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QUASI-EXPERIMENTAL STUDY

An assessment of a sequence of yoga exercises to patients with arterial hypertension

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Summary This quasi-experimental study describes the effects of a yoga sequence following hemodynamic and biochemical parameters in patients with hypertension. Thirty-three volunteers participated in the study (control = 16 and yoga = 17) for four months. Blood pressure measurements, cardiac and respiratory rate were collected monthly, while the biochemical profile was taken at the beginning and end of the program. To analyze the data, Student's *t* test and repeated measures analyses were performed. The yoga group showed a significant reduction of systolic blood pressure, heart and respiratory rate ($p < 0.05$). As for the biochemical profile, the yoga group showed correlation coefficients between initial values and final responses greater than the control of fasting glucose, total cholesterol, LDL-cholesterol and triglycerides. The elaborated sequence practice promoted significant cardiovascular and metabolic benefits. The yoga exercises performed in the proposed sequence constitute complementary non-pharmacological control of blood pressure in patients with hypertension.

Background

Arterial hypertension affects 26.4% of world's population and constitutes a challenge for the public health policy for prevention, control and treatment (Kearney et al., 2005). Studies indicate that the Complementary and Alternative Medicine, like the practice of yoga can contribute to the therapeutic process of treatment and disease control (Kaushik et al., 2006; Terathongkum and Pickler, 2004; Joseph et al., 2005; Cohen et al., 2011; Khattab et al., 2007). The Yoga practice involves: i) philosophical concepts; ii) body practices (asana); iii) breathing exercises (pranayama), and; iv) relaxation and meditation. The practice as a whole seeks self-knowledge, mental well-

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being and connection with spiritual aspects (Feuerstein, 2001).

In the technical literature on the subject, there is a reasonable number of studies that address the practice of breathing exercises, meditation and relaxation applied independently, which, have favorable effects for the control of hypertension (Kaushik et al., 2006; Liu et al., 2007; Benson et al., 1974). The simultaneous application of these techniques associated with the practice of asanas is still poorly investigated (Khattab et al., 2007; Sivasankaran et al., 2006; Telles et al., 1993), especially in hypertensive patients (Cohen et al., 2011). However, in the West, the yoga classes taught to the general population are drawn up with exercises of pranayama, asanas, relaxation and meditation in a single session. In this regard, there is little evidence to ensure that the benefits seen with the isolated corporal practices are maintained in this form of intervention, where different techniques are worked on simultaneously for a prolonged period.

From this finding, the aim of this research was to analyze the effect of the practice of the association of yoga techniques on the cardiovascular system and biochemical profile of patients with hypertension.

Methods

Subjects

This research is characterized as a quasi-experimental study, that sought to describe the effects of an intervention model based on the practice of yoga in patients with hypertension undergoing outpatient treatment versus a control group in the same condition.

The study was approved by the São Paulo State University (Case No. 993/46/01/09) Faculty of Science Research Ethics Committee and followed the recommendations of the Helsinki Declaration on human research. All participants were informed about the study objectives and signed a consent form.

Subjects were recruited from a primary health care unit in Brazil (PHCU) in the months of May and June 2009, through onsite posters and as appointed by the medical staff and nursing unit. The interested parties were scheduled for an interview with the study coordinators, which completed questionnaires for collecting personal information, health history and physical activity habits. The sample consisted of 33 individuals classified into two groups: (1) Yoga (GY) ($n = 17$): patients who had available time to attend classes, and (2) Control (GC) ($n = 16$): patients who reported scheduling conflict or gave up on the classes during the first months (two patients excluded). Classes were held three times a week in the afternoon.

The criteria for inclusion in the study were: (1) over 40 years of age, (2) be on medical and/or pharmacological blood pressure (BP) control treatment, (3) resting systolic blood pressure (SBP) $<$ 160 mm Hg and/or diastolic blood pressure (DBP) $<$ 105 mm Hg. Exclusion criteria were: (1) serious heart disease or its symptoms including myocardial infarction, angina or cardiac arrest, (2) stroke or transient ischemia, and (3) difficulty walking or performing the exercises.

Assessment

The volunteers were submitted to an anthropometric and clinical evaluation. An experienced assessor measured the BP in left arm with the patient in a sitting position after resting for at least 15 min using a properly calibrated aneroid sphygmomanometer following the instructions of the VI Brazilian Guidelines on Arterial Hypertension (VIBGAH) (Brazilian Society of Hypertension, 2010). Participants were asked to report changes in dosage or amount of medication prescribed by their doctor. There were no reports of changes in treatment regimen during the intervention period. The main medications taken by patients were: diuretics and associations ($n = 13$), angiotensin-converting enzyme inhibitor (ACE) ($n = 7$), beta blockers and associations ($n = 10$) and others ($n = 3$).

The physical activity during the intervention period was monitored by the International Physical Activity Questionnaire (IPAQ) (Craig et al., 2003) in the initial and final moments of the research. Students were instructed to maintain their usual physical activity routine at work and home such as housework, walking and exercise. None of the volunteers reported changes in their habits.

For biochemical variable evaluation, patients appeared on scheduled days for blood collection after fasting for at least 10 h. Analyses were performed in the laboratory under agreement with Bayer RA-XT (Belford Roxo, Brazil) equipment.

We evaluated the pranayama learning, particularly regarding the ability to control breathing frequency and rate. The breathing rate (BR) was recorded during the exercises and weekly records were organized in the form of monthly averages.

Blood pressure and heart rate (HR) of GY were measured at the beginning of every class. The students who had SBP$>$ 160 mm Hg or DBP $>$ 105 mm Hg were instructed to remain in class, but only performing breathing exercises.

Intervention

Sessions lasted an hour and a half and were given by a Yoga teacher. They began with a warm-up and general stretching for about 5 min, standing or sitting (neck, shoulder, wrist, hips and leg regions), rotational movement of the shoulders, head and hips. Then Pranayama were performed for about 10 min. The initial goal was to identify the diaphragmatic or abdominal and the standard thorax or intercostal in the first two weeks. After the third week, the complete pattern was adopted, that is, the diaphragmatic combination with the chest associated with a reduction in the breathing rate and an increase in the inspired volume. During pranayama, students were asked to observe the breathing movements, since each region has different degrees of expandability. The training started with a normal respiratory rate over the weeks and decreased gradually while the pace and chest breadth increased.

The following asanas were performed during class: Uttanasana, Parsvakonasana, Virabhadrasana I and II, Prasarita Padottanasana, Parsvotanasana, Trikonasana, Dandasana, Janu Sirshasana, Marichyasana, Paschimottanasana, Navasana, HA Exhalation, Setu Bandhasana, Supta Padangus

thasana, Shavasana (Iyengar, 1992; McCall, 2007). The initial two weeks were considered as a phase for adaptation and learning exercises. The sequence of positions was changed each week so the musculoskeletal system could gain an increase in its range of motion and muscle tone. The patients were instructed to carefully perform each asana, chest breathing, abdominal contraction and avoiding excessive stretching, respecting their limits in order to avoid joint pain or discomfort. The final 15 min of class were divided into progressive muscle relaxation and breathing meditation.

The GC remained with the normal routines during the four months of intervention. The recording of BP was made in PHCU, once a month during the nursing consultation and request for medication.

Statistical analysis

The Shapiro Wilk test was used to verify the data distribution. Variables without normal distribution were analyzed by nonparametric tests. Baseline characteristics of the groups were compared with Student's t test or the similar, Mann—Whitney test, while the statistical differences between the pre and post intervention, with the Wilcoxon test. The correlation between baseline values and the difference observed at the end of the biochemical indicators of the program was obtained by Spearman's correlation coefficient after plotting the values in scatter plots with linear regression setting.

The monthly measurements of systolic and diastolic blood pressure, heart rate and respiratory rates were compared over the month by the repeated measures analysis (Friedman). The level of significance for all tests was $p < 0.05$. Statistical procedures were performed using the Statistical Package for the Social Sciences (SPSS) 13.0 and Prism 3.0.

Results

Seventeen GY participants [67(7) years old] completed the four-month program and 16 CG patients [62(12) years old] were accompanied during the same period of the intervention.

Sixty-five percent of the GYs and the GCs 56% were overweight (BMI > 25 kg/m^2). Fifty percent of individuals in the CG group and 47% of the GYs had impaired fasting glucose. A similar situation was also observed in relation to concentrations of triglycerides (56% and 42% respectively). Table 1 shows the baseline characteristics of the groups.

Fig. 1 shows the correlation between baseline values and the differences observed at the end of the study the concentrations of fasting glucose, total cholesterol, LDL-cholesterol and triglycerides. The data were adjusted by linear regression. A significant reduction of blood glucose levels in seven GY cases was observed, while there were no differences between initial and final times (Panel A, GY, $r = -0.6310$; GC, $r = -0.2049$) in the control group. Eleven GY (65%) patients presented total cholesterol reduction with most significant decreases for higher concentrations, while in GCs, nine (56%) individuals increased serum levels in relation to the start of follow-up (Panel B, GY, $r = -0.7644$; GC, $r = -0.3355$). The plasma concentration of the fraction of low-density lipoprotein (LDL) cholesterol in both the GYs, and the control group showed a significant negative correlation, however, it's worth noting that the first group, eight subjects (47%) fell from baseline to end, while in the second, ten (62%) patients had high values in relation to initial rates (Panel C: GY, $r = -0.6791$; GC, $r = -0.5405$). The results suggest that there was a significant reduction in high triglyceride levels in GYs, compared with initial registrations, but in the GCs, there was no statistical difference between the time points assessed (Panel D, GY, $r = -0.4880$; GC, $r = -0.2000$).

Table 1 Initial characteristics.

	Yoga ($n = 17$)	Control ($n = 16$)	P
Sex (M:F)	3:14	2:14	0.680
Age (years)	67 (7)	62 (12)	0.001
Duration of illness (years)	12.3 ± 13.7	11 ± 10.2	0.802
Body Mass index (Kg/m^2)	27.4 (4.4)	26.4 (5.3)	0.552
Blood pressure (mmHg)			
Systolic	123 (13)	127.5 (20)	0.081
Diastolic	78 (10)	80 (16)	0.276
Biochemical profile (mg/dl)			
Fasting Glucose	99 (30)	101.5 (24)	0.465
Total Cholesterol	198 (64)	192 (49)	0.444
LDL Cholesterol	119 (41)	114.5 (40)	0.382
HDL Cholesterol	46.3 (10)	48 (10)	0.709
Triglycerides	140 (98)	163.5 (105)	0.763

Note: Data presented as average ± standard deviation or median (interquartile range).

The average BP values of GY and GC were followed over four months and are shown in Fig. 2. Although in the first month of observation the two groups have expressed different values from the second to the fourth month, the yoga group showed significant and sustained decrease in SBP when compared to the control group. Comparing the first and last months of the GY SBP, there is a significant reduction (123(13) versus 116(14), $p < 0.05$).

The Yoga group's HR and BR are presented in Table 2. The HR of months 3 and 4 were significantly lower when compared with month 2. Regarding BR, there was a significantly lower difference in month four, in comparison with months 1 and 2.

Discussion

This study examined the effect of a yoga program with breathing techniques, postures, relaxation and meditation on resting blood pressure and biochemical profile of patients with hypertension. When performed separately, each technique has a significant hypotensive effect (Kaushik et al., 2006; Terathongkum and Pickler, 2004; Joseph et al., 2005), but the investigations that used a combination of techniques as a model intervention are scarce (Cohen et al., 2011; Khattab et al., 2007; Harinath et al., 2004). This combined model is common in contemporary yoga classes, approaching reality of our intervention practiced in gyms that offer this practice.

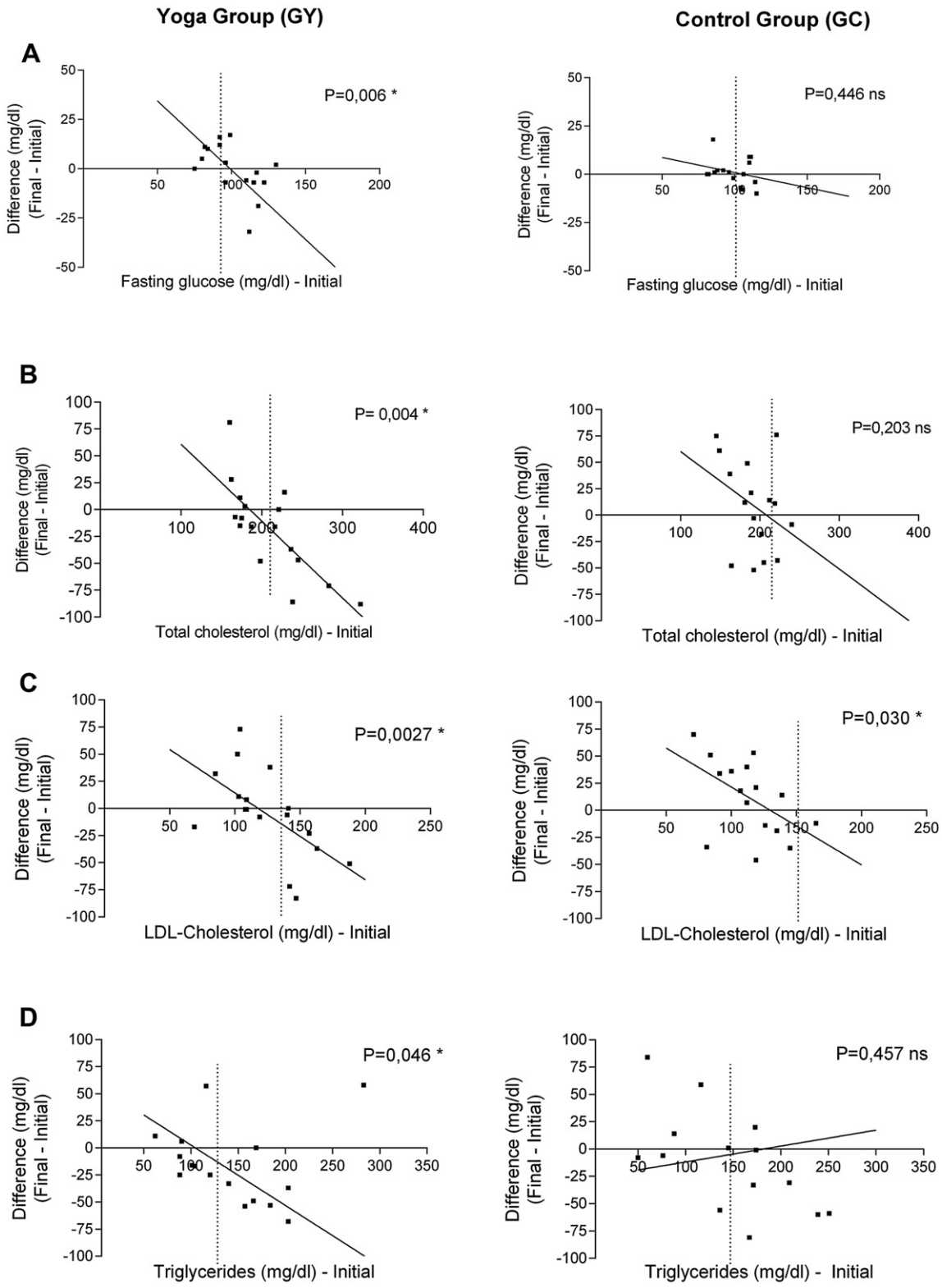

Figure 1 Correlation between initial values and responses after biochemical profile intervention. The dotted line represents the bordering limits in accordance with the Brazilian guidelines on Dyslipidemia and prevention of Atherosclerosis.

In this study we observed no changes in BMI. The intensity and frequency of activities performed in class were not enough to raise the energetic enough to promote weight reduction. In this regard, Clay et al. (2005), Hagins et al. (2007) evaluated the metabolic demands of normotensive subjects undergoing yoga classes similar to those performed in this study. During the 30 min dedicated to asanas practices, the practitioners, in order, found the

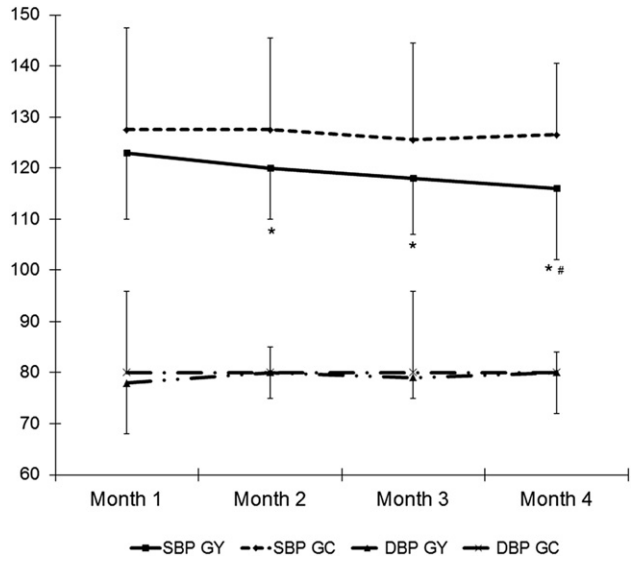

Figure 2 Systolic blood pressure (SBP) and diastolic blood pressure (DBP) throughout the program. GY — Yoga; GC — Control. *$p = 0.003$, versus month 1 (Wilcoxon); #$p < 0.05$, versus GC (Mann Whitney).

following physiological parameters: energy expenditure of 2.28 and 3.2 kcal/min, mean heart rate of 103.6 bpm and 89.7 bpm and the metabolic equivalent of 2.07 and 2.34. From a cardiorespiratory standpoint, this practice can be considered low intensity. The energy expenditure of a 30-min session of asanas is about 80 kcal. However, in research conducted by Sivasankaran et al. (2006), Gordon et al. (1998) there was a reduction of BMI of 29 ± 5—28 ± 5 kg/m^2 ($p < 0.01$) and 29 to 27 kg/m^2 ($p < 0.001$) at 6 and 12 weeks of treatment, respectively. These reductions were observed in patients with coronary artery disease and non-insulin-dependent diabetics, respectively.

The plasma concentrations of fasting glucose, total cholesterol, LDL-cholesterol and triglycerides analyzed in this study showed differences between the pre and post intervention. The dispersion between baseline values differences obtained with the end of the study shows those individuals in the yoga group who had elevated baseline plasma concentrations achieved reductions, benefiting those with biochemical changes, while those with the lowest initial maintained or slightly improved. Thus, the class model proposed was effective for those who were above the parameters established by the IV Brazilian Guidelines on Dyslipidemia and Prevention of Atherosclerosis (Brazilian Society of Hypertension, 2007).

Table 2 Heart and respiratory rate behavior throughout the program.

	Month				
	1	2	3	4	*p*
Heart rate	78 (13)	81 (18)	77 (17)[a]	76 (22)[a]	0.030
Respiratory rate	13 (9)	12 (7.5)[b]	12 (8.3)	10 (6.3)[b,c]	0.003

Note:
[a] $p < 0.05$ versus month 2.
[b] $p < 0.05$ versus month 1.
[c] $p < 0.05$ versus month 3.

Gordon et al. (2008) observed a significant reduction in fasting blood glucose and total cholesterol of diabetic patients who participated in 2-h yoga classes for three months, however, the authors did not mention which positions were executed during the lessons. Prasad et al. (2006) used a sequence of asanas with multiple chest extensions for 60 days and found a significant reduction in mean plasma total cholesterol, LDL-cholesterol and triglycerides and increased HDL-cholesterol in young normotensive women. A possible explanation is suggested by the authors that the practice favors the hydrolysis of triglyceride-rich lipoproteins to replenish the reserves used for intramuscular practice. The asanas protocol proposed by the researchers cited above also may have played a vital role in the results, since the positions of extension are the most demanding in terms of muscle when compared with the asanas developed in our experiment, which were aimed at reducing blood pressure.

Another hypothesis suggested to improve glycemic profile is that physical and mental relaxation can promote reduced levels of stress and sympathetic nervous system activity, thus normalizing the hormonal secretion of glucagon and insulin and therefore causing a decrease in rates of glucose and free fatty acids (Singh et al., 2008).

The Pranayama adopted in this research was slow and controlled breathing at a rate of six cycles per minute, which influences the autonomic nervous system and baroreflex sensitivity (Joseph et al., 2005). The GYs practiced pranayama and decreased from 13(9) breaths per minute in the first month to 10(6.3) cycles in the fourth month ($p = 0.003$). Pinheiro et al. (2007) using pranayama only twice a week for 30 min, found similar results with only one month of intervention (15 ± 2 vs. 10 ± 1, $p < 0.01$), a condition for which he also observed a reduction of the average systolic blood pressure, mean and diastolic values. Another study, using electronic devices for cadence breath for 15 min daily for a month, reduced resting BP in the clinic and average daytime ambulatory systolic BP in women (Anderson et al., 2010).

In our intervention protocol, slow breathing was performed for ten to 15 min, which may have prolonged the time required for exercise adaption. Students were instructed to gradually reduce their respiratory rate to avoid any discomfort, and some even reached the frequency of six breaths per minute. The learning and adaptation to pranayama occurred in the fourth month of intervention, as well as significantly reducing the value of the SBP. With regard to resting HR, GYs observed a reduction in the third and fourth months compared with the second, while in the studies cited above there was no reduction in resting HR.

The hypotensive effect of pranayama can be associated with autonomic modulation, an increase of parasympathetic predominance (Pramanik et al., 2009) and reduction of the sympathetic (Pinheiro et al., 2007) whose activity can be monitored by heart rate variability analysis. Another effect of pranayama is associated with increased baroreflex sensitivity that best promote adaptive responses to changes in BP (Joseph et al., 2005).

A total of 15 asanas and their variations selected from the knowledge reported by other researchers (Cohen et al., 2011; Khatthab et al., 2007; Iyengar, 1992; McCall, 2007; Harinath et al., 2004) which showed properties capable of acting in reducing BP and HR. Additionally, movements not recommended for hypertensive people were excluded. They should be implemented without any unnecessary effort, with breath control and constant attention to comfort and stability. Being a therapeutic practice, each asana has properties that can be beneficial or not recommended for certain diseases (Iyengar, 1992).

Malhota and Tandon (2005) investigated the acute effect of the execution of four different positions on normotensive blood pressure and the significant differences between them ($p < 0.000$), showing that each has a specific effect on blood pressure levels. For example, the position of the inverted arch (trunk extension in prone position with hands holding the ankles) increased BP and is contraindicated for patients with hypertension, while the corpse position (lying supine, with the arms slightly away from the trunk and palms up) reduced BP. We concluded that the choice of positions to be performed, the sequence and progression over the month was the determining factor in obtaining the final results.

Some asanas can be compared with isometric exercises, which increase SBP during its execution (Jianhua et al., 2007), with a reduction during the period of rest after exertion, associated with increased baroreflex sensitivity, which would fit with the increase of BP (Howden et al., 2002). This type of exercise can be used therapeutically in blood pressure control, however, the performance of asanas is only recommended in patients with controlled blood pressure.

Resting BP and HR measurements were taken when the GY at the beginning of each class, i.e., about 48—72 h after the previous session, indicating that the practice of yoga as it was performed, resulted in a prolonged hypotension and bradycardia effect, in contrast to other studies that acutely observed these effects soon after the effort (Pramanik et al., 2009).

This study has limitations. It was not possible to randomize the patients into Yoga and Control group, because some of the patients were not available to participate; and, the patients diet was not controlled.

Conclusions

The practice of yoga is instilled into the Indian medical rational and health care as a means of human development, designing a process of transformation and personal fulfillment, reconnecting or harmonizing the individual with the cosmos, the world and others (Terathongkum and Pickler, 2004; Iyengar, 1992).

Our experimental model showed properties that significantly reduced the hemodynamic and biochemical parameters after four months of intervention in patients with hypertension under outpatient treatment by the regular public health system, obtaining satisfactory acceptance by patients, medical staff and nursing, establishing itself as complementary therapy to conventional treatment. Given the observations amassed in this study, a wide range of possibilities opens up. It is understood that the subsequent step is to explain the physiological mechanisms that operate in the modulation of blood pressure and considered biochemical indicators. In this perspective, we suggest heart rate variability evaluation as an indicator of autonomic nervous system activity and biochemical analysis to identify changes in the endocrine system.

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