Efficiency and Costless of a Long-term Physical Exercise Program to Non-medicated Hypertensive Males

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Abstract

Hipertension is a highly prevalent disease that often goes undetected and is associated with other comorbidities and risk factors that create high costs and overhead. Lowering of blood pressure and prevention of hypertension is in first instance preferable by lifestyle changes with aerobic exercise being an integral component. However it has been neglected frequently by health care programs that has costly medication actions instead. To investigate the aerobic-training/detraining effects on blood pressure (BP) efficiency and costs the study involved 80 adults, overweight men who were not taking antihypertensive medications or dieting, and were accomplished to all intervention tasks. Based on

their initial BP the subjects were assigned for either a normal BP (NG, n=31, SBP 123.7 ± 8.3 /DBP 79.9 ± 6.5 mmHg, BMI 28.3 ± 3.7 kg/m²) or high BP (HG, n=49, SBP 146.5 ± 11.2 /DBP 94.3 ± 7.5 mmHg, BMI 29.4 ± 3.7 kg/m²) groups. The intervention phase was a two (NG)-three (HG) year period in which all the subjects followed an 8 month/year supervised exercise training followed immediately by a 4 mo./yr rest (detraining). The aerobic (80% of maximum heart rate) training occurred 3-5 times a week for 30 minutes walking/jogging, in addition to 30 min warm up and cool down. BP measurements were taken before and after the exercise sessions (LISC program). No dietary changes were recommended during the exercise intervention. Descriptive and mean values comparisons were undertaken among moments of intervention and between groups for $p < 0.05$. The LISC protocol gradually decreased the BP at rest. In the HG the 2-8 mo. average reductions in SBP and DBP varied from 6.2 to 11.9 mmHg and from 3.1 to 10.2 mmHg respectively. In the following years the BP decreased 8.0 (year 2) and 7.7 mmHg (year 3) for SBP and 7.2 and 4.9 mmHg for DBP. The normal BP was restored yearly after the 8 mo. training. The BP responses also occurred in NG, confirming that physical exercise is an effective approach to preventing hypertension. It is noteworthy that the BP reductions occurred in a stable diet and body weight situations. The 4 mo. detraining period resulted in BP increase nearly back to their baseline levels. With the found efficiency of 31.6% in normalizing high BP (affecting 28.5% of the Brazilian adults at an estimated cost of US\$ 1.18 billion a month) this 8 mo LISC (at a professional cost of US\$ 6000/8mo) would result in an estimated save of US\$ 373.3 million (spent with medication drugs) if the LISC would be replicated nationwide. In conclusion the present LISC as a tool for high BP normalization demonstrated to be feasible, efficient and costless (in comparison with drugs) highly recommendable for replication in other similar communities.

Keywords: hypertension, lifestyle modification program, physical exercise detraining

INTRODUCTION

Hypertension is an important preventable risk factor for death. The worldwide prevalence of hypertension is estimated to be as much as 1 billion, with an estimated 60% increase by the year 2025[28].

Data from the US Centers for Disease Control and Prevent (CDC), National Health and Nutrition Examination Survey (NHANES) for 1999-2002 showed a systemic arterial hypertension (SAH) prevalence of 27.8% in men and 29% in women for the US adults (Dib 2010:09). Wolf-Maier found an average SAH prevalence of 44.2% in European Countries and 27.6% in North America[30]. Studies estimate about one-third of the population in Latin America is affected by SAH and suggest a similar prevalence (about 30%) worldwide[15].

SAH has high medical and social costs, primary due to its many associated complications which lead to more severe cardiovascular disease the most frequent causes of mortality, morbidity, incapacity and the use of medical services worldwide.

Treatment of SAH and its associated complications among North Americans had an estimate cost of US\$ 37.2 billion in the 2003, being medications representing 47.8% of the estimated direct total expenses for health care in the US in 2003, an increase of 14% over the previous year[26]. The few studies available showed a spent of US\$ 546.6 million with cardiovascular disease in 2005 by the Brazilian Unified Health Care System (Sistema Único de Saúde, SUS). The existing Brazilian Federal for Diabetes and Hypertension (Hiperdia) provides free anti-hypertensive and hypoglycemic drugs to all diagnosed and registered (at the City hall centers) patients. Estimates of the direct annual cost of treating SAH in Brazil varied between about US\$ 372.9 million (best case scenario) to US\$ 1.3 billion (worst-case scenario).

The prevalence of hypertension is perpetrated by lifestyle factors, such as consumption of high fat and/or high-salt diets and physical inactivity [28].

Lifestyle and behavioral modifications are stressed for the prevention, treatment, and control of hypertension. These include weight loss, moderation of alcohol intake, a diet with increased fresh fruits and vegetables, reduced saturated fat, reduce salt-intake and, increased physical activity[18, 19].

For lowering blood pressure guidelines recommend predominantly aerobic exercises such as walking, jogging and cycling. However a body of research is emerging that show resistance training may also beneficially affect metabolic health[3, 24, 29]. An exercise frequency of 3 days per week has been considered to be the minimal frequency for BP reduction [5] and exercising more times at a low intensity may be more effective than more intense training performed less than 3 times per week in order to reduce blood pressure. Although mild hypertension state can be controlled with aerobic exercises.

The Nutritional and Physical Exercise Metabolism Centre (CeMENutri) at the Botucatu Medical school (São Paulo State, Brazil) conducts multiprofessionally since 1991 an ongoing epidemiologic study for healthy-lifestyle promotion with nutrition reeducation and regularly-supervised physical exercise (LISC). Clinical examinations and laboratory test are obtained at the state-clinical hospital at no cost for the patients and the physical exercises are conducted by graduate students of Physical Education holding an educational fellowship (US\$ 9000/year).

METHODS

Subjects

From the adult individuals attending the CeMENutri longitudinal study[22] (Mota et al, 2011, Coelho et al, during 1991 to 1999) eighty fulfilled the inclusion criteria for the present investigation. An initial medical screening

was carried out to exclude those individuals with severe hypertension, diabetes mellitus, cardiopulmonary, renal, hepatic, and severe orthopedic diseases. Eighty sedentary (as defined by the fact that none spent more than one hour per week in leisure-time physical activities) subjects, aged 36-74 years, were eligible for the study. Forty-nine patients were classified as hypertensives (HG) according to the JNC VI report criteria [4]. Individuals were considered hypertensive when their systolic blood pressure readings were persistently greater than or equal to 140 mmHg and/or their diastolic blood pressure readings were greater than or equal to 90 mmHg, according to at least two different readings over one or more weeks under standard conditions[1, 2]. All patients were asked to maintain their usual lifestyle inclusive dietary and none of them received medications during the study.

Study protocol

After providing written informed consents, they entered a run-in period of 4 weeks for drug washout and familiarization with the study staff and site. At the end of this period blood pressure (BP) levels were stable as verified by measurements taken three times per week. After the run-in period, hypertensive and normotensive subjects entered in the pre-training evaluation period. This evaluation was carried out over 2 weeks and included resting BP measurements for calculation of baseline values, anthropometric assessment and a treadmill test. After the pre-training evaluation all subjects entered the 8-month/year exercise training (LISC). In the final 2 weeks of the training program subjects were re-evaluate according to the same schedule as before training. Analysis of the results was accomplished to verify: 1) supervised training effects on BP and anthropometric aspects, 2) the temporary interruption of supervision (detraining) effects on the BP and anthropometrics and 3) the estimate costs (\$) of these effects.

Blood pressure measurement

Resting BP was measured using a digital automatic oscillometric device (Omron, USA). The measurements by means of this device were superimposed to parallel measurements taken with a standard mercury manometer in the initial screening period and there were no significant intra-and inter-device reading deviation. Initial and final BP used for statistical analysis are means of duplicate measurements taken at 5 min-intervals in a seated position on at least 6 different occasions over 2 weeks prior to training and during the last two weeks of the exercise training periods, respectively. During the exercise training, BP was evaluated 15 min before each exercise session.

Exercise training protocol

The exercise training (LISC) consisted in 60-min. sessions offered Monday to Friday, always at 6 p.m. and was performed in a gymnasium. Each session was divided in a 10-15 min. of warming-up, 30-40 min. of jogging and 10-15 min. of cooling-down. Once a week, recreational games replaced the jogging phase. All patients received constant instructions to train at least 3 times per week and to maintain their heart rate during jogging between 65 to 85% of their maximal heart rate (HRmax) as indicated by the treadmill test. These values

correspond approximately to 50% and 75% of maximal oxygen consumption (VO₂max). Professionals of the staff supervised all sessions and exercise heart rate. Three meetings assembling patients and study staff occurred during the exercise program to explain about the beneficial aspects of the exercise training and to discuss subject progresses. Patients had access to all their respective personal data of BP measurements and biochemical values.

Anthropometric assessment

Height and weight were measured for calculation of body mass index (BMI=weight/height²). The waist-to-hip ratio (WHR), calculated as the ratio of the minimal abdominal circumference divided by the circumference at the maximal gluteal protuberance, was used as an index of body fat distribution.

Statistical analysis

All results are expressed as mean $\pm$ SD. Statistical analysis was done with StatView software (Abacus Concepts, Inc., Berkeley, CA). After normality, pre-versus post-training differences were analyzed using Student's paired t-test. Between-groups comparisons were done using one-way ANOVA, and unpaired t-test.

RESULTS

Excepted for blood pressure and body weight both groups were homogenous at baseline (table 1).

The benefits of following the physical exercise had been shown to apply throughout the intervention for lowering blood pressure and heart rate. The effects in participants with hypertension were greater than the normotensives (table 2).

In the HG the 2-8 months average reductions in SBP and DBP varied from 6.2 to 11.9 mmHg and from 3.1 to 10.2 mmHg respectively (table 3). In the following years the BP decreased 8.0 (year 2) and 7.7 mmHg (year 3) for SBP and 7.2 and 4.0 mmHg for DBP with the normal controlled BP being restored yearly after 8 months training (table 2). Under the physical exercise the SBP normalized earlier (4 months) than DBP (6 months) (table 3). The BP reductions occurred in a stable body mass situations (table 2 and 3).

The detraining period resulted in BP and HR increase in both groups nearly reaching the baseline (table 2 and 4). Normal BP restored after 8 months of LISC in 31.6% of the patients following the fatness normalization of 36.6% and 1.7% respectively for total body and abdominal fatness (Figure 1).

In conclusion the LISC was effective in reducing BP to normal values irrespective to body mass index normalization. The LISC-dependent BP normalization was lost after the 4 months interruption of supervised-exercise and took another 8 months LISC to get back to the normal BP.

DISCUSSION

Several intervention studies have reported clinically significant reductions in systolic and diastolic blood pressure after moderate-intensity aerobic exercise training [10, 16, 24]. The average training-induced reductions in SBP and DBP have varied from 2 to 11 mmHg and from 1 to 8 mmHg, respectively [10, 16, 27]. These values were similar those found here after the first 8-mo of exercise training. Additionally our observations confirm the idea that the BP decrease after training is more evident in hypertensive (middle-aged subjects to similar training programs) [17] than normotensives.

Although weight loss has been shown to lower BP [12, 20] the present study corroborates the suggestion that the BP response to training is not dependent on body mass changes [27].

Exercise has the most potent effect on endothelium-dependent vasodilatation and the endothelium derived nitric oxide is thought to be necessary to maintain an adequate vascular response to increased blood-flow demands during exercise. Shear stress is an important component of exercise, and it affects vascular NO concentration, and increases the velocity of the endothelial high-affinity/low-capacity transport system for L-arginine [25]. This ensures substrate availability, as the rate-limiting step of eNOS, which generates ROS in the absence of L-arginine [9]. Muscular contraction dependent $[Ca^{++}]$ also modulates e-NOS activity but shear stress lead to eNOS phosphorylation on serine residues independent from increases in $[Ca^{++}]$ [6].

It has long been enigmatic why exercising training, which increases total oxygen uptake and in turn the production of ROS [14] can improve endothelial-derived NO increases the expression of ecSOD in vascular smooth muscle cells [8]. So it was demonstrated that exercise training increases both eNOS and ecSOD expression thus alternating the premature breakdown of NO by ROS [9]. Thus exercise training may correct endothelium-dependent vasodilatation by a variety of mechanisms. First, shear stress augments the expression of nitric oxide synthase in endothelial cells. Second, shear stress induces up-regulation of the cytosolic copper-and-zinc containing superoxide dismutase, a free-radical scavenger. The inactivation of nitric oxide by a vascular superoxide or other reactive oxygen species may thereby be attenuated. Third, shear-stress-mediated suppression of angiotensin-converting enzyme may influence endothelium-dependent relaxation by affecting local concentration of bradykinin by keeping it active [11].

In 2005, 28.5% (33.6 million) of the Brazilian population over age 18 were considered hypertensive by the public health system [13]. Three years before the distribution of hypertensives by the Brazilian guidelines accomplished 53.3% of stage 1, 35.7% of stage 2 and 11% of stage 3 [23]. The cost of medication spent with either one (US\$ 87.10), two (US\$ 159.00) or three (US\$ 194.00) drugs averaged monthly US\$ 39.50 for each non controlled hypertensive subjects [21]. Figuring out the medication cost for stages 1 and 2 (89%) of the 33.6 million

hypertensive (29.9 million) the cost in that year was estimated as US\$ 1.18 billion a month (29.9 x 39.50).

The estimated direct cost of SAH treatment in Brazil is 1.46 times higher in public than the private system. Together they represent 0.08% of the GDP (in 2005), or 1.11% of overall health care costs [7].

Our LISC showed an efficiency of 31.6% BP normalization after 8 months which when applied to 29.9 million of hypertensive (2005 data) would mean that 9.45 million of Brazilian hypertensive would become normotensives, with an economy of drugs estimated in US\$ 373.3 million a month. The professional cost of 8 months program was US\$ 6000 without considering indirect costs of laboratory tests and physical plant (gymnasium) use and conservation.

Thus the alternative treatment given by the presented LISC could be settled in cities provided by public medical schools either by public or private health systems.

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Table 1: Baseline values of the studied groups

Variables	Groups	
	Normotensives (NG) (n=31)	Hypertensives (HG) (n=49)
BW (kg)	84.1 ± 13.0 ^a	86.2 ± 11.9 ^a
BMI (kg/m ²)	28.3 ± 3.7 ^a	29.4 ± 3.7 ^a
BF (%)	23.6 ± 5.6 ^a	23.8 ± 4.9 ^a
W/H	0.94 ± 0.05 ^a	0.98 ± 0.06 ^a
SBP (mmHg)	123.7 ± 8.3 ^a	146.5 ± 11.2 ^b
DBP (mmHg)	79.9 ± 6.5 ^a	94.3 ± 7.5 ^b
HR (bpm)	73.5 ± 7.5 ^a	74.6 ± 12.3 ^a

Mean±SD, BW: Body weight, BMI: Body Mass Index, BF: Body Fat, W/H: waist/hip ratio, SBP: systolic blood pressure, DBP: diastolic blood pressure, HR: Heart Rate, ab: p<0.05 between groups.

Table 2: Blood pressure, heart rate and anthropometric variations during the whole protocol of physical exercises between groups

		Year 1				Year 2				Year 3			
		M0		M8		M0		M8		M0		M8	
SBP (mmHg)	NG	123.7 ± 8.3	Ab	115.9 ± 9.7	Ab	124.5 ± 15.4	Ab	118.8 ± 6.6	Ab	-		-	
	HG	146.5 ± 11.2	Aa	134.6 ± 13.0	Ba	142.3 ± 10.2	Aa	134.3 ± 6.8	Ba	142.7 ± 10.5	A	135.0 ± 11.2	A
DBP (mmHg)	NG	79.9 ± 7.5	Aa	74.7 ± 8.2	Aa	81.2 ± 9.6	Ab	75.5 ± 5.8	Ab	-		-	
	HG	94.3 ± 7.5	Aa	84.1 ± 8.2	Ba	94.4 ± 7.1	Aa	87.2 ± 6.6	Ba	92.3 ± 7.6	A	87.9 ± 9.6	A
HR (bpm)	NG	74.6 ± 12.3	Aa	70.8 ± 11.2	A	75.7 ± 10.5	Aa	71.2 ± 11.3	Aa	-		-	
	HG	73.5 ± 7.5	Aa	68.3 ± 8.4	Aa	74.5 ± 10.6	Aa	71.2 ± 11.3	Aa	73.0 ± 10.7	A	70.6 ± 12.3	A
BW (kg)	NG	84.1 ± 13.0	Aa	82.9 ± 10.2	Aa	80.4 ± 8.9	Aa	80.4 ± 8.9	Aa	-		-	
	HG	86.2 ± 11.9	Ab	83.4 ± 11.3	Aa	83.6 ± 10.3	Aa	83.6 ± 13.9	Aa	82.6 ± 9.3	A	82.9 ± 10.9	A
BMI (kg/m ²)	NG	28.0 ± 3.7	Aa	29.0 ± 2.6	Aa	27.0 ± 3.4	Aa	30.0 ± 2.6	Aa	-		-	
	HG	29.0 ± 3.7	Aa	29.0 ± 3.7	Aa	29.0 ± 3.3	Aa	29.0 ± 4.2	Aa	28.0 ± 3.6	A	28.0 ± 4.3	A
BF (%)	NG	23.6 ± 5.6	Aa	23.0 ± 3.3	Aa	22.1 ± 5.0	Aa	23.6 ± 6.6	Aa	-		-	
	HG	23.8 ± 4.9	Aa	19.8 ± 4.7	Aa	22.5 ± 4.3	Aa	21.2 ± 5.1	Aa	22.2 ± 4.1	A	20.9 ± 5.6	A
W/H	NG	0.94 ± 0.05	Ab	0.93 ± 0.02	Aa	0.98 ± 0.04	Aa	0.98 ± 0.06	Aa	-		-	
	HG	0.98 ± 0.06	Aa	0.98 ± 0.04	Aa	0.97 ± 0.06	Aa	0.96 ± 0.04	Aa	0.98 ± 0.05	A	0.97 ± 0.06	A

NG: normotensive group, HG: hypertensive group

Mean ± SD, SBP: systolic blood pressure, DBP: diastolic blood pressure, HR: heart rate, BW: body weight, BMI: body mass index

BF: body fat, W/H: waist/hip ratio. AB: p<0.05 between moments, ab: p<0.05 between groups

Table 3: Blood pressure, heart rate and anthropometric variations between groups during the first 8 months of experiment

		Moments (months) of evaluation									
		M0		M2		M4		M6		M8	
SBP (mmHg)	N G	123.7 ± 8.3	Ab	119.9 ± 9.0	Aa	119.9 ± 11.8	Aa	115.7 ± 6.2	A _a	115.9 ± 9.7	Ab
	H G	146.5 ± 11.2	Aa	140.3 ± 11.1	Ab	138.4 ± 11.0	Bb	137.2 ± 12.6	B _b	134.6 ± 13.0	Ba
DBP (mmHg)	N G	79.9 ± 7.5	Aa	78.0 ± 9.5	Aa	78.3 ± 8.6	Aa	74.5 ± 9.3	A _a	74.7 ± 8.2	Aa
	H G	94.3 ± 7.5	Aa	91.1 ± 9.5	Ab	90.3 ± 8.6	ABb	88.0 ± 9.2	B _b	84.1 ± 8.2	Ba
HR (bpm)	N G	74.6 ± 12.3	Aa	70.7 ± 10.8	ABa	68.7 ± 9.7	Ba	71.1 ± 10.9	ABa	70.8 ± 11.2	A
	H G	73.5 ± 7.5	Aa	67.2 ± 6.6	ABa	68.2 ± 7.5	Ba	68.2 ± 7.5	ABa	68.3 ± 8.4	Aa
BW (kg)	N G	84.1 ± 13.0	Aa	83.6 ± 13.9	A	83.4 ± 10.4	Aa	83.3 ± 11.1	A _a	82.9 ± 10.2	Aa
	H G	86.2 ± 11.9	Aa	85.5 ± 11.5	Aa	84.8 ± 12.0	Aa	84.7 ± 11.4	A _a	83.4 ± 11.3	Aa
BMI (kg/m ²)	N G	28.0 ± 3.7	Aa	28.0 ± 3.5	Aa	29.0 ± 3.4	Aa	29.0 ± 3.5	A _a	29.0 ± 2.6	Aa
	H G	29.0 ± 3.7	Aa	29.0 ± 3.6	Aa	29.0 ± 3.6	Aa	29.0 ± 3.8	A _a	29.0 ± 3.7	Aa
BF (%)	N G	23.6 ± 5.6	Aa	22.3 ± 3.8	Aa	22.0 ± 4.9	Aa	22.1 ± 4.2	A _a	23.0 ± 3.3	Aa
	H G	23.8 ± 4.9	Aa	22.4 ± 4.9	ABa	21.6 ± 4.8	Aa	20.7 ± 4.6	Ba	19.8 ± 4.7	Aa
W/H	N G	0.94 ± 0.05	Ab	0.95 ± 0.04	Aa	0.93 ± 0.05	Aa	0.95 ± 0.03	A _a	0.93 ± 0.02	Aa
	H G	0.98 ± 0.06	Aa	0.97 ± 0.05	ABa	0.97 ± 0.05	Aa	0.97 ± 0.05	A _a	0.98 ± 0.04	Aa

NG: normotensive group, HG: hypertensive group

Mean ± SD, SBP: systolic blood pressure, DBP: diastolic blood pressure, HR: heart rate, BW: body weight, BMI: body mass index

BF: body fat, W/H: waist/hip ratio. AB: p<0.05 between moments, ab: p<0.05 between groups

Table 4. Training/detraining effects on blood and anthropometric variables in the hypertensive group

	HG changes M8mo)		(Mo-	Detraining changes (HG)		Overall Changes
	Year 1	Year 2	Year 3	Year 1-2	Year 2-3	
SBP (mmHg)	-11.9 (-7.8)	-8.0 (-8.7)	- 7.7	7.7	8.4	-11.5
DBP (mmHg)	-10.2 (-5.2)	-7.2 (-5.7)	- 4.9	10.3	5.6	- 6.4
HR (bpm)	- 3.9 (-5.2)	-3.3 (1.5)	- 2.4	3.8	1.8	- 4.0
BW (kg)	- 3.8 (-9.3)	0.3 (9.3)	0.3	- 0.1	-1.0	-3.3
BF (%)	-4.0 (-0.6)	-1.3 (1.5)	- 1.3	2.7	1.0	- 2.9

SBP: systolic blood pressure, DBP: diastolic blod pressure, HR: heart rate, BW: body weight, BF: Body fat

HG: Hypertensive group

Figure 1: Frequency of hypertensives and high fatness subjects during the 8 months of study

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