Exercise program effectiveness on physical fitness, metabolic profile and blood pressure of hypertensive patients

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ABSTRACT

Background and objective: It has been shown that aerobic exercise is useful to reduce arterial pressure, however, the effectiveness of an exercise program is still controversial and not very well analyzed among populations with low-income. The objective of the present study was to set up an individualized physical fitness program – Projeto Hipertensão – focused on hypertensive people, patients from a Health Basic Unit (HBU) and, after that, to investigate the effects of this program on physical fitness, metabolic profile and pressure levels. **Methods:** Sixteen hypertensive women (56 ± 3yrs) under regular pharmacological treatment underwent 4 months of a supervised aerobic and stretching exercise program (3 sessions/wk, 90 min/session, 60% of $\dot{V}O_2$ max). Several physical and metabolic variables were compared before and after 4 months of training. **Results:** Training significantly reduced systolic arterial pressure (SAP, –6%), improved cardio-respiratory fitness (+42% of $\dot{V}O_2$max), flexibility (+11%) and plasma glucose content (–4%). BMI and % fat did not change. Besides modifying metabolic profile, it was found that training presented significant correlations between individual initial values of cholesterol total level (CT), high density lipoprotein (HDL-C) and low density lipoprotein (LDL-C) and its responses after exercise. **Conclusions:** The study shows that exercise programs can be personalized for hypertensive patients from a HBU and confirms the effectiveness of exercise on AP, physical fitness, flexibility and lipid profile on hypertensive patients. The expressive reduction of AP in hypertensive subjects suggests that this exercise intervention should be emphasized on other health centers which assist low-income population.

Keywords: Arterial pressure. Exercise training. Lipid profile.

INTRODUCTION

High arterial pressure (AP) is a powerful, independent and most important risk factor for cardiovascular diseases (CVD) and has become the major worldwide endemic disease(1-4). Accordingly to the 7th Joint National Committee on Prevention, Detection, Evaluation and Treatment of High Blood Pressure(4), individuals with a systolic AP (SAP) of 120 to 139 mm Hg or a diastolic AP (DAP) of 80 to 89 mmHg should be identified as pre-hypertensive and require health-promoting lifestyle modifications to prevent the progression to hypertension and CVD(4). If not treated, hypertension may cause serious problems such as coronary disease, stroke, congestive heart failure, renal failure, peripheral vascular disease and cerebral diseases, contributing thus to the increase of morbidity and mortality rate around the world(1). Approximately 20-30% of Brazilians have AP above the recommended level(5), and its consequences are responsible for 40% of early retirement(6). For this reason, lifestyle modifications, including diet and physical activity, are the first line interventions for high BP management, even when drug therapy is implemented.

Epidemiological studies have shown a negative correlation between physical activity and hypertension, meaning that active people has less chances to become hypertensive. In agreement to that, Church *et al.*(7) analyzing the results of 22.167 men in a follow up of 23 years, demonstrated that the mortality rate was higher among those ones with less physical capacity. More recently, Mokdad *et al.*(8) have demonstrated that poor diet and physical inactivity was responsible for 16.6% of the actual causes of death in the United States, reaching approximately about 15.000 deaths/year. In Brazil, the numbers are not different: the Brazilian National Health System, between 2000-2001 years, showed that from 1.800.155 hospital incomings for CVD, 14.95% were due to hypertension. For other different causes of hospital incomings, 80% were related to high blood pressure levels. High morbidity, mortality and elevated costs associated with drugs, pathology, radiology and complications due to stroke, coronary heart disease, kidney disease, heart failure, and end stage renal disease, make hypertension an important modifiable medical risk factor. Approximately 20-30% of the Brazilian adult population has AP above the recommended level. Our population will become old in a few years and this statistics increases as the population ages, which reinforces the importance of finding an efficient treatment for hypertension(5).

It has been shown that aerobic exercise is effective to reduce arterial pressure; however, the amount; type and intensity of exercise are still controversial. Despite of that, there is no doubt about the benefits of long-term exercise training on the control of arterial pressure and metabolic responses of hypertensive people. Few studies evaluate the results of a physical exercise program along several months in low social class hypertensive patients from a Health Basic Unit. Most of them are very organized trials, with several environmental controlled situations and expensive techniques. For this reason, the Department of Physical Education of UNESP, Bauru, decided to create one individualized physical conditioning program focused on hypertensive patients from a Health Basic Unit. The objective of the present study was hence to set up the "Projeto Hipertensão" at "Otavio Rasi" Health Basic Unit, located in the city of Bauru, SP and after that, to investigate the effects of this physical exercise program on physical condition, metabolic profile and pressure levels.

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METHODS

Patient selection

The subjects enrolled in this study were recruited from the Health Center "Otavio Rasi", at Bauru, São Paulo. From 298 patients of this health center, 50 with mild-to-moderate hypertension were assigned to participate in a long-term exercise training in collaboration with the Physical Education Department of the Science School – UNESP – São Paulo State University – Bauru. At the end of the program, a total of 40 people with mild-to-moderate essential hypertension (8 men; 32 women) were enrolled on this 16-week program. All patients had regular pharmacological treatment for hypertension, which included beta-blockers, diuretics, angiotensin II conversion enzyme inhibitors, calcium antagonists and vasodilators. None patients had counter-indications for exercise. Informed consent was obtained from the patients and the study was approved by the Health Center Ethical Committee.

All patients underwent a cardiac evaluation prior to exercise training as well as some laboratorial exams, which included dosages of total cholesterol (TC), high-density lipoprotein-cholesterol (HDL-C), low-density lipoprotein-cholesterol (LDL-C), triglycerides (TG), and plasma glucose levels. All laboratorial exams were repeated after 4 months at the Bauru Laboratory. After the medical consent, the patients were signed up to go to the Physical Education Department, UNESP, where they underwent different tests in order to evaluate their physical and cardiorespiratory fitness. Arterial pressure was measured with an aneroid sphygmomanometer 3 times after a 10-minute sitting rest with the arm positioned at heart level. An average of those measurements was considered as resting arterial pressure. These measurements were taken by trained monitors (each monitor was responsible for 5 patients, to avoid differences among evaluators). The sphygmomanometers were previously calibrated against the mercury column and appropriated to patients' arm size, in accordance to the V Brazilian Arterial Pressure Guidelines[6]. A one-mile gait test was used, in agreement to the index proposed by Kline *et al.*[9], and the results of this test were used to estimate the maximal oxygen uptake ($\dot{V}O_2$ max). The flexibility was analyzed using a sit and reach test[10]. To assess the presence of obesity, weight and height were measured (Filizola scale). The waist and hip circumferences were also measured with a measuring tape. Body weight and height were used to calculate the body mass index (BMI). In addition, 3 skinfolds thickness (triceps, subscapular, and thoracic for men and triceps, abdominal and suprailiac for women) were measured to estimate the body fat content (%G) based on the Jackson and Pollock[11] protocol. Those measurements were done by one trained monitor. The physical tests and laboratory exams were re-analyzed after 4 months of training and 24-72 hours after the last exercise session.

Training program

Individual exercise prescription was prepared based on the results of the physical evaluations and monitored by a physical educator. Three times a week, the patients were transported from the Health Basic Unit "Otavio Rasi" to the Physical Education Department, UNESP, Bauru Campus, by a bus kindly offered by "Grande Bauru bus company". This transportation is part of a partnership between UNESP and Bauru Management. Arterial pressure on sitting position was measured using a sphygmomanometer at the beginning of each session. Patients were allowed to start the exercise session if both their systolic (SAP) and diastolic arterial pressures (DAP) were less than 140 x 90 mmHg, respectively. Moreover, patients who did not take their usual anti-hypertensive medication were not allowed to exercise on that day. The SAP and DAP were used to calculate the mean arterial pressure (MAP). The exercise program included aerobic (gait) at 40-60% of $\dot{V}O_2$ max and stretching exercises three times a week, for 90 minutes total session. The intensity of the exercise was monitored by the heart rate (HR) before, during and after each aerobic exercise session. Each monitor was responsible for 5 patients.

Statistical analysis

The values were presented as mean ± SD. The comparisons between the two moments (initial and after training) were made using a Paired *T Test*. The monthly values of arterial pressure (SAP, DAP and MAP) are the mean of the daily measurements. One-way ANOVA with repeated measurements was used in order to evaluate the blood pressure profile along the training program, considering Tukey's as a post-hoc test. In order to evaluate the correlation between initial values and response after exercise, Pearson's test was used in order to evaluate the correlation between initial values and post-exercise response. The significance level used for all tests was $p < 0.05$.

RESULTS

From 40 patients, only 16 women whose sessions frequency were more than 80% were considered for analysis (56 ± 3 years). After training, performance during exercise test was significantly increased, expressed by a decrease of 12% on running time (17.1 *vs* 19.4 minutes at the beginning of the program, $p < 0.05$). Table 1 summarizes the effects of 4 months of an exercise program on the physical characteristic and lipid metabolism. According to the improvement on the running test, $\dot{V}O_2$ increased in 42% (table 1).

Although BMI and % fat have not changed, the exercise program was effective to increase flexibility on those patients (+11%, table 1, $p < 0.05$). At the beginning of the exercise stretching program, 34% of the patients were included in the normal flexibility range normalized by age (15 cm), but after intervention, this percentage increased up to 50%. Four months of exercise training significantly reduced the plasma glucose content as shown in table 1. Although training have not significantly changed the metabolic profile of the group (table 1), an important effect of exercise training was observed when the individual initial values were correlated to the response after training (figure 1). As shown in figure 1, there were significant correlations between initial values of TC, HDL-C and LDL-C and its responses after an exercise program. Table 2 shows the mean values of SAP, DAP and MAP along the 4 months of training. Each value represents an average of 12 monthly sessions. Aerobic exercise decreased about 8 mmHg of SAP ($p < 0.05$) and 3 mmHg of both DAP and MAP. Table 2 shows that after the third week of training the SAP reduced significantly. In order to analyze the individual response, a correlation test was also performed among those variables. As observed in figure 2, the effects of exercise were more expressive in patients who presented high pressure levels at the beginning of the training.

DISCUSSION

The main result of the present study was that the "Projeto Hipertensão" – an individualized physical fitness program created by the Physical Education Department, UNESP, Bauru, can be introduced at the Health Basic Unit – Otavio Rasi, to support hypertensive patients. Besides that, four months of physical aerobic and stretching exercises, associated to a pharmacological treatment, were effective to improve cardiorespiratory capacity, flexibility and reduce arterial pressure in hypertensive individuals.

Regular physical activity or cardiac rehabilitation using large muscle groups, such as gaiting, biking, running or swimming, produces cardiovascular adaptation which increases exercise capacity, endurance and skeletal muscle strength. Indeed, it is considered one of the main strategies in public health, contributing to reduce morbidity and mortality. Such reductions may be mediated via the indirect effects of exercise through improvement in the

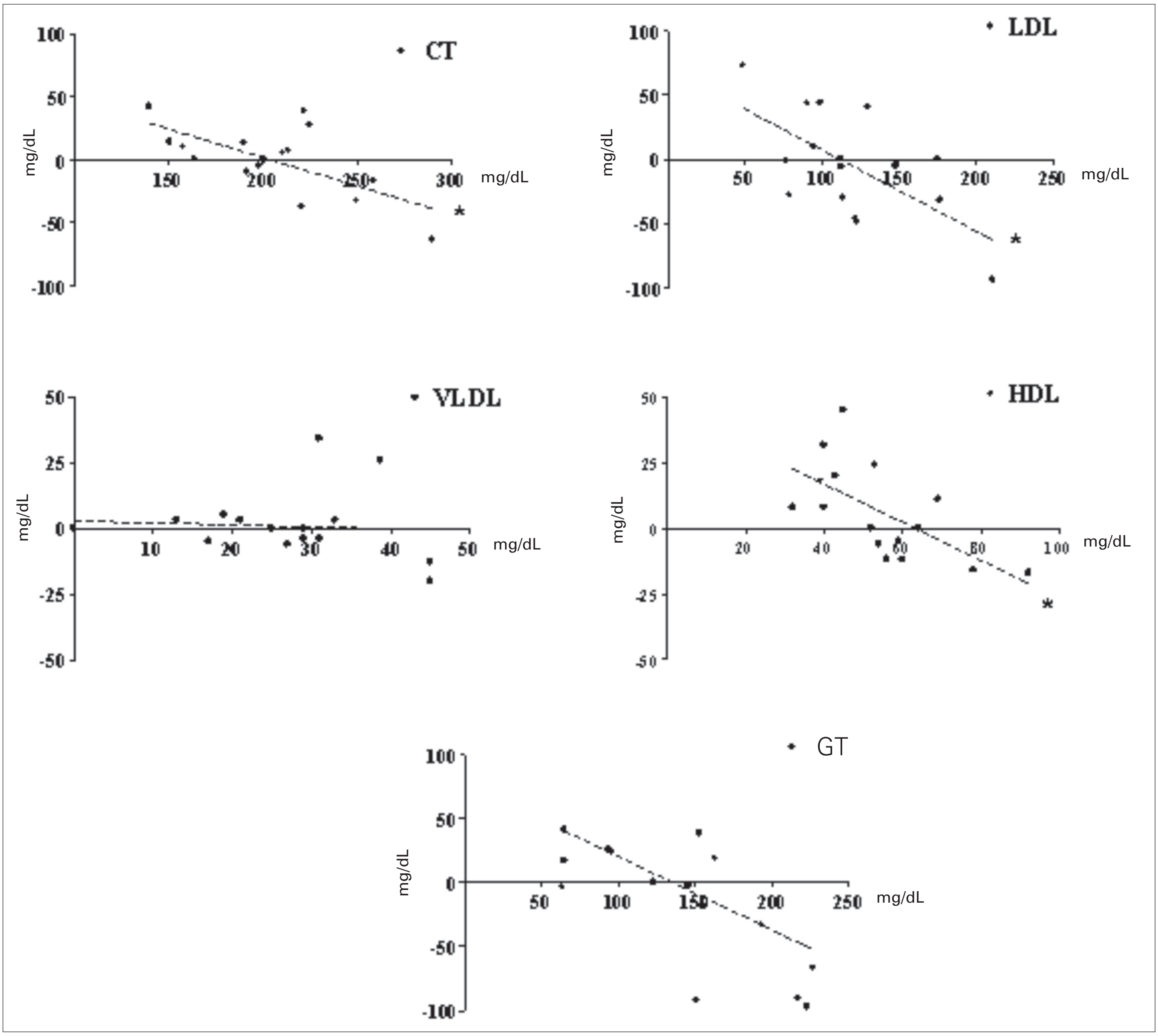

Figure 1 *– Correlation between initial values and response after 4 months of training on metabolic variables: Total cholesterol (TC, mg/dL, y = –0.4530x ± 92.4, r = 0.6636; panel A); low density lipoprotein (LDL-C, mg/dL, y = –0.6355x ± 71; r = 0.6301; panel B); very low density lipoprotein (VLDL-C, mg/dL, y = –0.07443x ± 2.82; r = 0.661; panel C); high density lipoprotein (HDL-C, mg/dL, y = –0.7303x ± 46.08, r = 0.6371; panel D), triglycerides (TG, mg/dL, y = –0.2845x ± 36.3, r = 0.2372, panel E) and plasma glucose content (mg/dL, y = –0.4082x ± 35.66, r = 0.7582; panel F) in hypertensive patients (n = 16). Significance: * p < 0.05.*

TABLE 1
Effects of an exercise program on physical characteristics and metabolic variables of hypertensive patients from "Otavio Rasi" Health Basic Unit

Variables	Initial	Final
Physical characteristics		
$\dot{V}O_2$ max *(ml.kg^{-1}.min)*	18.01 ± 2.54	25.86 ± 2.17*
Flexibility *(centimeters)*	25.06 ± 2.70	27.81 ± 2.37*
BMI *(Kg/m^2)*	31.37 ± 1.73	31.37 ± 1.77
% Fat *(Percentage)*	36.67 ± 1.30	36.58 ± 1.20
Lipid metabolism		
Plasma Creatine levels *(mg/dL)*	0.90 ± 0.04	0.88 ± 0.03
Plasma glucose levels *(mg/dL)*	97.31 ± 2.75	93.25 ± 1.90*
Total Cholesterol *(mg/dL)*	205.38 ± 10.15	204.75 ± 7.59
LDL – Cholesterol (*mg/dL)*	119.69 ± 10.42	114.63 ± 9.00
VLDL – Cholesterol *(mg/dL)*	28.04 ± 2.32	28.89 ± 3.83
HDL – Cholesterol *(mg/dL)*	54.75 ± 3.93	60.85 ± 3.63
Triglycerides *(mg/dL)*	143.28 ± 13.82	138.81 ± 15.71

$\dot{V}O_2$max – Maximal oxygen uptake; BMI – Body Mass Index; %Fat – Percentage of Fat tissue; LDL – Low density lipoprotein; VLDL – Very low density lipoprotein; HDL – high density lipoprotein. Significance: * *vs* initial, p < 0.05.

TABLE 2
Resting systolic arterial pressure, diastolic arterial pressure and mean arterial pressure during the exercise program

Month	SAP	DAP	MAP
1	133 ± 3	83 ± 2	98 ± 2
2	129 ± 1	83 ± 1	98 ± 1
3	126 ± 2*	80 ± 1	95 ± 1
4	125 ± 2*	80 ± 2	95 ± 2

SAP = systolic arterial pressure; DAP = diastolic arterial pressure; MAP = mean arterial pressure. Significance: * *vs* first month, p < 0.05.

risk factors such as hypertension, obesity, diabetes, blood lipid disorders and stress[3-4,12-17]. In agreement, Bonow[18] has also stated that subjects who keep desirable body weight, healthy diet, regularly exercise, avoid smoking, and drink alcohol with moderation; reduce their risk of cardiovascular disease by 84%. Although several reports have shown improvement on primary cardiac risk factors with exercise, the effect of a regular exercise program on health-related quality of life remains unclear.

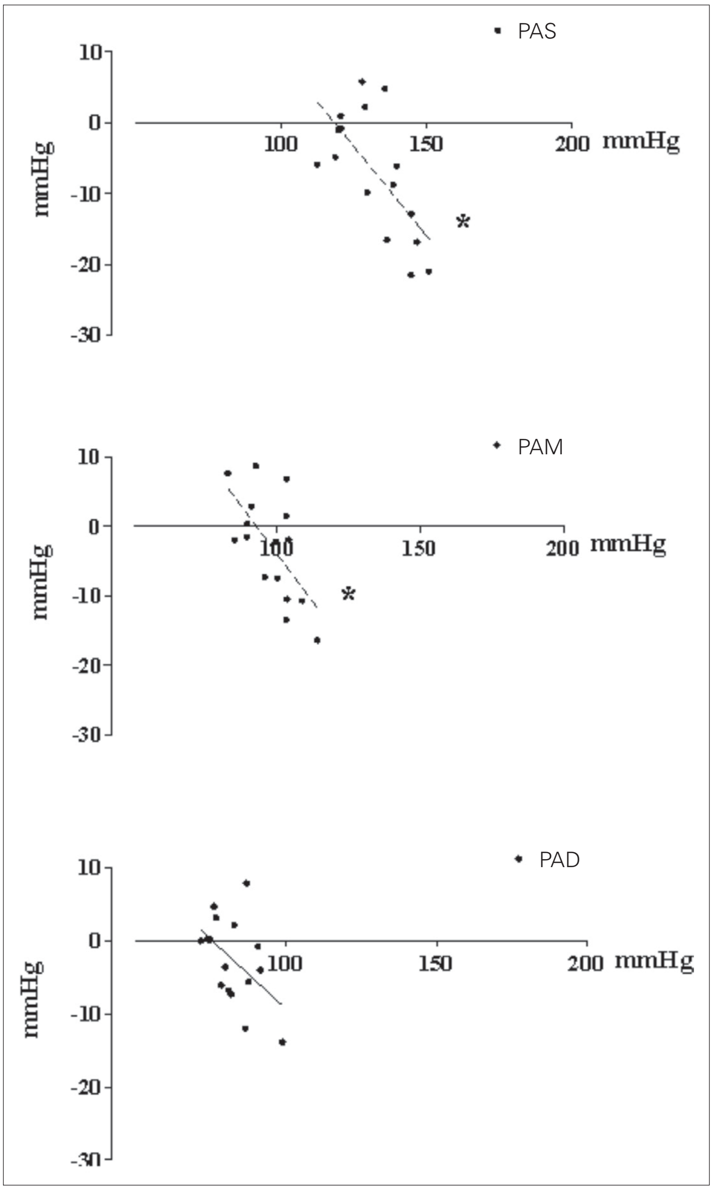

Figure 2 *– Correlation between initial values and response after 4 months of training on systolic arterial pressure (SAP, mmHg, y = –0.5064x ± 59.94, r = 0.6674; upper panel), mean arterial pressure (MAP, mmHg, y = –0.5512x ± 51.03, r = 6372; middle panel) and diastolic arterial pressure (DAP, mmHg, y = –0.3800 ± 28.64; r = 0.4771; lower panel) in hypertensive patients (n = 16). Significance: * p < 0.05.*

Hypertension is an important risk factor for cardiovascular disease with major impact on morbidity and mortality[4]. It is characterized by several skeletal muscle dysfunctions including decreased vessel density, which could contribute to the reduced aerobic capacity observed[19-21]. On the other hand, aerobic exercise training promotes numerous adjustments in skeletal muscle and cardiovascular system. Some of these adjustments include increases in the oxidative enzyme activity as well as the number and size of mitochondria. Increased capillary network plays an important role in aerobic capacity improvement, facilitates oxygen transportation and muscle extraction, therefore contributing to increase maximal oxygen uptake and physical performance[22]. In agreement to this, $\dot{V}O_2$ has been used as a marker of exercise training efficiency. The results of the "Projeto Hipertensão" demonstrated that four months of regular exercise training is enough to improve aerobic capacity of hypertensive individuals by increasing $\dot{V}O_2$max about 42%.

Another important result from the present study is that four months of regular exercise was efficient to reduce SAP of hypertensive patients. This decrease was more expressive and significant after the third month and was not associated with decrease of MAP and DAP, which suggests that a longer period of exercise effectively changes blood pressure. It is important to point out that the arterial pressure levels were not very high at the beginning of the exercise program, since the patients were under pharmacological treatment. Probably, the main result of this intervention was an association of facts that occurred with the patients including reductions on BP, and subsequent cost reduction with medication, exams and medical appointments (data not shown).

Several mechanisms might contribute to decrease blood pressure after exercise intervention. It has been shown that changes in blood pressure induced by chronic exercise are based on functional and/or anatomic responses, such as reduction of vascular resistance[19,23], cardiac output[24], insulin resistance[25-27] and sympathetic activity[28]. Chronic exercise has also been associated with increased capillary supply[22,29-30] which also helps to improve physical capacity.

The best exercise recommendation concerning amount, type and intensity is still controversial. The American College of Sports Medicine[1] recently stated that the most recommended exercise prescription for hypertensive patients should be at least 30 minutes of endurance activity, as many weekly times as possible, with moderate intensity (40-60% $\dot{V}O_2$-R). Conversely, Ishikawa-Takata *et al.*[15] have demonstrated that 8-weeks of aerobic exercise (50% of estimated $\dot{V}O_2$) was effective to reduce BP and that 61-90 min of exercise per week was better than 30-60 min per week in 207 untreated subjects with essential hypertension. They have also suggested that further increases in the exercise volume did not improve the results. The results of the present study showed that 135-180 minutes/week (45 to 60 minutes/session), were efficient to significantly reduce blood pressure of treated hypertensive patients which agrees with the results shown by Campane and Gonçalves[2].

It is well known that low plasma HDL-C together with high plasma TC and LDL-C is associated with high risk of CVD. On the other hand, there is a large number of experimental evidences suggesting that augments in HDL-C and/or its apolipoproteins promote a major vascular protective effect ranging from prevention to stabilization and regression of atherosclerosis, independent of cholesterol levels[16,31-33]. HDL-C is considered an important mediator of reverse cholesterol transport; a process that involves the transfer and uptake of free cholesterol from the peripheral tissues, such as the arterial wall, with subsequently delivery to the liver[34]. These observations support the hypothesis that exercise training, by increasing plasma HDL-C and decreasing TC and LDL-C levels, contributes to reduce the CVD risk[16,35-36]. Shah *et al.*[32] proposed in their review that every 1 mg/dL of increase in HDL-C is associated with 2%-3% lower risk of coronary heart disease. In agreement to that, our data suggest that the hypertensive patients probably decreased about 18% of the risk of coronary heart disease, since HDL-C levels of the group (table 1) increased 6.1 mg/dL after the physical exercise program. Although the group average did not show a significant increase (11%, p > 0.05) on HDL-C levels, an individual response of exercise training was demonstrated, showing a significant correlation between baseline HLD-C values and changes of HDL-C after exercise, which means that patients who presented lower levels of HDL-C at the beginning of the program got more benefits from the exercise training (r = 0.6373, P < 0.05). Since the population was very heterogeneous, with different lifestyle, diet, weight and life conditions, it was not surprising that significance was not found when the groups were compared. In fact, the essential thing to consider is that individuals who had altered values had the most benefits from the exercise. The result of this study is in agreement with those presented by Zmuda *et al.*[37] who have shown an exercise-induced improvement of HDL-C in subjects with low HDL-C levels. It is important to highlight that the improvement of HDL-C levels found in this study (+11%) was about the same as shown by other authors using only pharmacological treatment[38] and the patients were not taking medication for lipid profile adjustments. Couillard *et al.*[35] have shown that exercise if effective in increasing HDL-C if the exercise training stimulus is sufficient. Furthermore, several studies have suggested that the HDL-raising effect of endurance exercise training could be largely explained by the concomitant loss of body mass or fat[39]. Our study did not have a nutritional recommendation and it probably contributed to the non-significance changes on lipid profile. The TC and LDL-C levels had the same pattern, but in opposite direction. The patients who had higher baseline TC or LDL-C levels presented more expressive changes after the intervention.

Taylor *et al.*[33] have recently published a meta-analysis of 48 trials with a total of 8940 patients submitted to a three to 15 months of cardiac rehabilitation program. This review confirmed the benefits of exercise-based cardiac rehabilitation in all-cause mortality, which was associated with reductions of TC, TG and SAP. There were no changes in high-and-low lipoproteins cholesterol levels of patients. The authors suggest that more time would probably be necessary to improve these variables. These results represent an encouraging sign to increase the number of exercise-based rehabilitation programs, like our study.

Another common risk present in adults is musculoskeletal injury, which can be exacerbated by low flexibility. The degenerative process along aging contributes to decrease the movement amplitude and limits the mobility. The risk of injury increases with obesity, volume and intensity of exercise; however, when individuals at high risk are excluded, the injuries are rare in supervised exercise training among older adults[16]. In this investigation, 34% of patients were included in the normal flexibility range normalized by age at the initial evaluation, and after intervention with stretching and flexibility exercises, this percentage increased up to 50%. The recommended flexibility and stretching exercises was performed 3 times a week for 30 minutes each section, which is in agreement with the ACSM recommendations[40]. Heyward[41] suggested a combination of stretching and strengthening exercises for the abdominal and low back muscles to prevent low back problems.

In summary, the results of the present study showed that the Projeto Hipertensão- an exercise-based program developed by the Department of Physical Education of UNESP, Bauru, was successfully introduced and confirmed the benefits of exercise to decrease AP, increase physical fitness and flexibility of hypertensive patients from Otavio Rasi Health Basic Unit. Although a significant correlation between baseline levels of metabolic parameters (HDL-C, TC and LDL-C) and their respective changes after exercise has been found, a longer exercise program associated with a nutritional control, might be necessary to improve physical characteristics and lipid profile. The expressive reduction of AP in hypertensive subjects suggests that this exercise-based intervention should be emphasized in other health centers which assist low income population.

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