$)	0.2 ± 0.03	0.2 ± 0.02
VO_2Rest ($ml.kg^{-1}.min^{-1}$)	2.7 ± 0.2	2.7 ± 0.1
HR maximum (bpm)	173.8 ± 9.3	178.3 ± 5.5
HR rest (bpm)	68.1 ± 7.6	59.9 ± 12.9
MRR(kcal/day)	1.401.5 ± 214.7	1.893.0 ± 184.1
MET Max	8.75 ± 1.6	10.3 ± 1.5
kcal/min	0.9 ± 0.1	1.31 ± 0.1

HR – heart rate; bpm – beats/minute; MRR – metabolic rate at rest; MET max – maximum metabolic equivalent; kcal/min – kilocalories per minute.

Table 3. Oxygen consumption, metabolic equivalent (MET) and energy expenditure mean and standard deviation of the different parts of the classes and respective statistical tests.

Session A				
Segment	**Time (min)**	**VO_2 ($ml.kg^1.min^1$)**	**METs**	**kcal/min**
Warm-up	20	12.9 ± 2.7[b]	4.7 ± 0.8	94
Walking	40	15.6 ± 2.8[a]	5.8 ± 0.9	232
Flexibility/Balance	20	10.1 ± 2.2[b]	3.6 ± 0.7	72
Total	80	-	-	398 ± 86.72
Session B				
Segment	**Time (min)**	**VO_2 ($ml.kg^1.min^1$)**	**METs**	**kcal/min**
Warm-up	20	12.5 ± 3.2[b]	4.6 ± 1.2	92
LMR	30	13.2 ± 2.9[a]	4.8 ± 1.0	144
Walking	30	15.4 ± 2.6[a]	5.6 ± 1.0	168
Total	80	-	-	404 ± 38.85

LMR – local muscular resistance; a ≠ b ($p < 0.05$).

DISCUSSION

In the present study, similarly to others performed with indirect calorimetry[1,19] the metabolic equivalent at rest value was lower than the one which is used as reference in the literature (3.5 $ml/kg^{-1}/min^{-1}$)[10]. These data corroborate the study performed by Fardy and Hellerstein[20], where the use of indirect calorimetry has demonstrated that the conventional 1MET value overestimates the energy expenditure and the real oxygen consumption at rest.

Concerning the maximum exercise intensity (MET maximum), Fletcher *et al.*[21] and the ACSM[13] determined some reference values for this variable, which is different according to sex and age of the subjects (nine to 11 METs for men and eight to nine for women in the age range from 40 to 69 years). The data obtained by our subjects were within these normal zones, namely, from 10.3 and 8.75 for men and women, respectively, which also corroborates another study [22] similar to ours.

In the present study, for each type of exercise which was part of the sessions, individual analysis of the MET and caloric expenditure values was performed, which were classified as moderate, obtaining values range between 3.6 and 5.8 METs.

Almeida *et al.*[23], in their study with mail carriers, found values of 4.0 METs during walk to deliver the mail (moderate activity) and values of 2.5 METs for the triage activity (light activity). The research with adult men practitioners of yoga, the MET values ranged from 1.3 to 2.1 METs, according to the given position characteristics of the activity[24].

Farinatti[11]in their study, which had the aim to design a complete version of the Compendium of Physical Activities, based on the values present in the compendia designed by Ainsworth *et al.*[9] and Ainsworth *et al.*[14], determines that for conditioning activities such as general circuit or exercises in health fitness clubs and/other health centers, approximately 8.0 and 5.5 METs are spent, respectively, values close to the ones found by us during the LMR activity (4.8 METs). The same author proposes values of 2.5 METs for light stretching activities and of 3.3 for walk on flat surface (moderate walk) to 5.0 METs (very fast walk), values which are also very similar to the ones obtained by us in the present study, in both variables.

According to Fletcher *et al.*[21], the physical activity intensity necessary to improve conditioning varies among the individuals. However, the exercise intensity and duration ratio suggests that exercise of lower intensity requires more time to increase functional capacity, but with lower probability of complications concerning the exercise of higher intensity.

Thus, the classification of the physical activities intensity and the estimation of the caloric expenditure aassociated to it are important aspects of the exercise prescription and the exercise physiology, due to the need to adequate the activities proposed to the performance ability of the practitioner. Therefore, our training protocol prioritized the performance of exercises of moderate intensity, with low risk of injury onset or possible collateral cardiovascular effects, in a trial to minimize the risks and maximize benefits.

Concerning the training sessions of the present study, they were standardized about the total duration time (80 minutes) and aimed at improving the health-related physical fitness components (cardiorespiratory, flexibility and muscular resistance) and promoting increase of daily energy expenditure. Thus, the training proposed and applied in the Tuesday and Thursday sessions (Session B) obtained caloric expenditure of 404 ± 38.9 kcal, while caloric expenditure of session A was of 398 ± 86.7 kcal, that is, the difference between them was of only 6 kcal.

Although the population recommendations for adults[7,13] and older subjects[25] recommend 30 minutes of daily physical activities, five days per week (total of 150 min/week) for reduction of cardiovascular diseases and cancer, the recommendations for obesity control support the use of longer durations (200 to 300 weekly minutes) and energy expenditure with physical activity of about 2,000 kcal/week for individuals with free diet[26].

Therefore, the protocol of the present study would meet the expenditure for maintenance and/or prevention of non-transmissible chronic diseases and obesity control, since it presents caloric expenditure of approximately 400 kcal/session, which would come to an end of 2,000 kcal/week if performed in the frequency it is offered, that is, 5x/week.

The energy expenditure during the activity could determine higher or lower alteration in the body fat supplies. Therefore, the manipulation of the type of exercise would be necessary. However, there is considerable controversy concerning the impact of the many types of physical training on the energy expenditure and, consequently, on the body composition of the practitioners.

Thus, when resistance and aerobic resistance exercises are compared, some studies[1,22,27] evidence that both were efficient in promoting benefits to body composition and VO_{2max}.

Another factor which corroborates for the indefinition on which activity is the most effective in caloric expenditure and fat loss is the EPOC effect (excess post-exercise oxygen consumption) provided by the physical activities[28]. Probably, resistance exercises of high intensity could require more energy expenditure during and/or immediately after exercise[29,30].

Nonetheless, in the present study, the LMR training was not different from walking concerning the oxygen consumption during exertion, and the metabolic equivalent values (MET) of both classified them as activities of moderate intensity. The LMR energy expenditure in the present study (144 kcal/30 minutes) was slightly lower than in the walk (168 kcal/30 minutes).

The protocol of the present study would hence meet the expenditure for maintenance and/or prevention of non-transmissible chronic diseases, since it is performed with weekly frequency of five times and it has its structure based on and aimed at the improvement of the health-related physical fitness components and caloric expenditure above the minimum recommendation for prevention of these diseases.

As a summary, our study reveals that the two exercise sessions applied could promote expressive increase in daily energy expenditure, but it is worth mentioning that the association of resisted, aerobic and flexibility exercises is essential in the promotion and/or maintenance of physical fitness, as well as for prevention and rehabilitation of cardiovascular diseases in adults of all ages[2].

Limitations were found when we tried to compare our data with the ones in other studies, since great part of the research available considers in their evaluations only the total daily energy expenditure. No study which analyzed the metabolic equivalent of an exercise protocol, the way ours did, was found.

Moreover, these studies are based on pre-existing data from physical activity compendia to estimate the energy expenditure or exercise intensity, that is, the existing individual differences between sexes and perceived exertion, in some cases, may be big, which represents a difficulty in establishing comparison between values.

CONCLUSION

Thus, the protocol performed in this study meets the recommendations for health due to its intensity of 3 to 6 METs (moderate exercises) structure, time longer than sixty minutes, frequency (5x/week) and caloric expenditure of 1,200 to 2,000 kcal/week, meeting the minimum demands of energy expenditure recommended by the WHO, AHA and ACSM.

All authors have declared there is not any potential conflict of interests concerning this article.

REFERENCES

1. Poelhman ET, Denino WF, Beckett T, Kinaman KA, Dionne IJ, Dvorak R, et al. Effects of endurance and resistance training on total daily energy expenditure in young women: a controlled randomized trial. J Clin Endocrinol Metab 2002;87:1004-9.
2. Ciolac EG, Guimarães GV. Exercício físico e síndrome metabólica. Rev Bras Med Esporte 2004;10:319-24.
3. Varo JJ, Martinez-Gonzáles MA, Irala-Estevez J, Kearney J, Gibney M. Distribution and determinants of sedentary lifestyles in the european union. Int J Epidemiol 2003;32:138-46.
4. Fernandes FS. Fatores precoces e tardios determinantes de sedentarismo em adultos jovens [Dissertação]. Porto Alegre: Faculdade de Medicina, Universidade Federal do Rio Grande do Sul, Porto Alegre; 2009.
5. Jakicic JM. The Role of physical activity in prevention and treatment of body weight gain in adults. Symposium: adult weight gain: causes and implications. J Nutr 2002;132:3826S-9S.
6. Rising R, Harper IT, Fontvielle AM, Ferraro RT, Spraul M, Ravussin E. Determinants of total daily energy expenditure: variability in physical activity. Am J Clin Nutr 1994;59:800-4.
7. Haskell WL, Lee IM, Pate RR, Powell KE, Blair SN, Fanklin BA, et al. Physical activity and public health: updated recommedation for adults from the American College of Exercise. Med Sci Sports Exerc 2007;39:1423-34.
8. McArdle WD, Katch FL, Katch VL. Fisiologia do Exercício, energia, nutrição e desempenho humano. 4ª ed. Rio de Janeiro: Guanabara Koogan, 1998.
9. Ainsworth BE, Haskell WL, Whitt MC, Irwin ML, Swartz AM, Strath SJ, et al. Compendium of physical activities: an update of activity codes and MET intensites. Med Sci Sports Exerc 2000;32:S498-516.
10. Montoye HJ, Kemper HCG, Saris WHM, Washburn RA. Measuring physical activity and energy expenditure. Champaign: Human Kinetics, 1996.
11. Farinatti PTV. Apresentação de uma versão em português do compêndio de atividades físicas: uma contribuição aos pesquisadores e profissionais em fisiologia do exercício. Rev Bras Fisiol Exerc 2003;2:177-208.
12. Porto LGG, Junqueira JR LF. Atividade física e saúde: evolução dos conhecimentos, conceitos e recomendações para o clínico. Bras Med 2008;45:107-15.
13. Pollock ML, Gaesser GA, Butcher JD, Després JP, Dishman RK, Franklin BA, et al. American College of Sports Medicine. Position stand: the recommended quantity and quality of exercise for developing and maintaining fitness in healthy adults. Med Sci Sports Exerc 1998;30:975-91.
14. Ainsworth BE, Haskell WL, Leon AS, Jacobs Jr DR, Montoye HJ, Sallis JF, et al. Compendium of physical activities: classification of energy costs of human physical activities. Med Sci Sports Exerc 1993;25:71-80.
15. Heyward VH, Stolarczyk LM. Avaliação da composição corporal aplicada. Barueri: Manole, 2000.
16. Lukaski HC, Johnson PE, Bolonchuck WW, Lykken GI. Assessment of fat free mass using bio-electrical impedance measurements of the human body. Am J Clin Nutr 1985;41:810-7.
17. Gray DS, Bray GA, Gemayel N, Kaplan K. Effect of obesity on bioeletrical impedance. Am J Clin Nutr 1989;50:255-60.
18. Brandson RD. The measurement of energy expenditure: instrumental, pratical considerations and clinical application. Resp Care 1990;35:640-59.
19. Marins JC, Giannichi RS. Avaliação e prescrição de atividade física. Rio de Janeiro: Editora Shape, 1998.
20. Fardy, PS, Hellerstein HK. Comparison of continuous and intermittent multistage exercise tests. Med Sci Sports 1978;10:7.
21. Fletcher GF, Balady GJ, Amsterdam EA, Chaitman B, Eckel R, Fleg J, et al. Exercise standards for testing and training a statement for healthcare profissionals from the American Heart Association. Circulation 2001;104:1694-740.
22. Fett CA, Fett WCR, Marchini JS. Exercício resistido vs jogging em fatores de risco metabólicos de mulheres com sobrepeso/obesas. Arq Bras Cardio 2009;93:519-25.
23. Almeida ED, Xavier GNA, Carminatti LJ, Giustina MCD. Gasto calórico nas atividade de trabalho e cotidianas, dos carteiros que utilizam bicicleta. Rev Bras Cine Des Hum 2004;6:53-61.
24. Ray US, Pathak A, Tomer OS. Hatha yoga practices: energy expenditure, respiratory changes and intensity of exercise. eCAM 2010;2011:1-12.
25. Nelson ME, Rejeski JW, Blair SN, Duncan PW, Judge JO, King AC, et al. Physical activity and public health in older adults: recommendation from the American College of Sports Medicine and the American Heart Association. Med Sci Sports Exerc 2007;39:1435-45.
26. Fogelholm M. Walking for the management of obesity. Dis Manage Health Outcomes 2005;13:9-18.
27. Gettman LR, Ayres JJ, Pollock ML, Durstine JL, Grantham W. Physiologic effect on adult men of circuit strength and jogging. Arch Phys Med Rehabil 1979;60:115-20.
28. Gaesser GA, Brooks GA. Metabolic bases of excess post-exercise oxygen consumption: a review. Med Sci Sports Exerc 1984;16:29-43.
29. Haltom RW, Kraemer RR, Sloan RA, Hebert EP, Frank K, Tryniecki JL. Circuit weighttraining and its effects on excess post exercise oxygen consumption. Med Sci Sports Exerc 1999;31:1613-8.
30. Thorton MK, Potteiger JA. Effects of resistance exercise bouts of different intensities but equal work on EPOC. Med Sci Sports Exerc 2002;34:715-22.