

Research Article

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Hatha Yoga Program Determinants on Cardiovascular Health in Physically Active Adult Women

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Abstract

Background: Hatha Yoga (HY) is an alternative exercise system for improving health in adults and older people with low physical capacity. Although the HY benefits on cardiovascular health have been demonstrated, its physical determinants haven't been demonstrated. Therefore, this study evaluates the effect of an HY intervention on cardiovascular risk factors, in physically active adult women.

Methods: Sixteen healthy and physically active adult women (56.31±10.47 years) were enrolled into an 11-week HY program (55 sessions/ 90 min each session). The program adherence, *asana* performance and work intensity were assessed along the intervention. Anthropometry and biochemical analysis were evaluated before, and after HY intervention. Cardiovascular fitness and dietary parameters were evaluated before and after HY intervention.

Results: A decreased of ~1.5 kg of body fat and ~17 mm of skinfold thickness ($p<0.05$) was detected in women. Total serum cholesterol, HDL-C, LDL-C, glucose and lactate increased 27 mg/dl, 11 mg/dl, 19 mg/dl, 11 mg/dl and 5 mM, respectively ($p<0.05$). The maximum oxygen uptake (VO_{2peak}) increased ~3 ml/kg/min. Systolic and diastolic blood pressure decreased 6 mmHg and 3 mmHg respectively ($p<0.05$). Heart rate (56 ± 8 beats/min) during HY determined changes in the Σ skin folds and systolic blood pressure (78 and 58% of the variance, respectively). Likewise *Asana* performance skills determined changes in HDL-C, glucose and maximal lactate (79, 42 and 89% of the variance, respectively). Finally, the program adherence, measured as % session attendance, determined changes in diastolic blood pressure (55% of the variance).

Conclusions: The proposed HY intervention improves physical fitness and reduces CVD risk factors in physically active adult women. In addition, heart rate during HY exercise, *asana* performance skills and percentage assistance to the intervention program, determined about 42-89% of the changes in cardiovascular health in senior physically active women.

Keywords: Aerobic Exercise; Alternative Therapy; Blood Lipids; Complementary Medicine; Silver Yoga; Hatha Yoga

Introduction

Yoga is a popular discipline practiced in India and it has increased as well in Western society [1]. Yoga is a millenarian discipline developed as a part of philosophy principles, and to attain health and well-being. Its origins are found 5000 years ago in the Indus Valley, being The Upanishads, Bhagavad Gita, and The Yoga Sutras, the most ancient books treating this issue, and Patanjali likely the most important writer. From the philosophical point of view, Yoga aims through self-understanding, to free the spirit from the body and incarnations. In a concrete manner, Yoga seeks the mastery of the body, emotions, sensations and thoughts. In order to achieve it, Patanjali produced an eight step series, which result in: a) exercises to improve physical development and breathing control, b) mental exercises for thoughts, sensations and emotions control, and c) an ethical behavior and a disciplined and austere life. Nowadays, a yoga session, called Western countries as Hatha Yoga, includes several segments of these steps mentioned above, including talks and recommendations about changes in people habits and lifestyles for other aspects which are believed to be healthier (third point mentioned above). A growing body of research evidence supports the belief that certain yoga techniques may improve physical and mental health. The benefits observed from this set of practices are very diverse, including: feel good, improving self-esteem, and satisfaction in working and daily living activities [2,3]; as well as diminishing pain, [4] stress, [5] depression, [6] risks of cardiovascular disease (CVD), and chronic degenerative diseases, [7]. However, there have been no major cardiopulmonary benefits, given the low

intensity in most of these exercises, especially when young subjects are studied [8]; instead, its efficacy and safety for elderly and handicapped people has been demonstrated [9]. In view of the aforementioned, and given the wide range of benefits that yoga aims to achieve in people, it is currently being used like alternative therapy in complementary medicine [10], it is especially recommended for people, who does not exercise intensely, or because of either their age or any disability cannot exercise in an intense manner.

It is difficult to study the effects around the yoga session performed in the classic way, that is to say, with all components mentioned above. In this sense, including just the physical part and eliminating the philosophical part, the most representative items that can be analyzed in a feasible way, they would correspond to Yoga Postures (Yogasanas), Voluntary Regulation Breathing (Pranayama), and reflexive thinking exercise (Meditation); in literature there is little consistent information about the effects on cardiovascular health from those aspects, especially

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when studying healthy and physically active subjects. For example, Chen and Tseng studied a group of healthy senior females during four weeks of Silver yoga (SY) exercise; they only report reductions in systolic pressure values (-19 mm Hg), [11] also Khatri et al. [12] studied healthy adult subjects on whom detected reductions in systolic as well as diastolic pressure values (-15/8 mm Hg). However, Blumental et al., studied men and women older than 60 year old, during 4 months of yoga classes; they did not find modifications in any cardiovascular parameter evaluated (VO_2 peak, anaerobic threshold and blood lipids) [13].

Therefore, here we study the effect of an intensive HY program (IHY) Table 1 which includes only Yogasanas, Pranayamas and Meditation, on cardiovascular health in physically active adult women.

Materials and Methods

Subjects

A non-probabilistic sample of sixteen healthy and physically active women (56.31 ± 10.47 years: 39-72 years) from the YMCA center, in Chihuahua, Mexico, volunteered for the study. Considering to VO_2 peak as the reference criterion to determine the sample size, sample power reached 81%. The inclusion criteria were: being a yogi with more than 3 years of systematic practice, being physically healthy, and not consume any drugs that affect neither the energy metabolism nor the hormonal status. The exclusion criterion was practicing Yoga less than 3 h per week.

A sports physician performed a routine physical examination including an electrocardiogram to guarantee the health status of each participant, before and during the IHY. Each participant signed a written informed consent, and the Ethics Committee of the Autonomous University of Chihuahua (Mexico), like Helsinki declaration states, approved the study protocol.

Study experimental design

The IHY program characteristics, blood biochemistry, anthropometric, physiologic, and dietary analysis, were described in a previous manuscript [14]. Briefly, the participants were enrolled in an 11-week IHY program Table 1 consisting of 5 sessions/week, 75 min per session (55 sessions) with a prospective quasi-experimental design. The 15 min step of relaxation exerciser was avoided from the original protocol, to ensure a real correlation between execution time and physiological responses. Blood biochemistry consisted of lactate, hematocrit, hemoglobin, glucose, total cholesterol (TC), triacylglycerols (TAG), High-density lipoprotein cholesterol (HDL-C), and low-density lipoprotein cholesterol (LDL-C) determinations; anthropometric (body weight, height, body fat and skin folds), physiologic (peak O_2 consumption, VO_2 peak, maximal heart rate, HR_{max} , maximal O_2 pulse, systolic and diastolic blood pressures, BPs and BpD, respectively), and diet analyses were performed before and at end of the IHY program. The IHY program adherence was evaluated by the number of sessions completed. Asana performance skills were assessed through a Likert-type scale, as follows: 1 = very poor, 2 = poor, 3 = good, and 4 = very good. The work intensity, measured as the heart rate during the IHY session, was recorded with a telemetric heart rate monitor (Polar F6; Finland).

Statistics

Anthropometric, biochemical, cardiovascular fitness, and dietary

parameters were compared at initial and final time by a paired samples test. The IHY program variable independence of cardiovascular health variables was evaluated through multiple regression analysis, and the best model was selected by all the possible regression procedures. The dependent variables values, in the regression model, represent the residual values, that is the differences between initially and finally times. Results were expressed as the mean $\pm$ SD. The nominal level of statistical significance used was $P < 0.05$. Data were analyzed using the statistical program SAS system software, version 8.0.

Results

During the 11 weeks of the HY program the subjects did not present any health problem or discomfort. The program adherence was $82 \pm 9.5\%$ and asana performance skills were 2.94 ± 0.85 (good skills). The average nutrient adequacy for energy, protein, fats and carbohydrate was 93 ± 5 , since diet was carefully supervised as part of the global study.

The subjects decreased ~ 1.5 kg of body fat, and ~ 17 mm of skin folds thickness Table 2. Total cholesterol, HDL-C, LDL-C, glucose and lactate increased about 27 mg/dl, 11 mg/dl, 19 mg/dl, 11 mg/dl and 5 mM, respectively, all within normal ranges. In physiologic variables, the VO_2 peak increased about ~ 3 ml/kg/min; on the other hand, the systolic and diastolic blood pressure decreased 6 mm Hg and 3 mm Hg, respectively.

Multiple regression analysis Table 3 showed that heart rate, during IHY (56 ± 8 beats/min), determined changes in the Σ skin folds and systolic blood pressure (the model explained the variance of 78 and 58% respectively). In addition, asana performance skills produced changes in HDL-C, glucose and lactate values (the model explained the variance in 79, 42 and 89%, respectively). The program adherence, measured as assistance determined changes in diastolic blood pressure (the model explained the variance in 55%).

Discussion

In this work, the metabolic effect and physical determinants of a 90 min IHY protocol in healthy and physically active adult women was studied. The results show that in an eleven-week physical training IHY program which only includes asanas, pranayamas and meditation, diminishes the risk of cardiovascular diseases (CVD) in physically active adult women, wherein the heart rate (HR) during the Yoga practice, the ability to do asanas and the assistance to the program independently determined about 42% and 89% of the modifications to the cardiovascular health parameters studied Table 3.

In a previous work, we disclosed that IHY improves cardiovascular health without modifying the blood pressure and body composition [14]. In the present study, which includes a bigger sample, we additionally observed that blood pressure is normalized and fat percentage and skin folds are decreased. Likewise through a multiple regression analysis, we reported the extent to which training variables modify the physiological parameters.

Previous works have reported that exercise capacity and energy expenditure required in recreational activities determine independently the changes in the lipids profile, obesity and hypertension, [15,16] wherein higher capacity for exercising measure in METs and increased caloric expenditure (> 2000 kcal/wk) lower cardiovascular mortality ($> 50\%$ reduction in mortality risk). Nevertheless, we didn't find studies regarding the effects of low-intensity program exercise variables over

Posture/exercise	Name	Description/comments	Time (min)
Corpse	Savasana	Resting and restorative pose	5
Dynamic warm-up exercise Walking, joint exercises and stretching			5
Mountain	Tadasana	Basic standing pose	2
Corpse	Savasana	Resting and restorative pose	5
Half Spinal twist	Ardha Matsyendrasana ^a	Half lateral twist pose	3
Head-to-knee	Paschimottanasana	Sitting in a forward bend	3
Wind Relieveing	Ardha Pavana-muktasana ^a	Half knee to chest pose	3
Wind Relieveing	Pavana-muktasana	Knee to chest pose	3
Buttocks	Urdhva Mukha Paschimottanasana	On the buttocks pose	1
Plough	Alazana	Plough pose	3
Ear-knee	Karna Peedasana	Knees clasping ears, from plough	3
Shoulder stand	Sarvangasana	Every part or complete inversion	3
Inverted	Viparitarani Mudra	On the high back and forearms	3
Fish	Matsyasana	Fish pose	3
Wheel	Chakrasana	Wheel pose	1
Cobra	Bhujangasana	Serpent or snake pose	1
Lobster	Ardha Salabhasana	On the abdomen	0.5
Crocodile	Makarasana	Lie on your stomach	3
Bow	Dhanurasana	Bow pose on abdomen	0.5
Camel	Ustrasana	Backbend, hands to heels	1
Kneeling	Vajrasana	Thunderbolt or diamond pose	3
Warrior	Supta Virasana	Lying back lowered to floor	3
Head Stand	Shirsasana	On the head and supported by the forearms	1
Warrior	Virasana ^b	Also called hero pose, sitting	5
Butterfly	Baddha Konasana	Sitting pose	3
Perfect	Siddhasana ^c	Devine or adept pose	5
Lotus	Padmasana ^c	Lotus sitting pose	5
Triangle	Trikonasana ^a	Standing Extended Triangle Pose	1
Hands-to-feet	Padahastanasana	Standing on hands in forward bend	1.5
Corpse	Savasana	Resting and restorative pose	2

^a Performed on left and right side. ^b Performed with breathing exercises (pranayamas). ^c Performed with meditation exercises. Detailed descriptions and pictures can be obtained in Arjuna [30].

Table 1: Sequence of Intensive Hatha Yoga Program.

the cardiovascular health. The main research evidence has shown that above improved physical and also mental health of yoga techniques is through vagal and parasympathetic stimulation that promotes a down-regulation of the hypothalamic-pituitary-adrenal (HPA) axis and the sympathetic nervous system (SNS) [17,10]. Because these systems decrease the release of cortisol and catecholamines, a series of events are raised, for instance including reduction on the systolic and diastolic blood pressure and atherogenic dislipidemia [18]. The effects of yoga may be similar to those of massage therapy, with yoga being a kind of self-massage [19]. Massage and yoga both appear to stimulate pressure receptors under the skin which, in turn, it leads to an enhanced vagal activity and reduction of cortisol, blood pressure and heart rate [20,19].

There are many styles of Pranayama and Yogasana that range from

very dynamic active movements (like Surya Namaskar) which go from one posture to another (and result in a thorough aerobic workout) to more slow-paced practices that hold postures for several minutes and form an intense strength training and balanced workout, like our study. The first one could increase the hearth rate (HR) near maximum peak, [21], therefore inducing a cardiovascular improvement. In the second one the HR is maintained near the baseline or resting point, hence the cardiovascular improvement is doubtful. The most popular type of yoga in the Western world is Hatha Yoga, in Mexico it is practiced in around 30 minutes of aerobic calisthenics [22], therefore developing the cardiovascular aspect. This work attempts to make known the benefits of the classic Yoga, due to the fact the 30 minutes of calisthenics was eliminated from the intervention program. However, the subjects of this study were yoginis practicing the popular HY three times per week;

Feature	Basal state	Final state
Body weight, kg	62.0 ± 7.1	61.6 ± 7.0
BMI (kg/m ²)	25.3 ± 2.9	25.1 ± 2.8
Body fat, %	28.7 ± 4.9	27.2 ± 5.3 [*]
Σ Skin folds, mm	158.3 ± 32.1	141.9 ± 36.0 [*]
Hematocrit, %	38.2 ± 2.1	39.0 ± 1.8
Hemoglobin, %	13.2 ± 0.9	13.4 ± 0.7
Triacylglycerols, mg/dl	132.7 ± 72.8	137.1 ± 41.3
Total cholesterol, mg/dl	185.2 ± 28.2	212.6 ± 35.1 [*]
HDL-C, mg/dl	43.4 ± 7.3	54.6 ± 16.2 [*]
LDL-C, mg/dl	166.3 ± 38.2	185.3 ± 45.0
Glucose, mg/dl	69.8 ± 10.0	81.0 ± 12.1 [*]
Maximal lactate, mM	5.5 ± 2.4	10.1 ± 3.4 [*]
Maximal heart rate, lat/min	158.7 ± 12.8	157.1 ± 19.2
VO ₂ peak, ml/kg/min	25.7 ± 5.1	28.9 ± 4.0 [*]
Maximal O ₂ pulse, VO ₂ peak/FCmax	0.16 ± 0.02	0.19 ± 0.02 [*]
Systolic blood pressure, mm Hg	128.9 ± 11.1	123.4 ± 8.8 [*]
Diastolic blood pressure, mm Hg	86.0 ± 8.8	83.1 ± 6.6 [*]

Values are expressed as the mean ± SD. ^{*}statistically, different from basal time. P < 0.05, BMI = Body mass index, HDL-C = High-density lipoprotein cholesterol, LDL-C = Low-density lipoprotein cholesterol, VO₂ = O₂ consumption, FCmax = Maximal heart rate.

Table 2: Effects of intensive Hatha Yoga program on physiological fitness in adult women.

Dependent variable ^a	Independent variable	R ²	P level
Σ Skin folds, mm	= - 0.295 HR ^b	0.78	< 0.001
HDL-C, mg/dl	= 3.928 <i>asana</i> performance skill ^c	0.79	< 0.01
Glucose, mg/dl	= 3.774 <i>asana</i> performance skill ^c	0.42	< 0.05
Maximal lactate, mM	= 1.523 <i>asana</i> performance skill ^c	0.89	< 0.001
Systolic blood pressure, mm Hg	= - 0.126 HR ^b	0.58	< 0.01
Diastolic blood pressure, mm Hg	= - 0.059 % assistance	0.55	< 0.01

^aModifications between initial and final time, ^b heart rate during Hatha Yoga, ^c values among 1-4, HDL-C = High-density lipoprotein cholesterol

Table 3: Hatha Yoga program predictors on physiological fitness in adult women.

for this reason, it is possible to observe that the subjects were fastened to a detraining aerobic process during our HY program. For this unique situation we could expect decreases in the cardiovascular conditioning, nevertheless and contrary to it, we observe an improvement on almost all the assessed parameters.

Increases in general and cardiovascular fitness programs conferred to Yoga have been very modest, and have been reported mainly in those programs which include aerobic endurance exercises [23]. Likewise, our program achieved modest benefits (decreased body fat ~ 1.5%, Σ skin folds ~17 mm, systolic and diastolic blood pressure ~5.5/3 mmHg and increased HDL-C ~11.2 mg/dl, VO₂ max ~3 mL/kg/min and maximal oxygen pulse ~3 VO₂ peak/FCmax), although the aerobic section has been deleted. Chen and Tseng in a similar Yoga program named Silver Yoga (three sessions of 70 min per week during four weeks) found similarly a decreased in body fat (~2.2%) as well as systolic and diastolic blood pressure (~20/4 mmHg) [11]. In addition and regarding lipids, the Pranayama and Yogasana diminished the levels of serum cholesterol, low-density lipoprotein (LDL) cholesterol, serum triglycerides, and very-low-density lipoprotein (VLDL)-cholesterol, but not HDL-C, in normal healthy junior footballers [18]. In our knowledge, this is the first study wherein a HY program which

only includes asanas, pranayamas and meditation, reveals a large decrease in the cardiovascular risk factors including increments in the HDL-C and VO₂ peak. The most probable reason of our finding is the intensity of the HY program; though being considered of low intensity, the energy expenditure (~ 1,003 kcal/week) was higher than the minimal recommended value to promote and maintain health in adults [24]. The aforementioned is due to HY duration was 450 min/week and had a metabolic equivalent of 2.17 METs/min (2.23 kcal/min) [25]. Furthermore, because aerobic and resistance exercise from low-to-moderate intensity (40-70% of HRmax) have shown to increase the VO₂max in adults [26].

The increase in TC (27.4 mg/dl) y LDL-C (19 mg/dl) could be due to the diet. According to our results, the most reasonable explanation for these increased CT and TAG values was directly related to the diet, which although it was in the normal range (~1,800 kcal/day) it was badly balanced as observed from the macronutrients, with high lipid and protein values and low values for carbohydrates. This type of diet is typical of Northern Mexico and has been associated with increases in TC and LDL-C [27]. Also, there was an increase in blood glucose within normal values (P < 0.05). This marginal increment could be due to gluconeogenesis favoring the influx of glycerol to the hepatocyte

from adipocyte's TAG breakdown [28], which is possibly associated with the light trend to diminish body fat as observed.

With respect to Hatha Yoga predictors on physiological fitness, this is the first study which reports the extent to which Yoga is involved in physiological and biochemical alterations. In this sense, the skills to perform the different asanas represented between 42 to 89% of the HDL-C, glucose and lactate changes; as for the FC, it represented between 78 and 58% of the systolic blood pressure and Σ skin folds alterations, respectively. The specific asana effect on physical, biochemical and physiological changes has not been demonstrated, however, these changes can be due, on one hand, to a major effort made by subjects for keeping right posture, which can mean a greater caloric expenditure, a greater heart rate during practice, and therefore, greater cardiovascular benefits and decreased in the skin folds. On the hand, as shown in Table 1, asanas that represented a greater physical effort were performed during 30 to 60 s, which might have an anaerobic fitness effect, thus increasing the glycolytic metabolism. Finally, regarding the attendance effect on the decrease of the diastolic blood pressure, it is known that greater adherence to yoga programs the greater are the health benefits [29]. In this sense, this *IHY* program had a good adherence in studying adult women (82%), however, Chen and Tseng found higher adherence for Silver Yoga (91%) [11]. The difference in attendance between these two studies may be due to the age of the participants, because older adults have lower work and family responsibilities

Conclusions

Heart rate during HY exercise, asana performance skills and percentage assistance to the intervention program, determined about 42-89% of the changes in cardiovascular health in physically active adult women; additionally, HY has an excellent long-term adherence. Hatha Yoga, such as Silver Yoga, is an exercise with multiple health benefits; it is an easy performing exercise, and it can be safely practiced by adults and elderly individuals.

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