Decrease in Blood Pressure, Body Mass Index and Glycemia after Aerobic Training in Elderly Women with Type 2 Diabetes

Luciana Zaranza Monteiro[1], Cássio Ricardo Vaz Fiani[1], Maria Cristina Foss de Freitas[1], Maria Lúcia Zanetti[2], Milton César Foss[1]

Departamento de Clínica Médica - Divisão de Endocrinologia e Metabologia - Faculdade de Medicina de Ribeirão Preto, Universidade de São Paulo - USP[1]; Escola de Enfermagem de Ribeirão Preto, Universidade de São Paulo - USP[2], São Paulo, SP - Brazil

Abstract

Background: The aging process is associated with the development of several diseases, which can be attenuated by the practice of physical activities. Aerobic training is an effective method to maintain and improve cardiovascular function. Additionally, it has a crucial role in the prevention and treatment of several chronic-degenerative diseases, especially diabetes mellitus.

Objective: To verify the effect of a 13-week aerobic training program on blood pressure (BP), body mass index (BMI) and glycemia levels in elderly women with type-2 diabetes mellitus (DM2).

Methods: Eleven sedentary elderly women with DM2, aged 61.0 ± 9.1 years, were submitted a 13-week aerobic training program, constituting group G2. Eleven controlled elderly women (aged 60.2 ± 6.8 years) were not submitted to the aerobic training, constituting the control group (G1). G1 attended educational lectures once a week, whereas G2 walked three times a week.

Results: Both groups presented a significant decrease in glycemia and diastolic blood pressure levels. No significant decreases in BMI were observed after the aerobic training in either group.

Conclusion: The 13-week aerobic training program was enough to promote significant decrease in the diastolic blood pressure and glycemia levels; therefore, this type of exercise training decreases the risk factors for cardiovascular and metabolic diseases. (Arq Bras Cardiol 2010; 95(5): 563-570)

Keywords: Hypertension/prevention and control; exercise; physical exercise; body mass index; aged; diabetes mellitus.

Introduction

Arterial hypertension (AH) and diabetes mellitus (DM) are two important public health problems in Brazil and due to their high prevalence, as well as acute and chronic complications, give origin to risk factors associated with cardiovascular diseases[1-3].

The aging process results in a tendency toward the decrease in functional autonomy, due to a reduction in muscle mass and strength, as well as in the cardiorespiratory capacity. The adequate prescription of physical activity seems to be able to ensure the maintenance of these qualities, prolonging functional independence and improving the quality of life of elderly patients[4]. A sedentary lifestyle is more common among elderly individuals than in any other age range, which can contribute to the loss of functional independence at advanced ages[5].

Mailing address: Luciana Zaranza Monteiro •
Av. Bandeirantes, 3900 - 14049-900 - Monte Alegre - Ribeirão Preto, SP - Brazil
E-mail: lucianazaranza@usp.br
Manuscript received October 26, 2009; revised manuscript received April 28, 2010; accepted May 25, 2010.

Although physical exercises (PE) constitute an important factor to decrease the cardiovascular and all-cause morbimortality rates[6], there seems to be also additional and independent benefits of the regular practice of PE and the improvement in the aerobic condition[7], which emphasizes the importance of its increasingly more frequent practice.

One of the effects of PE practice is the decrease in the post-training blood pressure (BP) levels in comparison to the pre-training BP levels, with this decrease being more accentuated in hypertensive individuals, when compared to normotensive ones[8,9]. Although there is abundant evidence demonstrating the beneficial effect of PE on AH, mainly aerobic exercises (AE), both acute[10] and chronic[9,11-14], and, at a lower proportion, of resistance exercises, studies carried out in elderly individuals are relatively scarce.

Aerobic training is considered an effective means to maintain and improve cardiovascular function and, therefore, the physical fitness[15]. Moreover, it has a fundamental role in the prevention and treatment of several chronic-degenerative diseases, especially diabetes mellitus, thus contributing to increase life expectancy and maintain functional independence[16].

Therefore, it is crucial to carry out studies to analyze the effects of aerobic training on elderly women with DM. Thus, the objective of the present study was to verify the effect of a 13-week aerobic training program on BP, body mass index (BMI) and glycemia levels on elderly women with type 2 DM.

Methods

The study was carried out between August and November 2004 and the data were collected on Mondays, Wednesdays and Fridays at the Sports Gymnasium of the Physical Education Sports and Recreation Center - CEFER of Universidade de São Paulo de Ribeirão Preto (USP-RP). Before the training, all the volunteers signed the Free and Informed Consent Form, which contained all the information on the procedures to be developed during the study. The study was approved by the Ethics Committee of the School of Nursing of Ribeirão Preto of *Universidade de São Paulo-USP*.

The sample was randomly selected and consisted of 22 elderly women followed at the Educational Center for Patients with Type 2 DM (DM2) of *Universidade de São Paulo* de Ribeirão Preto. Patients were aged > 60 years, had DM2, did not regularly practice physical exercises and presented capillary glycemia < 240 mg/dl, and were divided in two groups:

G1 (control group) - comprised 11 elderly women who attended educational lectures once a week, which lasted two hours per session, totaling 13 weeks; and

G2 (aerobic group) - experimental group comprising 11 elderly women submitted to the aerobic training program, three times a week, for 13 weeks; those with an attendance rate ≥ 5 sessions were selected.

As all patients belonged to the Nursing Educational Center for Patients with DM2, they followed the routine established by the Center, i.e., activities for all patients were interrupted during the month of December due to the holiday season. Thus, the study was carried out in 13 weeks, up to November 2004.

Inclusion criteria

Elderly female patients with DM2 that agreed to participate in the study and who, after clinical assessment, were considered eligible for the training by the assistant physician were included in the study. The clinical assessment consisted of the evaluation of the cardiovascular, metabolic and osteoarticular status. This evaluation determined whether the participants were eligible for the safe practice of physical activities.

The diagnosis of DM2 was established through clinical-laboratory criteria, according to the ones recommended by the Brazilian Society of Diabetes[2], which were obtained through the review of the patients' medical files.

Exclusion criteria

The exclusion criteria included the patient's refusal to participate, those with severe heart diseases, decompensated coronary and heart diseases, limiting peripheral neuropathies, osteoarticular lesions, extremity ulcers, severe dermatological lesions and proliferative retinopathy.

To define these criteria, we used data from the anamnesis, physical examination and complementary routine assessment of the Center.

Used medications

Of the 22 elderly women, 12 used anti-hypertensive drugs - 5 mg + antidiuretics - 1.5 mg (07 from G1 and 05 from G2) and 17 used oral hypoglycemiant drugs - 500 mg (09 from G1 and 08 from G2). The use of medication was not modified during the study period.

Measurement of blood pressure, BMI and glycemia

a) Blood pressure (BP)

The measurement of BP values was carried out by the indirect method, using cuffs with rubber bulbs, of which width was compatible with the brachial circumference of the participant (8, 12 and 15 cm wide), using a Dixtal 1710 oscillometric equipment, in the automatic operation mode, according to the IV Brazilian Guidelines on Arterial Hypertension.

The examiners placed individuals so that they were in a state of absolute rest for a period of 3 to 5 minutes, sitting on a chair with back support, relaxed legs, parallel feet and relaxed arms. Before measuring the BP, the examiner determined the maximum BP to be attributed to the sphygmomanometer, with the help of the second and third fingers positioned on the radial artery. The examiner then inflated the sphygmomanometer cuff until the pressure at which the individual's pulse disappeared was identified.

The BP measurement was carried out with the sphygmomanometer placed on the right arm (the measurement was carried out in the left arm in patients submitted to catheterism) and the stethoscope placed on the brachial artery. When the patient presented bulky arm mass, the sphygmomanometer was placed on the forearm and the stethoscope was placed on the radial artery.

b) BMI

Weight (kg) was measured once using a portable Filizola digital scale with a maximum capacity of 150 kg and accurate to 0.1 kg. Height (cm) was measured once using an inextensible measuring tape. Body mass index (BMI) was determined as body weight (kg)/height (m)^2. The BMI is used by the World Health Organization (WHO) to classify the nutritional status of adult and elderly individuals[17]. The WHO[17] considers as normal a BMI up to 25 kg/m^2 and overweight a BMI > 25 kg/m^2.

c) Capillary glycemia

Capillary glycemia was assessed using a portable blood glucose meter (One Touch Ultra™, Johnson & Johnson). The participant sat on a chair and the skin of the finger used for the capillary glycemia measurement (lateral portion of the distal phalanx of the middle finger) was swabbed with a cotton swab embedded in alcohol at 70.0%. The examiner used a disposable lancet to puncture the finger and a drop of

blood was placed on the reagent strip inserted in the blood glucose meter.

Although extremely important, the glycated hemoglobin test was not carried out, as some patients were not enrolled at *Hospital das Clínicas de RP*.

Procedures

The protocol applied to G1 consisted of educational lectures attended once a week, which lasted two hours each, totaling 13 weeks. The lectures included the following subjects: healthy diet, arterial hypertension, chronic complications of diabetes, physical exercises and correct medication use. These educational lectures were given by the multiprofessional team (physical education professional, nurses, nutritionists and psychologists) of the Nursing Educational Center for Patients with DM2.

The protocol applied to G2 consisted firstly in measuring the maximum oxygen consumption (VO_{2max}), determined in an ergometric treadmill model ATL 10200 (Inbramed) and walking three times a week at an intensity determined as 60, 70 and 80.0% of the maximum heart rate (HR_{max}). The patients walked for 50 minutes at the CEFER and the heart rate was verified every two minutes. Initial and final BP and capillary glycemia were measured at each session. The VO_{2max} test was carried out on the first and the last day of the training program. VO_{2max} was measured using a Vista CPX system, Vacumed, 1996. This system allowed the measurement of O_2 and CO_2 of the expired air at every 30 seconds, using a mixing and analysis chamber, Oxygen Analyzer OM-11 and Carbon Dioxide analyzer LB-2 respectively and determining the expired-air volume using a fluxometer, Flow Transducer K-520.

G2 did not participate in the educational activities, although it was important for the elderly women. The fact that lived far from the Center and needed public transportation to get there was taken into account when deciding that this group would not be submitted to both procedures (aerobic training + educational lectures).

Statistical analysis

The statistical analysis was carried out using the Student's *t* test and ANOVA. Analysis of variance (ANOVA) for repeated measures and post-hoc Tukey's test were used to verify the difference between the groups. Values are expressed as means ± standard deviations. SAS software release 9.0 was used for all statistical analyses and the level of significance was set at $p < 0.05$.

Results

Tables 1 and 2 show the characteristics of G1 and G2. The sample consisted of 11 sedentary elderly women with DM2, whose mean age was 61.0 ± 9.1 years, weight was 73.1 ± 10.6 kg and height was 1.7 ± 0.1 m, who comprised the aerobic group (G2); and 11 elderly women, whose mean age was 60.2 ± 6.8 years, weight was 74.9 ± 18.3 kg and height was 1.6 ± 0.1 m, who comprised the control group (G1).

Regarding the VO_{2max} of the elderly women in G2, we observed a significant difference ($p<0.01$) between the first (34.9 ± 8.9 ml.kg.min.$^{-1}$) and the last day of aerobic training (35.9 ± 9.2 ml.kg.min.$^{-1}$).

Chart 1 shows that there was no statistical difference between the basal and final BMI in G1 ($p = 0.68$) and G2 ($p = 0.65$). Chart 2 shows that there was a significant difference in G1 ($p < 0.01$) and G2 ($p < 0.01$) regarding the glycemia levels after the 13-week aerobic training program and educational lectures. These differences were significant between the basal and final glycemia levels in G1 and G2. Although G1 was not submitted to the aerobic training, we believe that the educational interventions were of utmost importance for the participants to improve glycemic control.

Table 1 - Characteristics of the Control Group (G1)

Patient	Age (years)	Basal SBP (mmHg)	Final SBP (mmHg)	Basal DBP (mmHg)	Final DBP (mmHg)	Basal BMI (kg/m²)	Final BMI (kg/m²)	Basal glucose (mg/dl)	Final glucose (mg/dl)
1	60	158	158	91	81	32	30.6	188	92
2	60	112	110	83	81	31	30.5	142	89
3	61	109	100	73	71	22.1	21.9	269	155
4	60	140	113	80	65	36.4	32.6	121	117
5	60	150	119	71	71	19.9	19.9	146	95
6	60	161	161	90	79	32	31.6	120	83
7	61	140	100	79	59	29.5	28.6	92	89
8	60	133	133	71	71	18	17.9	309	116
9	60	141	141	56	50	22.5	21.5	217	149
10	60	170	170	89	72	37.6	36	235	91
11	60	124	104	70	60	27.7	27.4	89	82
Mean	60.2	139.8	128.1	77.5	69.1	28.1	27.1	175.3	105.3
SD	0.40	19.53	25.92	10.64	9.83	6.61	5.92	73.81	25.87

DBP - diastolic blood pressure; SBP - systolic blood pressure.

Table 2 - Characteristics of the Aerobic Group (G2)

Patient	Age (years)	Basal SBP (mmHg)	Final SBP (mmHg)	Basal DBP (mmHg)	Final DBP (mmHg)	Basal BMI (kg/m²)	Final BMI (kg/m²)	Basal glucose (mg/dl)	Final glucose (mg/dl)
1	61	121	109	68	52	28.3	27.2	110	75
2	61	155	162	72	50	21.1	20.6	132	70
3	61	136	133	76	58	25.7	25.6	136	75
4	60	135	121	77	50	26.4	25.6	85	73
5	60	168	156	110	59	27	26	92	90
6	61	150	116	62	57	25	21.8	170	97
7	61	125	110	78	52	33.5	32	180	108
8	64	151	111	58	52	29.3	29	241	90
9	62	131	110	68	53	24.2	24.2	92	92
10	60	129	111	76	55	26.6	24.5	112	62
11	60	139	130	84	60	35	33	220	74
Mean	61.0	140.0	124.5	75.4	54.4	27.5	26.3	142.7	82.4
SD	1.18	14.35	19	13.73	3.61	4	3.83	53.31	13.84

BMI - body mass index; DBP - diastolic blood pressure; SBP - systolic blood pressure.

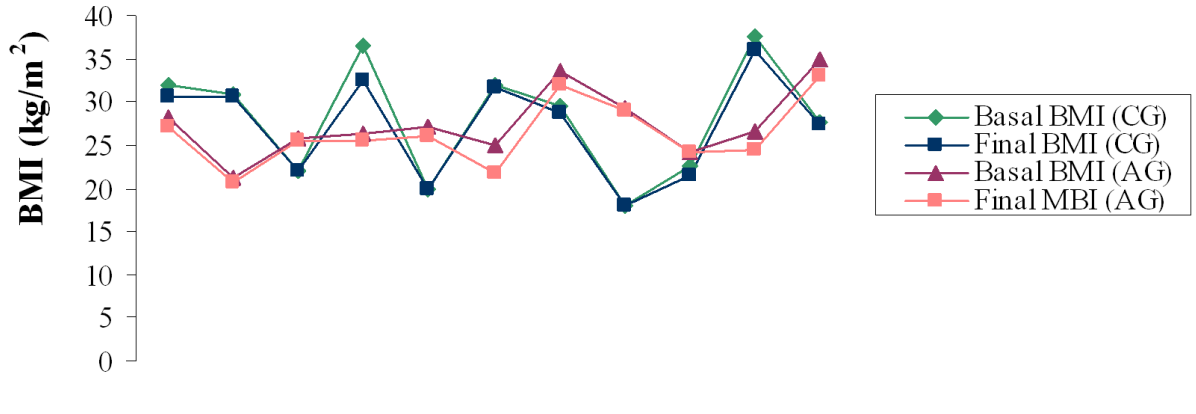

Chart 1 - Basal and final body mass index in the control group (CG) and aerobic group (AG).

Charts 3 and 4 depict the effects of the 13-week intervention period on BP, showing that both G1 and G2 attained decreases in SBP and DBP. Although these decreases were verified, we did not observe a significant difference in BP between the aerobic group and the control group ($F = 1.74$ and $Sig = 0.174$). As for the DBP, we observed a significant difference in G2, which presented a significant decrease in basal and final DBP ($p < 0.01$). G2 presented a 27.0% decrease in the final DBP.

We observed that educational interventions are also extremely important to obtain the improvement of BP control in diabetic patients.

Discussion

The study results demonstrated that a 13-week aerobic training program is capable of promoting significant reductions in glycemia and BP levels in elderly diabetic women.

Some limitations to the present study must be considered. The small sample size somewhat impaired the analysis of the data, but only these met the inclusion criteria. This number is explained by the fact that the participants lived far from research site and needed public transportation to get there.

In our study, we observed that the elderly women presented an increase in VO_{2max} after the 13-week aerobic training program.

With the objective of evaluating the effectiveness of a physical exercise program (PEP) in sedentary individuals, a study observed a significant increase in VO_{2max} in a group of 22 individuals that trained three times a week, with sessions lasting 50 minutes at intensity of 60.0%-75.0% of VO_{2max}[17].

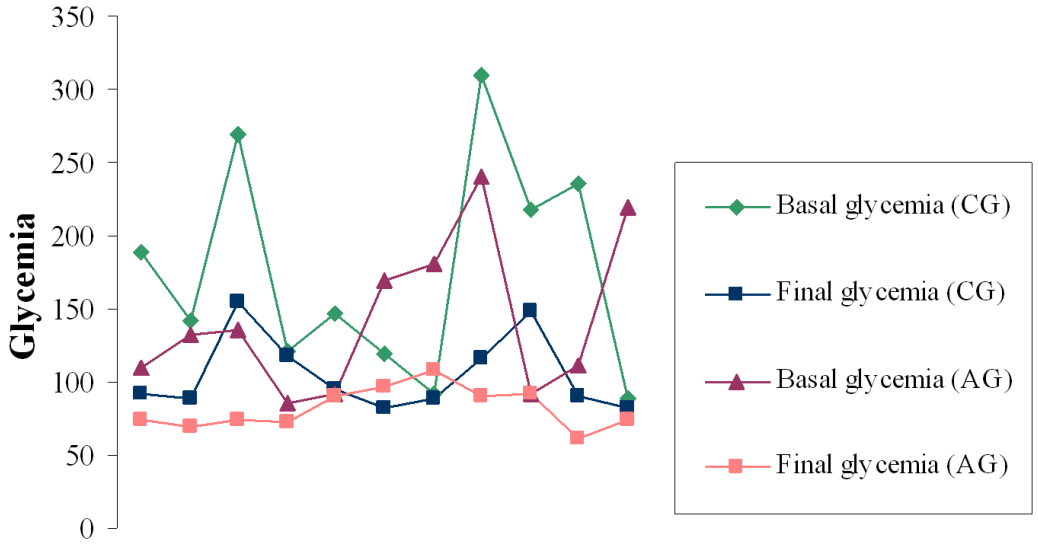

Chart 2 - Basal and final glycemia in the control group (CG) and aerobic group (AG).

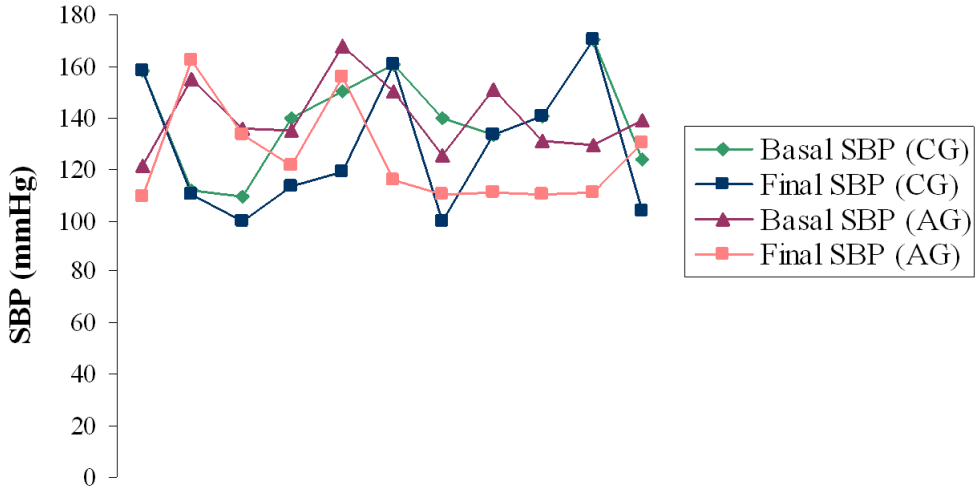

Chart 3 - Basal and final systolic blood pressure (SBP) in the control group (CG) and aerobic group (AG).

Such data corroborate the findings of other authors[18-20] and, according to Monteiro[18], the mechanisms related to the decrease in BP are associated with hemodynamic, humoral and neural factors.

Stathokostas et al[21] verified that the VO_{2max} decreases with age, although women present a lower decline rate. Tjonna et al[22] studied 32 individuals with metabolic syndrome and observed that, after a 16-week aerobic training program at moderate intensity, three times a week, these individuals presented a significant decrease in VO_{2max}.

We know that moderate-intensity aerobic activity (such as walking), for at least 30 minutes 3-5 times a week results in benefits to cardiovascular health.

A study by Conte et al[23] verified that elderly women presented a decreased or average VO_{2max} and that these women have a 9.84-fold higher risk of presenting obesity than women with elevated VO_{2max}.

Overweight individuals have 180.0% higher chance of developing arterial hypertension and 1,000% higher chance of developing insulin resistance than individuals with

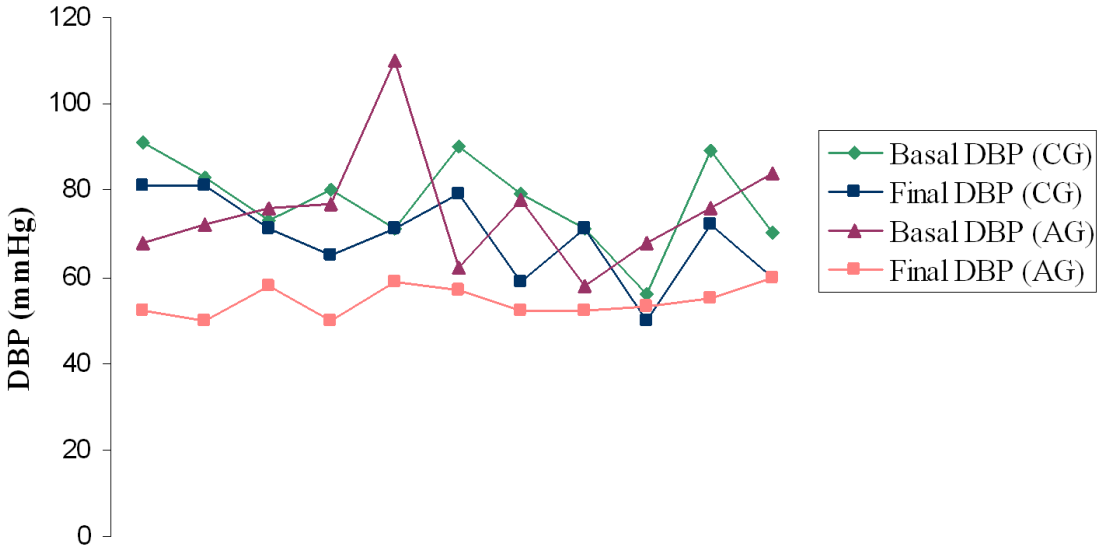

Chart 4 - Basal and final diastolic blood pressure (DBP) in the control group (CG) and aerobic group (AG).

normal weight, which shows a direct association between BMI and BP[24].

The BMI of the study group was improved, which was assessed by the decrease in the post-training values. Pratley et al[25] demonstrated that the aerobic training decreases the amount of body fat in elderly individuals, which can mediate some metabolic effects of the aerobic physical exercise, mainly due to the fact that excess of abdominal fat is associated with insulin resistance and hyperinsulinemia.

Our data are in agreement with those of other studies[26-28], which also observed a decrease in BMI after a physical training program.

In another study, we verified that the authors did not find significant differences in BMI values of diabetic individuals submitted to a physical exercise training program[29]. Tjonna et al[22] studied 32 individuals with metabolic syndrome and observed that such individuals, after a 16-week aerobic training program at moderate intensity, presented a decrease in BMI, although it was not significant.

Other studies have demonstrated that the aerobic training decreases body mass in diabetic individuals[30,31]. Most of these studies, in addition to the intervention through physical activity, associated a controlled diet for the patients.

We must consider that the physical exercise, even without a significant loss in body weight, improves the metabolic profile and has an anti-inflammatory effect on patients with DM2[32].

In our study, we observed that the elderly women presented significant decreases in glycemia, with the control group being 22% higher than the aerobic group at basal glycemia and presenting a 27% decrease in the final glycemia. Duarte and Martins[33] reported that significant decreases in fasting glycemia were demonstrated in the first three months of training; after this period, the decreases in this variable did not present a significant difference until the end of the training program, which lasted 9 months.

The decrease in capillary glycemia, immediately after the physical exercise session, indicated the acute effect of the exercise. A lower capillary glycemia variation could be detected after the physical exercise in diabetic patients; however, this variation was not statistically significant[34].

The association between fasting glycemia levels and the physical exercise programs is controversial.

A recent study[35] showed that the fasting glycemia increased within 24-72 hours after a physical exercise session (60.0% of VO_{2max}, with a one-hour duration, three times a week). In this program, the patients were being treated with diet and oral medications. The decrease in BP levels after an aerobic exercise session confirms the results obtained by other authors that also demonstrated post-exercise hypotension[36].

The systolic and diastolic blood pressures did not show any statistically significant differences in the group submitted to the aerobic exercise training three times a week. In the group submitted to an exercise program 5 times a week, there was tendency toward a decrease in the SBP and DBP. AH is one of the main risk factors for the establishment and progression of chronic complications of DM2. One of the mainstays of the hypertension treatment in diabetic patients is physical exercise, which has a positive influence on BP decrease in patients with DM2[37].

The effect of physical exercise on resting BP levels of mild to moderate degree is especially important, as the hypertensive patient can decrease the anti-hypertensive medication dose or even have the AH controlled without

the necessity of pharmacological therapy[38]. The tendency to use pharmacological agents at an early stage has been substituted by non-pharmacological approaches, and among them, aerobic physical exercises have been recommended for the treatment of mild systemic arterial hypertension[38].

More recently, Takata et al[39] submitted 207 individuals with essential hypertension grade 1 and 2 to an 8-week physical exercise program. The patients were divided in 5 groups, based on the duration and frequency per week of exercise training (control group - sedentary, 30 to 60 minutes/week, 61 to 90, 91 to 120 and > 120 minutes/week). They verified that the resting DBP did not change in the control group. However, there was a significant decrease in the resting systolic and diastolic BP in the 4 groups submitted to the exercise program. The magnitude of the decrease in the systolic BP was higher in the group that exercised 60 to 90 minutes/week, when compared with the group that exercised 30 to 60 minutes/ week. A higher decrease was not associated with the increase in exercise volume. The magnitude of the decrease in the diastolic BP was not significantly different in the four groups.

Conclusion

The results of the present study add knowledge to the scientific literature, by demonstrating that diabetic individuals can improve their metabolic control, blood pressure and anthropometric parameters through the practice of aerobic exercises performed just three times a week. Other benefits for elderly diabetic women that practice physical activities have been demonstrated in the literature, supporting the idea that the physical activity must be encouraged since childhood.

Potential Conflict of Interest

No potential conflict of interest relevant to this article was reported.

Sources of Funding

There were no external funding sources for this study.

Study Association

This study is not associated with any post-graduation program.

References

1. Ministério da Saúde. Secretaria de Políticas de Saúde. Plano de reorganização da atenção à hipertensão arterial e ao diabete mellitus. Brasília; 2001.
2. Sociedade Brasileira de Diabetes (SBD). Consenso brasileiro sobre diabetes: diagnóstico e classificação do diabetes melito e tratamento do diabetes melito tipo 2. Rio de Janeiro: Diagraphic Ed; 2003.
3. Brandão AP, Brandão AA, Magalhães MEC, Pozzan R. Epidemiologia da hipertensão arterial. Rev Soc Cardiol Estado de São Paulo. 2003; 13 (1): 7-19.
4. American College Sports of Medicine. Position stand on exercise and physical activity for older adults. Med Sci Sports Exerc. 1998; 30 (6): 992-1008.
5. American College of Sports Medicine. Physical activity programs and behavior counseling in older adult populations. Med Sci Sports Exerc. 2004; 36 (11): 1997-2003.
6. Almeida MB, Araújo CGS. Efeitos do treinamento aeróbico sobre a freqüência cardíaca. Rev Bras Med Esporte. 2003; 9 (2): 104-12.
7. Willians PT. Physical fitness and activity as separate heart disease risk factors: a meta-analysis. Med Sci Sports Exerc. 2001; 5 (5): 754-61.
8. Mac D Jr. Potential causes, mechanisms, and implications of post exercise hypotension. J Hum Hypertens. 2002; 16 (4): 225-36.
9. Halliwill JR. Mechanisms and clinical implications of post-exercise hypotension in humans exerc. Sport Sci Rev. 2001; 29 (2): 65-70.
10. Taylor-Tolbert NS, Dengel DR, Brown MD, McCole SD, Pratley Re, Ferrell RE, et al. Ambulatory blood pressure after acute exercise in older men with essential hypertension. Am J Hypertens. 2000; 13 (1 pt 1): 44-51.
11. Fagard RH, Cornelissen VA. Effect of exercise on blood pressure control in hypertensive patients. Eur J Cardiovasc Prev Rehabil. 2007; 14 (1): 12-7.
12. Whelton SP, Chin A, Xin X, He J. Effect of aerobic exercise on blood pressure: a metaanalysis of randomized, controlled trials. Ann Intern Med. 2002; 136 (7): 493-503.
13. Fagard RH. Exercise is good for your blood pressure: effects of endurance training and resistance training. Clin Exp Pharmacol Physiol. 2006; 33 (9): 853-6.
14. Wallace JP. Exercise in hypertension: a clinical review. Sports Med. 2003; 33 (14): 585-98.
15. Mattos M, Farinatti P. Influência do treinamento aeróbico com intensidade e volume reduzidos na autonomia e aptidão físico-funcional de mulheres idosas. Rev Port Cien Desp. 2007; 7 (1): 100-8.
16. Cervi A, Franceschini SCC, Priori SE. Análise crítica do uso do índice de massa corporal para idosos. Rev Nutr. 2005; 18 (6): 765-75.
17. Barbosa LC, Bündchen DC, Richter CM. Benefício da resistência muscular localizada como otimização da atividade física programada. Arq Bras Cardiol. 2005; 85 (supl. 4): S174.
18. Monteiro MF, Filho DCS. Exercício físico e o controle da pressão arterial. Rev Bras Med Esporte. 2004; 10 (6): 513-6.
19. Nunes APOB, Rios ACS, Cunha GA, Barretto ACP, Negrão CE. Efeitos de um programa de exercício físico não supervisionado e acompanhado a distância, via Internet, sobre a pressão arterial e composição corporal em indivíduos normotensos e pré-hipertensos. Arq Bras Cardiol. 2006; 86 (4): 289-96.
20. Silva E, Otterço NA, Sakabe DI. Efeito agudo e crônico do treinamento físico aeróbio sobre a resposta da pressão arterial sistêmica de indivíduos hipertensos. Rev Soc Cardiol Estado de São Paulo. 2006; 16 (1): 9-20.
21. Stathokostas L, Jacob-Jonhson S, Petrella RJ, Paterson DH. Longitudinal changes in aerobic power in older men and women. J Appl Physiol. 2004; 97 (2): 784-9.
22. Tjonna AE, Lee SJ, Rognmo O, Stolen TO, Bye A, Haram PM. Aerobic interval training versus continuous moderate exercise as a treatment for the metabolic syndrome: a pilot study. Circulation. 2008;118 (4): 346-54.
23. Conte M, Domingues SPT, Godoi VJ, Más EF, Vazatta R, Teixeira LFM. Interação entre VO2 máx, índice de massa corporal e flexibilidade. Rev Mackenzie Edu Fis Esp. 2003; 2 (2): 23-30.
24. Lopes HF, Barreto Filho JAS, Riccio GMG. Tratamento não-medicamentoso da hipertensão arterial. Rev Soc Cardiol Estado de São Paulo. 2003; 13 (1): 148-55.
25. Pratley RE, Hagberg JM, Dengel DR, Rogus EM, Muller DC, Goldberg AP. Aerobic exercise training induced reductions in abdominal fat and glucose

stimulated insulin responses in mild-aged and older men. J Am Ger Soc. 2000; 48 (9): 2022-33.

26. Leong KS, Wilding JP. Obesity and diabetes. Bailliére's Clin Endocrinol Metab. 1999; 13 (2): 221-37.

27. Kannan V. Diet, activity and diabetes. J Assoc Phys India. 1999; 47 (8): 761-3.

28. Gumbiner B. The treatment of obesity in type 2 diabetes mellitus. Primary Care. 1999; 26 (4): 869-83.

29. Boulé NG, Haddad E, Kenny GP, Wells GA, Sigal RJ. Effects of exercise on glycemic control and body mass in type 2 diabetes mellitus: a meta-analysis of controlled clinical trials. JAMA. 2001; 286 (10): 1218-27.

30. Kannan V. Activity and diabetes. J Assoc Physicians Índia. 2001; 47 (8): 742-8.

31. Silva CA, Lima WC. Efeito benéfico do exercício físico no controle metabólico do diabetes mellitus tipo 2 a curto prazo. Arq Bras Endocrinol Metab. 2002; 46 (5): 550-6.

32. Kadoglou NP, Iliadis F, Angelopoulou N, Perrea D, Ampatzidis G, Liapis CD, et al. The anti-inflammatory effects of exercise training in patients with type 2 diabetes mellitus. Eur J Cardiovasc Prev Rehabil. 2007; 14 (6): 837-43.

33. Duarte MFS, Martins DM. Efeito do exercício físico sobre o comportamento da glicemia em indivíduos diabéticos. Rev Bras Ativ Fís Saúde Londrina. 1998; 3 (3): 32-44.

34. Martins DM, Thiago DDBS, Borges PSS. Efeito do exercício físico regular sobre o controle da glicemia capilar de mulheres diabéticas não insulino-dependentes. Rev Bras Ativ Fis Saúde. 1997; 2 (2): 17-23.

35. Boulé NG, Weisnagel SJ, Lakka TA, Tremblay A, Bergman RN, Rankinen T, et al. Effects of exercise training on glucose homeostasis. The HERITAGE Family Study. Diabetes Care. 2005; 28 (1): 108-14.

36. Forjaz MLC, Santaella FD, Rezende OL, Barreto PCA, Negrão ECA. Duração do exercício determina a magnitude e a duração da hipotensão pós-exercício. Arq Bras Cardiol. 1998; 70 (2): 99-104.

37. Mathieu ME, Brochu M, Beliveau L. DiabetAction: changes in physical activity practice, fitness, and metabolic syndrome in type 2 diabetic and at-risk individuals. Clin J Sport Med. 2008; 18 (1): 70-5.

38. Rondon MUPB, Brum PC. Exercício físico como tratamento não farmacológico da hipertensão arterial. Rev Bras Hipertens. 2003; 10: 134-7.

39. Takata KI, Ohta T, Tanaka H. How much exercise is required to reduce blood pressure in essential hypertensives: a dose-response study. Am J Hypertens. 2003; 16 (8): 629-33.