

Effect of Yoga Practice on Blood Pressure

Yoga Therapy Project Report

by

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Dedication

We are grateful in all aspects of our learning for the wisdom and inspiration of TKV Desikachar.

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INTRODUCTION

This paper presents the results of the project we have completed for the Krishnamacharya Healing Yoga Foundation (KHYP) Yoga Therapy Training (North America). For our project, we assessed the effect of therapeutic yoga on a group of participants with high blood pressure. We investigated whether the application of yoga techniques (specifically, yoga techniques oriented toward individuals with hypertension) could result in a measurable effect on an individual's blood pressure.

The central challenge of this project has been learning how to bring together a holistic approach to therapeutic yoga, based on 2000-year-old principles explicated by Patanjali and other fundamental sources, with a methodological approach to validating the effects of yoga that is based on reductionist principles and modern scientific measurement.

Yoga as a Complementary Therapy

Yoga is an ancient discipline that is increasingly being employed in many parts of the world as a complement to allopathic medical treatment (i.e., it functions as a complementary alternative medicine, or CAM). Conditions that are commonly approached through yoga range from structural pain (e.g. back pain, neck and shoulders, knees, etc.) to functional disorders (e.g. asthma), and neurological or circulatory conditions such as epilepsy or migraine. Moreover, restorative yoga is very effective in promoting relaxation for stressful lifestyles. The intention of this study was to explore whether practicing this ancient discipline with a therapeutic emphasis can significantly affect hypertension, a leading risk factor for cardiovascular disease in North America and globally.

In a practical sense, the practice of yoga utilizes various tools to effect a holistic approach to body, breath, behavior, and health. One interpretation of the word "yoga" means to link, which in itself can have many meanings. It may imply tying the strands of the mind together, or linking the body, breath, and deeper mind. Another definition implies "to obtain the previously unobtainable" (TKV Desikachar, Heart of Yoga, p.6) The dimensions and paths of yoga are described in the Yoga Sutras of Patanjali.

Yoga has its origins in India, where it has long been practiced; and aspects of therapeutic yoga have expanded greatly in recent years throughout the world. Hatha yoga is the source of many of the

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contemporary types and styles of yoga. Each of these styles varies, with a different emphasis on the blending of classic yoga tools such as physical movement (asana), breath (pranayama), sound, gesture (nyasa) and meditation. This study utilizes methods of yoga in the tradition of T. Krishnamacharya and TKV Desikachar as incorporated in the training program of the Krishnamacharya Healing and Yoga Foundation (KHYP).

Yoga in the tradition of T. Krishnamacharya, as applied to therapeutic goals, is based on a framework of principles that emphasizes the individual person. This emphasis on the individual is important both as a holistic context for understanding health and in designing an appropriate practice. As a consequence, a condition recognized in allopathic medicine, such as hypertension, does not have a generic prescription of yoga practices that would be applicable to all people, as a pharmaceutical prescription for high-blood-pressure medication might be. Some general principles of yoga can be followed for specific conditions. In the case of hypertension, the principles include avoidance of over-stimulation (strong brahmana practices), and avoidance of certain vigorous movement (vigorous asana) or breathing techniques (pranayama) that could increase pressure on the heart (e.g. strong forward bends, or application of bandhas). In addition, we hypothesized that there could be therapeutic effects on an individual's hypertension, of a yoga practice that integrates breath, movement, and conscious awareness, that can lead to improvement in well-being. Some of these effects may be measurable. It is these effects that this study was intended to explore.

Hypertension

The Centers for Disease Control and Prevention lists cardiovascular disease as the leading cause of death in the United States (www.cdc.gov/nchs/fastats/death.htm). In 2006, 631,636 people died of heart disease, (http://www.cdc.gov/nchs/data/nvsr/nvsr57/nvsr57_14.pdf), which is more than 26 % of all deaths. In 2010, the total direct and indirect cost (including lost productivity, medications, and health care services) of heart disease in the United States is estimated at \$316.4 billion.

Several risk factors can contribute to heart disease. These include inactivity, obesity, high blood pressure, smoking, high cholesterol, and diabetes. High blood pressure (HBP) is a major risk factor for cardiovascular disease in North America, and, according to the World Health Organization, poses

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the highest risk contributing to the cause of death in the world. High blood pressure is costly. The American Heart Association estimated the direct and indirect cost for high blood pressure in 2009 in the United States alone was \$73.4 billion

(<http://circ.ahajournals.org/content/early/2008/12/15/CIRCULATIONAHA.108.191261.full.pdf>)

In the United States, one in three adults has high blood pressure. But, according to the American Heart Association, “because there are no symptoms, nearly one third do not know they have it. Uncontrolled high blood pressure can lead to stroke, heart attack, heart failure or kidney failure” (<http://www.hearthumb.org/hc-high-blood-pressure.htm>). High blood pressure places a higher workload on the heart and arteries, which can lead to damaging of the artery walls, increased buildup of plaque, and hardening of the arteries. Ultimately, this can lead to insufficient blood supply and damage to the body’s organs and/or blood clots, with consequences that can affect the brain (with a stroke or TIA) eyes (with blindness), the heart (with angina, heart attack, or heart failure, i.e. lack of sufficient blood supply to the body), kidneys (kidney failure), and/ or legs (peripheral artery disease).

Risk factors for HBP include heredity, age due to the loss of flexibility in the arteries , gender (higher percent of men above age 45, even percentages between 45 and 64, and above age 64 a higher percentage of women have HBP than men), obesity, smoking, high cholesterol, diabetes, lack of physical activity, and poor diet including elevated salt intake. In addition, stress, smoking, and sleep apnea have a correlation to HBP.

Blood pressure can be classified in two phases: a systolic phase (SBP, a measurement of the heart’s active pumping pressure) and a diastolic phase (DBP, a measurement of the heart’s relaxation phase between contractions, when the ventricles fill). The heart has an intrinsic control of this heart-beat pattern, i.e. it is triggered within its own tissues; and also has extrinsic control, via the autonomic nervous system (sympathetic/parasympathetic) (see http://en.wikibooks.org/wiki/Human_Physiology/The_cardiovascular_system; and http://en.wikipedia.org/wiki/Blood_pressure).

Although high blood pressure is in itself symptomless, it can have serious consequences. People whose blood pressure is higher than 140 systolic or 90 diastolic (measured in mm Hg) are often

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considered to meet the criteria for treatment with medication. Readings above 180 systolic or 110 diastolic are considered severely elevated. Similarly, a healthy heart rate is 60 to 80 beats per minute; an elevated heart rate (>80) is considered a cardiovascular risk factor, as well as a risk factor for increased mortality (<http://www.sciencedaily.com/releases/2010/08/100812151640.htm>). See Table 1 below from the Centers for Disease Control website (http://www.cdc.gov/dhds/dsp/data_statistics/fact_sheets/fs_bloodpressure.htm).

Table 1. Hypertension Thresholds

Blood Pressure Levels	
Normal	systolic: less than 120 mmHg diastolic: less than 80mmHg
At risk (prehypertension)	systolic: 120–139 mmHg diastolic: 80–89 mmHg
High	systolic: 140 mmHg or higher diastolic: 90 mmHg or higher

Stress

Acute and chronic stress are known to greatly increase the risk of cardiovascular (CV) events, as emphasized by Śivaśankaran et al 2006: “Chronic stress doubles the risk of myocardial infarction (MI), while acute psychological stress is a known trigger of myocardial ischemia and acute coronary events”. The interaction of stress and cardiac health, and the experimental studies investigating how yoga practice may affect these conditions, are discussed further in the Literature Review.

Yoga Practices

The yoga practices developed in the context of this study on hypertension emphasized a set of breathing practices coordinated with gentle movement and focused attention, with the specific intention of therapeutic application. For the purpose of this paper, we will refer to this yoga practice as KHYF Yoga, discussed in more detail in the Methodology section.

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Classically, the purpose of asana and pranayama was to prepare for the meditative state, allowing the mind to sustain focus without distraction. In North America today, yoga is commonly understood as a physical (asana) practice. One of the challenges of applying yoga in modern day North America, particularly a yoga practice oriented to helping participants with hypertension, is to provide a practice that will meet the needs of these individuals, but at the same time is not boring, and provokes enough interest that a person is motivated to do the practice on a prolonged, regular basis.

Effect of Yoga Therapy on Hypertension

With this study we intended to determine the effect of therapeutic yoga on hypertension, measured as blood pressure. Given the significant cost of cardiovascular disease, and the fact that high blood pressure is a major cardiovascular risk factor, it is important for society to find effective and inexpensive ways to address this problem. Can yoga, which is non-invasive and is intended to be self-empowering to the participant, be utilized as an effective therapy? If so, which specific yoga tools will be most effective?

II. LITERATURE REVIEW

Yoga has been applied as a complementary alternative modality (CAM) for high blood pressure for some time. Perhaps the most popularly known example is the early work of Dr. Dean Ornish, who included yoga practice in his “heart-healthy” regimen of diet and lifestyle changes (http://www.pMRI.org/dean_ornish.html). This work has been continued by medical professionals trained in asana and pranayama techniques for heart patients (CT Kappagoda, UC Davis Cardiology Rehabilitation Center, pers. comm.).

There is also a quite extensive body of scientific literature on the effects of various yoga practices on blood pressure. We have used over 20 recent published experimental studies in our literature survey, on the effects of yoga on high blood pressure and related cardiovascular health. In addition there are several unpublished studies that can be found at ClinicalTrials.gov, using search terms “yoga” and “heart”. Some of these studies are currently in process, so have not reached publication stage.

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One of the most useful findings was a 2008 review and meta-analysis, carried out by Dr. Ather Ali of Yale University School of Medicine, that evaluated and statistically re-analyzed many previous studies, to compare effects of yoga with other complementary and alternative medicine modalities. He first screened and selected only those studies that had a rigorous statistical design, discarding several studies published previously in the literature. His findings were that yoga practices, more-so than meditation or guided imagery, reduced blood pressure significantly, especially systolic blood pressure. Although his study is not yet published in a journal, he presented the results in 2008 as a recorded talk with Powerpoint slides, both of which are available at this website:

http://apha.confex.com/apha/135am/techprogram/paper_150991.htm.

Moreover, as reviewed by Śivaśankaran et al (2006), multiple studies have shown improvements in parameters of cardiac health due to yoga practices, including decreased systolic and diastolic blood pressure (SBP, DBP), heart rate (HR), and heart-rate variability, a measure of parasympathetic control of cardiac function. Selected breathing techniques (pranayama) alone, as often used in yoga, were shown to reduce the risk of a new coronary event after angioplasty (Śivaśankaran et al 2006).

Stress and Hypertension

Human stress has been shown to lead to autonomic nervous system disorder, i.e. sympathetic rather than parasympathetic responses. The traditional measures of cardiovascular health focus on blood pressure (systolic and diastolic), and heart rate. In recent years, measurement of endothelial vasodilation has been shown to be an independent indicator of cardiac health (Śivaśankaran et al 2006), measured by imaging brachial endothelial vasodilation. Endothelial vasodilation appears to be regulated by autonomic nervous system control (parasympathetic/sympathetic), i.e. stress-response mechanisms.

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The autonomic nervous system (ANS) in turn is a regulator of cardiovascular system. Independently, the vascular endothelial cells, (endocardium), regulate cardiovascular health by controlling vascular dilation. Harris and Matthews (2004) suggest that these two systems, the ANS and the endocardium, work in interrelated ways to govern cardiovascular function. The autonomic nervous system is in dynamic tension with endothelial vasodilation in maintaining healthy blood vessel tone. Endothelial dysfunction may therefore be one step on a path that connects the mind-body continuum, that in turn influences cardiac health. Studying the combination of ANS and endothelial measures could help explain the mind-body continuum from perceived stress to cardiovascular dysfunction, as illustrated in Figure 1 from Harris & Matthews (2004), below.

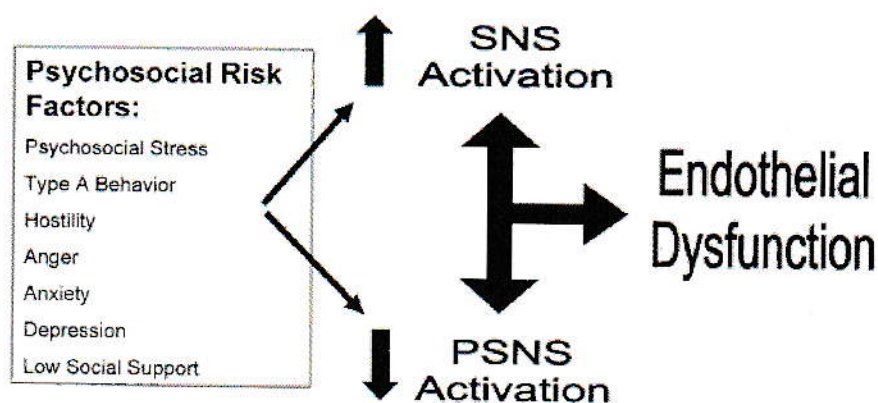


Figure 1. Model of associations between psychosocial factors, autonomic nervous system regulation, and endothelial function.

Yoga, Stress and Hypertension

In a study related to cardiac health and stress, Yogendra et al (2004) found that a year-long course of yoga, in combination with management of diet, stress, sleep, interpersonal relationships, and other risk factors, lowered cholesterol and actually caused reduction in some arterial deposits, in coronary-artery-disease patients. While blood pressure was not measured, they did measure anxiety, and found that to be reduced. The study was a relatively large one (80 initial participants and 60 control group members), and the participants followed a very intensive course of yoga, training together with their families at a Yoga Institute for a weekend, then at intervals throughout the year. Details of the yoga practices were not included in the publication.

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Bhavanani et al (2011) measured the effects of 6 months' training in slow- vs. fast-paced surya namaskara on several measures including brachial cardiac performance, of school children. Cardiac measures included systolic and diastolic blood pressure (SP and DP), pulse (HR), and several measures that were calculated from these numbers. It was found that DP decreased significantly ($P < 0.05$) following slow SN training while pulse pressure ($PP = SP - DP$) increased. By contrast, the fast SN group on the other hand showed a significant ($P < 0.05$) rise in SP following 6 months of training. The main determinant of DP is peripheral vascular resistance/tone, which is modulated by sympathetic tone. A decrease in DP could indicate an improvement in parasympathetic regulation of cardiovascular health, which correlates with the model of Harris and Matthews (Figure 1 above).

Importance of pranayama: recent work

Pranayama (conscious breathing techniques) may have a biomechanical effect on blood pressure: expansion of lungs can activate stretch receptors that affect the ANS (Jerath et al 2006), triggering a parasympathetic response that in turn could influence both the heart rate and circulation. In a study of therapeutic yoga training of HBP patients, Latha (Satish) and KV Kaliappan (1991) showed such a dual effect, in that systolic BP, a measure of heart function, decreased significantly, and finger temperature increased significantly, indicating improved circulation.

At least three studies showing positive yoga effects on blood pressure that were not included in Ali's meta-analysis have recently been published (Barnes et al 2004, Cade et al 2010, Cohen et al 2011). In each of these studies, some form of pranayama practice was given, either as an entire practice, or as part of an asana-pranayama sequence.

1. Barnes et al (2004) gave a simple breathing meditation practice to young student participants (average age 12) for 10 minutes every day for 3 months, compared with a control group. Participants were instructed to focus on the movements of their diaphragm while breathing in a slow, deep, relaxed manner. Significant ($p < 0.05$) differences were found between the breathing-meditation and control groups for resting systolic blood pressure, ambulatory systolic and diastolic blood pressure, and heart rate.

2. As reported by Cade et al (2010), an intensive, vigorous yoga practice was given to HIV-positive participants with hypertension ($>130/>85$) for 20 weeks, 2-3 times per week, that included asana, pranayama, bandhas (locks), and drishti (gazing) – and compared with a “standard care” group. There was no significant difference between treatments, but a lower trend of resting systolic and diastolic BP was observed. The study was carried out at Washington University Medical School, St. Louis, USA.
3. At the University of Pennsylvania Medical School (Cohen et al 2011), a yoga class was given once a week, and a home practice was given, over a 12-week period, compared with “enhanced usual care” control group. The practice included strenuous asana with many forward bends, followed by ujjayi pranayama. There was a significant decrease in 24-hour systolic and diastolic BP for the yoga participants at the end of 12 weeks, but not in the control group. There was a high attrition rate, though, especially among the yoga group, and the participants reported difficulty incorporating into a personal practice.

III. OBJECTIVES OF THE STUDY

Objective 1. The primary aim of this study was to determine the effect of a therapeutic yoga practice on high blood pressure. This main objective can be refined into further sub-objectives:

- A. To determine whether a KHYP-based practice with langhana (relaxation) emphasis and with pranayama as primary tool, focusing on extending exhale, can produce measurable changes in blood pressure of participants over a 12-week period.

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- B. To determine whether a practice as described in A can be learned by participants and established as a home practice within the 12-week period of the study.
- C. To assess the correlation between a regular home practice and positive improvement in BP measurements.

Objective 2. A secondary objective was to conduct a pilot study that might provide us with insight for future research and help shape our practical methods, asking these questions:

- A. How to translate a KHYP practice into a western context for yoga-naïve subjects.
- B. How to translate the individual approach emphasized by KHYP tradition into a systematic, reproducible research study.

To achieve these objectives, we have carried out a two-pronged study aimed at:

- 1) gaining a set of objective measurements of the effects of yoga practice on hypertension; and
- 2) providing training and tools to the participants that will have a beneficial effect on their lives.

IV. METHODOLOGY

Methods Overview

This is an investigator initiated open label, single cohort observational study. Blood pressure and heart rate were recorded at three phases of the project: before the start of the study, after 6 weeks, and after 12 weeks. Blood pressure was recorded using an automated system (Tiba Medical) which is approved for use in a clinical setting. This is a common, non-invasive clinical procedure using an FDA approved device. The device was to be worn by the participant for 24 hours, recording the blood pressure automatically at one-hour intervals. The information was downloaded onto a computer at the end of this period. Participants also maintained a written activity log during the 24-hour period, corresponding to each measurement time, to the best of their ability. Student assistants recorded all the measurements, to avoid any conflict-of-interest.

In addition, students were given a short home practice with instruction to do the home practice daily, and keep a daily home practice log. At the end of the 12 weeks, students were asked to fill out a brief subjective well-being survey.

The classes and virtually every aspect of the project have been carried out as a collaborative effort between us. This provided us both with feedback at every step of the planning and implementation of both the study and the class, and we worked together on completion of the project report as well.

Highlights of Project Development

Pilot Class 2010

In summer, 2010, we organized a pilot class that emphasized techniques that might be effective in reducing stress and blood pressure. The 4-week class utilized KHYF yoga approaches to coordinating breath and breath awareness with gentle movement, using pranayama as the primary tool. The emphasis was on teaching a langhana (relaxation) practice with methods for extending exhale. No measurements were taken. Participants filled out a one-page assessment at the conclusion of the class.

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IRB Approval Process, 2010.

To work with human subjects, approval by the University of California, Davis Medical School, Internal Review Board (IRB) was required. This was a stringent process that required 8 hours of training by both teachers (AMB and TJW) as well as passage of an exam on responsibilities towards and rights of human subjects. Dr. Tissa Kappagoda, professor and cardiologist at UC Davis, served as the Principal Investigator for the project application. The original IRB application was submitted in April 2010. Approval was obtained in November 2010.

12-week class (2011)

1. Participant qualifications

Subjects were drawn from the general population (see recruitment, below). Subjects were selected if they met the following criteria: 1) considered well enough to participate in a yoga program, as certified by their Primary Care Physician with a signed consent form; 2) blood pressure over 120/80 mmHg, whether taking medication or not (an elevation in either number or both numbers was acceptable).

2. Recruitment

Participants were recruited by posting flyers at locations in the city of Davis (the Davis Senior Center, the Davis Athletic Club, the Davis Food Cooperative, several locations on the University of California campus), that contained a description of the study, and our contact information; and by word-of-mouth with local therapeutic fitness teachers (e.g. teachers of yoga, Pilates, Feldenkreis, senior fitness, campus employee fitness, and personal trainers). To complete the recruiting process, two interviews were conducted.

First interview: Each prospective participant was interviewed by phone to ascertain whether they could be included, and asked to submit a signed Physician's Consent Form .

Second interview: After completing the Physician's Consent Form, a second telephone interview with each potential participant was carried out by both teachers together, as required by the IRB process. This interview consisted of question-and-answer about subject's health history, previous yoga experience if any, and goals and interest in

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participating in the study (Appendix A). In addition, participants signed an informed consent form prior to participating in the study.

3. Yoga classes (see below).

4. Exit Interview. On the thirteenth week, the class met in a campus seminar room to thank the participants, to discuss their experiences during the study, and to fill out a participant assessment form (Appendix B).

Yoga Classes

Yoga sessions were conducted once per week, for one hour, over a 12-week period in the summer and fall of 2011 on the University of California at Davis campus. Participants were not offered any compensation for the classes. Classes were designed and conducted according to principles of the KHYP training program, based on therapeutic yoga methods developed by T. Krishnamacharya and TKV Desikachar, and currently in use in the Krishnamacharya Yoga Mandiram (KYM), Chennai, India. These principles of yoga therapy emphasize a holistic approach to mind-body integration, making use of a potentially wide range of possible yoga tools applied in a therapeutic context, i.e. well within an appropriate threshold of activity for participants. In addition, the emphasis of these yoga therapy methods is on self-empowerment of the individual student, i.e. offering training that leads to integrating the practices learned into the daily lives of the participants. The specific tools applied to designing appropriate practices for this study, and the teaching methods used to encourage individual practice, are discussed in detail below (*Practice Approach*).

In addition to the weekly classes, subjects were encouraged to practice at home. A home practice was given each week. Subjects were requested to maintain a diary to record their home practice sessions, and also to note any use of yoga tools in their daily life, in their workplace, or in any particular situations that they found useful.

Practice Approach

The yoga practices in this study were based on the following foundational principles:

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- 1) addressing the person's health or disease in relation to five levels of being (physical, energetic, intellectual, character, and emotional), presented in the classical yoga Pancamaya model, and designing a personal yoga practice based on particular interactions among these levels.
- 2) selection of appropriate tools based on the eight limbs of yoga and additional techniques such as gesture and sound, in designing the practices to affect the whole person; and
- 3) applying these tools in a way that can be modified for each person individually, depending on their needs, desires, and capabilities.

Yoga teachers must consider that all the eight limbs of yoga (yama, niyama, asana, pranayama, etc.) are important for a person's well-being, and must be reflected upon when preparing and teaching therapeutic yoga practices. With that as a high-level general intention, the detailed course planning was designed to address the condition of hypertension in our students. It focused on balancing the body, breath and mind, through teaching techniques of pranayama in combination with gentle asana, sound, and gesture (nyasa), as well as some limited visualization. In addition, since this was a controlled study, we did not discuss diet and lifestyle changes with the participants, but focused only on these specific yoga tools.

Group Class Sequencing

We maintained a conservative set of practices throughout the twelve weeks for several reasons. First, this was a conscious decision to allow the practice to be learned through repetition. The repetition allowed habits to be formed (*samskaras*), so participants had something to carry on into the future. Secondly, since this was a controlled study, we did not want to vary the practices greatly. Third, because the group class included a 79-year-old participant who had had open-heart surgery, and a participant who had had post-quadruple bypass surgery, we chose a conservative set of practices to accommodate the range of capabilities.

The group class was offered in the evening, at 6:00 p.m. From the pilot study in 2010, one of the most important lessons we learned was that participants typically arrived at an evening class feeling tired and "stressed out" at the end of the day. This shaped the strategy for the class practice sequence, as follows:

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Following a brief period of seated conversation, to discuss practical matters:

1. We began the practice with relaxation and breathing, on the back, to allow transition into yoga.
2. Next was a series of breathing and movements lying on the back.
3. Next we moved to seated breath and movement, together with some sound;
4. Then to standing postures;
5. Followed by rest, observing breath on the back, and with simple movement.
6. We ended the practice with seated breathing and sound, accompanied by gesture (nyasa).

The intention was to bring the participants back to focus and prepare them for the transition back to their evening activities.

Diagrams depicting the class practices for the first class, the sixth class, and the twelfth (final) class and an example home practice, are included in Appendix C. The activities within the practices, and the underlying focus for each set of activities are discussed in Table 2, and are summarized below. In the diagrams, pranayama breath patterns are shown as ratios. A single breath is broken into four parts: inhale; hold after inhale; exhale; and hold after exhale. A number is assigned to each part to indicate duration.

Pranayama

In accordance with the principles learned in the KHYF yoga therapy training, and using specific case studies of people with hypertension as presented during our training, we chose pranayama - conscious breathing - as the primary tool for the group practice and the home practice. According to classical yoga texts, pranayama plays a vital role in a person's well-being. In the Yogayajnavalkya Samhita (TKV Desikachar translation, p. 61), the power of breathing links the prana vayu (one of the five main life-force energies) to the distribution of energy (via the nadi-s) and vital nourishment (blood circulation). The heart is within the prana vayu. The inhale is prana (bringing energy in) linking to apana (elimination of impurities), while the exhale is apana meeting prana (Bhagavad Gita IV.28, as cited in Yogayajnavalkya Samhita, p. 75). Together the inhale and exhale lead to elimination of impurities and well-being. A lengthening of the exhale allows further calming and clarification to be achieved. In our modern scientific context, these effects of pranayama would correspond to increasing parasympathetic regulation in the autonomic nervous system.

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The main focus of the pranayama practice was on extending exhale (done without excess) to induce a relaxed state in the body and mind. This focus was presented in many steps to encourage the formation of conscious breathing habits, both in the students' practice and in their daily lives.

1. In the first practices, we taught observation of the natural breath length, while lying on the back after brief relaxation.
2. Then we taught "exhale longer than inhale", lying on the back with hands on abdomen. Later in the class, we taught "exhale 2 times longer than inhale". This number seemed to be an effective instruction, easily followed.
3. In seated position, we taught extending the exhale by counting to fixed numbers (2-0-2-0, 2-0-3-0, 2-0-4-0, etc). The use of fixed ratios seemed to be a less effective method, in the group class setting. Some individuals had very short breath cycles and struggled to get to 2-0-4-0, while others had longer breath cycles and got bored.
4. Still later during the 12 weeks, we taught free inhale followed by exhale with alternate nostrils (anuloma pranayama). The intention of this was to provide added focus on, and conscious control of, the extended exhale.
5. Another approach to extending exhale was the use of sound, see paragraph below.

Asana

Simple asanas were used in the practices. The general principle of pose followed by counterpose was followed. In keeping with the therapeutic approach, classical asanas were modified to more appropriate techniques for this group. The movement in all asanas was coordinated with the inhale and exhale. See Table 2, the diagrams in Appendix A, and the discussion of group class sequencing below. Several simple seated movements (chair yoga) with conscious breathing were taught as tools that the participants could use in any situation (at work, etc.). During class discussion, emphasis was placed on pointing out how the exercises could be adapted to participants' daily lives.

Sound

We began teaching the syllables: "A-lo-ha" in the group practice, beginning in the second week of class, accompanied by niyam (gesture) or other simple movements. This combination of syllables incorporates sounds that can typically be used to contribute to relaxation (aaa, looo) together with

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“ha”, which we did not teach with diaphragmatic expulsion of breath (*maha prana*), so that it was a softer sound. The word “aloha” is well-known to a wide range of people in North America and elsewhere. In Hawaiian, it means a peaceful welcoming or greeting, and it has some feeling of gentle waves in the combination of sounds. Since many people take holidays in Hawaii, “aloha” also connotes a relaxing vacation, which we could suggest to the participants. Finally, the word “aloha” has no religious connotations that might negatively affect people in North America who misunderstand Sanskrit words such as “om santih”.

We also used simpler sounds of “aaaa” and “ooo” in the home practices.

Making the sound was always optional in case anyone was uncomfortable with vocalization, but it seemed that the participants did vocalize.

Gesture

We utilized simple gesture (*nyasa*) primarily by means of touching thumb to fingertips sequentially, as a method of focusing the mind, stimulating the nerves, and bringing focused energy (*prana*) to the extremities.

Home Practice Design

The intention of the design for the home practice was to provide a simple, do-able practice that could be adopted readily in people’s lives. To do this, we based the home practice on elements of the class practice. We also maintained a relatively consistent home practice throughout the 12-week period, again to make it easy for the participants to develop the habits of practice. The practice was intentionally short, to facilitate participants’ willingness to incorporate a home practice in their lives.

Objective Measures

The purpose of this study was to determine the magnitude of possible changes in blood pressure and heart-rate associated with training in therapeutic yoga practices designed according to principles of the KHYP training program. No additional discussions or training about diet and lifestyle were included in this study, so we were measuring only the effects of incorporating the yoga practice into daily life.

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Twenty four hour blood pressure readings were obtained at weeks one, six, and twelve. The heart monitors returned data on the following measures: systolic BP, diastolic BP, and average BP (systolic + diastolic)/2, and heart rate. Measurements were divided into day and night readings, which were analyzed separately.

The end-points of the study were calculations based on the sequential measures, i.e. comparing values between the pre-class measurement, measurement at 6 weeks (1-6), and measurement at 12 weeks (1-12). Two types of calculation were determined: A) the individual average blood pressure (systolic, diastolic, complete; day, night) and heart rate (day, night, and complete); and B) group averages for the same measures.

Data Analysis

A paired Students t-test was used for statistical analysis of the blood pressure and heart-rate data between weeks 1-6 and 1-12, for each individual who completed the study, and as a group average. A p-value of 0.05 or less is required to demonstrate statistical significance.

V. RESULTS

Participant description

Thirteen subjects originally began the study. Nine completed the study. One dropped out without completing the first measurement. One dropped out before the second measurement, due to unforeseen personal health issues. The remaining eleven stayed in the class for the majority of sessions (Table 2). Two of these dropped the class before the final BP measurement due to personal scheduling conflicts, leaving nine total who completed the study. Eight of the nine completers were female, one was male. Of these nine, seven had complete measurements for all three measurement periods. The age range of those who completed the study was 48-79 years. The average age was 65.8 y.

Adherence to home practice

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Participants were instructed to do a home practice, and given a weekly instruction sheet with a short practice utilizing gentle movement, a focus on breath with long exhale, and use of sound and nyasam, as described in the Methods. Participants reported practicing at home an average of at least three times per week (see Table 2). Three of the participants reported practicing at home more than four times per week. Notably, nearly all participants mentioned the usefulness of the breath practice in their daily lives. Participants were also asked to maintain a daily practice log that included any observations about the practice (circumstances, personal effect, etc.). Six of the nine participants submitted practice logs, with varying degree of detail.

Heart Monitor Equipment

Of the nine participants, two did not have complete readings for the second cycle (week 6) due to equipment malfunction. Two participants were required to repeat the week 12 readings, due to equipment malfunction. The total number of participants who completed all 3 measurements dropped from nine to seven.

Statistical Findings - Blood Pressure and Heart-rate Measurements

Class BP Measurements

Seven students completed all 3 measurements (beginning, after 6 weeks, and after 12 weeks). Averages for daytime systolic BP and daytime diastolic BP were computed for each participant, and then the group averages as a whole for Systolic-day and Diastolic-night were computed and analyzed statistically (Tables 5 and 6). Statistical analysis using the t-test did not reveal any significant differences for the class as a whole, between the first and sixth week, although the average systolic and diastolic values both declined. Interestingly, between 6 and 12 weeks, average systolic and diastolic values increased, significantly in the case of systolic BP (Table 6). For the night-time measurements, there were too few valid measures for several individuals; it was not possible to statistically analyze the night-time data, and these data are not presented in the Tables.

Individual BP measures

In comparing the 3 BP measurement time points, we observed statistically-significant changes (i.e. improvements) in some BP measures in a total of 6 participants, as summarized in Table 7. Three participants showed a significant decrease in systolic BP measurement at 6 weeks, compared with

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initial value. Two participants showed a significant decrease in systolic BP measurement at 12 weeks, compared with initial value (one of these also had systolic improvement at 6 weeks). One participant showed significant decrease in diastolic BP, at 6 weeks; and one other individual had significant decrease in diastolic BP at 12 weeks.

One of the above 6 participants (3W) showed statistically-significant improvement in systolic BP, between the first and second measurement (6 wk); and also between the first and third measurement (12 wk).

For the rest of the measurements, including all of the night values (data not shown), and including measurements for individuals who participated in the class but did not complete 3 sets of measurements, we observed no statistically-significant change one way or the other.

Heart rate

Two participants in the class showed a significant change (lower) in heart-rate, either at 12 weeks, or at both 6 and 12 weeks (Table 7). One of these participants had a significant change (lower) in DBP at 12 weeks, as well.

Weight Loss

Two completers (3W and 7D) mentioned the desire to lose weight. Although we did not measure weight or BMI in this study, these two were, by inspection, the only two of the completers with an apparently high BMI. Of these two, one lost 30 pounds during the study and stated during the exit interview "I find I can eat a lot more healthy (*sic*) and maintain a sense of well-being."

Participant Perception of Yoga Effects

Participants generally reported a sense of well-being from the classes. Participants particularly mentioned the use of breath techniques as useful and beneficial, as well as a portable tool that can be used anywhere, anytime. Effects reported by individual participants included: ability to sleep;

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incorporating a daily practice; weight loss; moderating stress at work; moderating stress during commuting. Direct quotes by participants are shown below:

Overall

“I believe this class saved my life”.

“I’ve tried everything. It’s been a life-saver in my very stressful life.”

“I hope the awareness of the power of it never subsides.”

“I was amazed at how stressed I felt coming in at the start, and how much calmer I was at the end of each class.”

“Breathing as taught has been invaluable to me.”

“I use it in the morning to face fear.”

“More positive outlook on life, less depression”.

Practice

“I can bring myself to deeper slower breathing more quickly now, and am more aware when I am starting to get stressed.”

“I will add more conscious breathing to my asana practice, and practice more frequently.”

“The combination of breath and movement provides a way to start...meditation. It showed me another tool that would be useful to control my blood pressure. Seems to work about the same as meditation.”

“I definitely felt relaxed after doing just 10 minutes of yoga (which for me was only deep breathing).”

“Breath alone sometimes, but movement to add a focus.”

Lifestyle

“Many times I utilized one or two of the exercises. The finger-touching (nyasa) was a favorite. Other times, I’d be driving, in an elevator, or waiting for something, and I’d breathe.

“I notice that when I was tired mid-day, the practice would make me feel better.”

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“Of particular use was the chair yoga that I could do either in my office or after pulling over to the side of the road on a long commute (after getting out of heavy traffic of course).”

“Plan to use breathing (counts) at stoplights, meetings, boring waiting, lines, etc., because it would be easy to do inconspicuously.”

“The class has brought an awareness to me about how I can manage (immediately) anxiety and stressful situations.”

“Most specifically the breathing, is something I can do at any time without drawing attention to myself.”

“I slept for the first time in years.”

“I sleep much better and can cope much better in stressful situations.”

“My blood pressure has gone back to normal range. I find I can eat a lot more healthy to maintain a feeling of well-being.”

“Breath alone sometimes, but movement to add a focus.”

“I incorporate it with prayer and sometimes just do deep breathing.”

“I have already incorporated some movement while in a warm exercise pool.”

“My ability to cope is definitely improved!”

“I have more energy, lost 30 pounds, and find a feeling of well-being when I do the exercises.”

VI. DISCUSSION OF RESULTS

Findings

Individual improvements in the three blood pressure measurements (systolic BP, diastolic BP, and heart rate) were observed in several – but not all -- participants. The majority of the improvements observed were in systolic blood pressure. There was no obvious pattern of correlation between systolic v. diastolic improvement, or whether the participant was on medication or not. We also found that improvement in blood-pressure values did not correlate with whether the participant was on BP medication or not.

Regardless of whether the objective measures improved, nearly all participants reported many subjective benefits from the practice, including feeling more relaxed. Even those participants who

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are on medication reported that they appreciated and utilized the yoga tools to calm and feel better, and to better deal with life situations. As illustrated in the direct quotes from the previous section, some participants reported dramatic results from the yoga practices, and nearly all comments we received were positive.

Home Practice

The most striking outcome we observed was the correlation between keeping a detailed daily practice log and presenting statistically significant improvement in blood pressure results. Three of the participants who maintained regular practice logs with self-observation notes showed decreases in systolic or diastolic BP between measurement dates, and in one case, heart rate. This may be related to the increased awareness each participant had of 1) the practice itself, and 2) their response to the practice. This increased awareness would correspond to the yoga concept of *svadhyaya* (study with self examination).

Several participants experienced a drop in blood pressure over the first six week period, but the drop was either not maintained, or did not continue its downward trend. Something changed after the second set of measurements, after 6-8 weeks of the class. The downward trend (i.e. improvement) in systolic and diastolic blood pressure was reversed between weeks 6 and 12. Class attendance was not as consistent, and two participants did not remain in the study.

There are several explanations for these observed patterns.

First, it is plausible that there was a “ceiling effect” - an initial period of progress as the participants learned the relaxation practices and implemented changes in their habits, that reached a plateau after about 6 weeks, when the maximum benefit was gained from the specific practices that we taught. After this, little further gain could be achieved with that particular set of practices. As we point out in the group class sequencing discussion, we maintained conservative practices over the course of the twelve weeks. If such a ceiling effect was experienced, then long-term effects of therapeutic yoga as taught in this type of group setting may require a different strategy starting at 6 weeks.

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Secondly, a major part of the plateau in this study is likely to be attributable to the fact that the study was strictly focused on effects of yoga practice, and did not include any attention to diet or broader lifestyle changes. Diet and lifestyle changes have been shown to play a major role in reducing symptoms associated with hypertension and improving cardiac health (Yogendra et al. 2004, and the Ornish study).

Third, the mid-point of the course corresponded to the end of summer and the summer vacation season in California (Sept. 16), with a transition to less sunlight and colder weather. People's lives may change as the seasons change. As focus changes in their lives, yoga practice may not be as diligent. We could also speculate that seasonal change itself, with all that it brings, may have influenced the relationship of the students to the yoga practice they had established, and they were not able to adapt.

Fourth, at least six of the students reported that new events in their lives had created extremely stressful situations. These included: a job promotion with more hours and responsibilities; a hostile neighbor; moving the entire household to another city; emotional stresses within the home; increasing incapacity in elderly spouse; and increased chronic pain (hip). Yoga practice may be dropped when stresses are high, and this was reported by some participants – even though several students recognized that these are the times when their yoga practice can help them most usefully. In addition, since our yoga class was also a scientific study, some participants may not have had the capacity to tolerate continued participation in a project that was inconvenient or uncomfortable, once they had learned the basic techniques.

Although we distributed home practice sheets each week, a number of the participants noted that the practice sheets were difficult to follow during the first few weeks. These remarks lessened as the classes proceeded. This may be due to the fact that the asana and pranayama were not so strange, and could be incorporated into daily life more easily. This is consistent with Patanjali's Yoga Sutra 1.18 (Desikachar 2010) which states that a new activity slowly becomes internalized with practice and familiarization, "at first this understanding is at a more superficial level. In time, comprehension becomes deeper".

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Other Factors

No doubt other factors in individual lives and lifestyles have strong influences on hypertension. For example, one participant who had no significant change in blood pressure values, and who was on BP medication, also had a long-standing meditation practice (a guided meditation CD that he has followed faithfully since rehabilitation from cardiac surgery). It may be that the combination of medication and a daily meditation practice had already reduced his BP to a point below what could be improved upon by our classes. His starting BP values were already lower than the defined values for "high blood pressure." This participant reported that, from his perspective, the effect of the yoga practice was similar to that of meditation, and that he appreciated having an additional set of tools at his disposal. It is interesting to consider the potential effects of a meditation practice, and compare these to a therapeutic yoga practice. There are shared elements of mindfulness in yoga and meditation; a yoga practice itself is a path to meditation, as described in the Yoga Sutras. Ali et al. (2008) found in their meta-analysis that, among published studies, yoga practice gave significantly greater improvement in reducing BP than guided meditation. It may be that, particularly for hypertension, pranayama and gentle movement are able to more specifically address high blood pressure than other modalities, through biomechanical stimulation of parasympathetic controls, as described in the Introduction.

Other Considerations

There are limitations inherent in the use of blood-pressure measurements as an indicator of cardiovascular health. As noted above, blood pressure is highly variable. It can vary within a single twenty-four-hour period, from week to week, and month to month. The blood-pressure comparisons between time-points of the study were based upon three 24-hour measurements, beginning with a single baseline measurement. Utilizing a single set of measurements as a baseline, rather than, for example, a series of measurements over 1-2 weeks before beginning the classes, may skew results. In future studies, a more frequent measurement interval, beginning 2 weeks prior to the start of classes and continuing throughout the experiment, could improve the accuracy of the findings.

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Furthermore, the equipment utilized in our study to take the twenty four hour readings was cumbersome and uncomfortable. Measuring BP with the inflatable cuff was onerous for the participants. It seems likely that the process of taking measurements caused stress in itself. Future experimental design should consider the negative effect of the methods on potential results.

In future studies, these limitations could be addressed by exploring additional measurement techniques. Measurement of blood pressure values may not give as much information about parasympathetic responses as other possible measures. For example, galvanic skin response, electrocardiograms, or measurement of cortisol levels in the blood are all methods that are relatively simple and non-invasive, but that provide information about the autonomic nervous system responses. Brachial endothelial vasodilation is another indicator used in some studies (Śivaśankaran et al 2006) although it requires specialized equipment in a medical facility. In addition, finger thermocouples, as described in Latha (Satish) and Kaliappan (1991) provide a non-invasive, indirect measurement of improved circulation corresponding to increased temperature.

Study structure

Our project study comprised a much smaller cohort than some of the major university-based medical studies currently ongoing. One consequence was that it was not possible to obtain valid statistical values for group patterns. However, we could observe trends in individuals, by comparing across the three sampling times for each individual.

There are two other primary considerations in designing a future study. 1) A large enough number of people should be included in the study to permit robust statistical evaluation. A minimum of 30 people per treatment could be regarded as a statistical baseline.

2) The study should include both “treatment” and “control” groups. Treatment groups could comprise stand-alone yoga training; and yoga plus lifestyle education. Corresponding control groups given standard health care instructions should also be included. Effects of yoga on medicated and non-medicated participants could also be evaluated.

Participant subjective measures

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For our study, we asked participants to complete a short questionnaire at the conclusion of the study, to assess the perceived benefits. A future study could use more detailed and standardized assessments including psychological measurements, to more fully contribute to the body of scientific knowledge.

Course Design

We encouraged participants to incorporate parts of the practice in their daily activities. It was one of our goals in teaching to give the students tools that could be applied to reduce stress in daily situations, focusing on the immediate problem of hypertension. This goal was achieved. As reflected in their comments, they used the practices often in their day-to-day situations.

Our second main goal as teachers was to encourage students to maintain a daily home practice, which could allow them to follow a path of long-term personal transformation. These two goals are not interchangeable. Foundational to the KHYF method is encouraging students to do a daily prescribed practice. This develops self-empowerment (svatantra), self awareness, and the observational skills that will allow participants to modify their behavior and cope with stress by employing the yoga tools they have learned. The prescribed practice is important and can lead individuals to expand capabilities to apply pieces of the practice in day-to-day situations.

It may be useful to consider these possibilities when the yoga teacher is designing a course plan for a small group, or for an individual student, over a period of time. How can yoga teachers strengthen the relationship between the student and his or her practice, so that they are sustained through periods of fluctuation or extreme stress? This is especially important to consider for students who lack previous yoga experience, and so are not skilled in modifying their own practices. Such is likely to be the case, for the most part, in North America. Life changes and other factors that contribute to stress should also be considered in future studies.

For future studies, we recognize that a dynamic tension exists between focusing on the therapeutic intent, and carrying out a scientific study that can be reproduced. In our case, because of the group class framework and the fact that we were constrained by the experimental component of our project, we were limited in being able to refocus the practice appropriately for each individual's life.

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This leads to the larger question, how to design a standard yoga practice, for the purpose of controlled research studies about therapeutic yoga applied to a group of individuals. There are many elements to consider within this larger question: which combinations of yoga tools, practice frequency, and length of practice are most effective? Moreover, in surveying the literature as a whole, there are many approaches under the label of “yoga”, with different emphases and tools employed. A more precise delineation of the specific yoga practices applied in therapeutic experiments is needed in conducting future scientific studies.

VII. CONCLUSIONS

In conclusion, we found that some of the participants who completed the study experienced a statistically significant drop in systolic blood pressure, especially between the first and sixth weeks. From this we can conclude that the yoga practice was effective and merits further study. For such further experiments, a larger study group with appropriate controls is needed for statistical soundness.

Those participants who showed positive results were those who practiced and kept records. The efficacy of yoga as a tool is highly dependent upon a participant’s willingness and capability to do a daily practice. It may be that in our contemporary cultural context, keeping a log is a way to focus attention and maintain dedication to practice.

In future studies, a variety of indicators could be monitored in addition to the direct measurement of blood pressure. Additional measures could reveal more information about the connection between the circulatory system and parasympathetic feedback interactions that may be pertinent to therapeutic yoga. These can include: galvanic skin response, thermal skin response, electrocardiogram, endothelial vasodilation, and other measures of ANS such as blood cortisol levels.

The study participants reported many very positive subjective responses to the yoga practice that they learned. To quantify participant self-perception, standardized psychosocial tools and surveys

could add valuable dimensions to future experimental design.

Finally, to explore the question of whether or not a ceiling effect was experienced in the group therapeutic yoga course, and to better help participants to adjust to ongoing fluctuations in their lives, it might be useful to combine a group practice in the early stages, to enable this yoga-naïve population to learn basic yoga skills applicable to hypertension, with subsequent individual practices developed within a set of appropriate guidelines.

Table 2: Course Sequence in Relation to Focus	
Activity	Focus
Begin on floor to connect to breath, transition in to class. Extending exhale. Easy movements of the core, with breath.	Relaxation of body and mind, stress reduction, breath awareness. Bring prana to core and link prana to apana.
Easy movement of joints and pelvic tilt.	Bring prana to extremities and increase circulation.
Transition to sitting and fully engaging spine. Diaphragmatic breathing; pranayama to extend exhale (ratios); sound and nyasa,	Bring circulation and prana to spine and up from the (sitting) base. Core relaxation and attention.
Standing for gentle dynamic asana with breath; crown asana requiring balance and strength.	Coordination of entire body and breath, increase concentration and circulation.
To floor for relaxation. Focus on relaxation and breathing.	Hands on the cakras allowing the prana to permeate; relaxation and preparation for meditation.
To sitting for conscious breathing, nyasa and sound, followed by transition back to evening activities.	Simple pranayama and meditation and transition back to normal life activities.

Table 3: Course Sequence Components

	Week 1	Week 6	Week 12	Home Practice
Class Sequence	1)Begin on floor to transition, connect to breath, easy movement. 2)Sitting for pranayama, fully engaging spine, diaphragm. 3)Standing crown asana. 4)To floor for relaxation. 5)Sitting for pranayama, transition to evening activities.	Same	Same	1) Begin on floor to connect to breath, body. 2) To sitting asana, engaging entire spine. 3) To seated pranayama with extended exhale. 4) Write down any observations on practice log. Note: The home practice was intended to be short (fifteen minutes), and similar to the corresponding class practices, for continuity.
Primary Goal	Connect to breath	Extend Exhale	Extend Exhale	Extend Exhale
Secondary Goal	Coordinate breath and movement	Coordinate breath and movement	Increase concentration Gentle movement	Increase concentration Gentle movement
Tools Utilized				
Asana	Lie on the floor for most asana, Gently engage spine with pelvic tilt, arm & leg movement gentle twist, Introduce coordination of breath and movement	General pattern same as Week 1 Engage entire spine in seated cakravasana	General pattern same as Weeks 1 & 6, except began standing due to cold room. Seated cakravasana with breath ratios, exhale longer than inhale, sound to increase concentration.	Gentle movement. Seated cakravasana to engage entire spine. Hands on stomach, heart, eyes, etc. to facilitate connection of body and breath.

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Pranayama	Connect to breath by hands on abdomen	Exhale longer than inhale, and notice pause at end of exhale in order to extend exhale. Introduce counting number of breaths to increase concentration.	Add breath ratios: 1:0:2:0 and add increasing exhale via ratios to build exhale. Do this in combination with asana.	
Nyasa	Touch thumb to finger in rhythm to breath to increase focus	Same gesture & sound to increase concentration & extend exhale.	Same	Same
Sound	----	Introduce easy sound with movement to extend breath. Sound at end of practice to facilitate meditation.	Same	Easy sound at end of practice to extend exhale and facilitate meditation.

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Table 4. Participant description: Age, whether or not on medication for High Blood Pressure, reported home practice frequency, and whether they kept a log of their home practice.

Student ID	Age	HBP medication	Home practice frequency	Home practice log
1A	55	no	3x/week avg	yes-regular
2S	49	no	3x/week avg	no
3W	60	no	almost every day	yes-regular
4B	62	yes	almost every day	yes-regular
5H	72	yes	3x/week avg	yes - not regular
6J	73	yes	3x/week	yes- regular
7D	64	yes	4x/week avg	no
8T	79	yes	5x/week	no
9HO	77	yes	4x/week avg	yes - regular
10K	65	yes	unknown	no
11B	62	yes	unknown	no

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Table 5. Class averages for daytime measurements: Systolic (S), Diastolic (D), average (S+D/2), and pulse. Statistical analysis of change between any of the measurement dates (M1-M2, M2-M3, or M1-M3) showed no significance in any of these values. Night-time measurements were also not statistically different (data not shown).

Identity	Measurement periods			Systolic (day)			Diastolic (day)			Pulse (day)		
	M1	M2	M3	M1	M2	M3	M1	M2	M3	M1	M2	M3
1A	115.1875	122.3125	120.0714	66.5625	60.8125	58.14286	77.6875	79.375	69.85714			
2S	120.5833333	110.1176	121.8571	87.66667	78.23529	86.64286	84.33333	87.11765	91.57143			
3W	144	126.9333	129.5385	82.66667	81.26667	71.92308	85.91667	73.6	75.84615			
4B	110.1428571	109.5714	115.9375	60.57143	62.21429	68.1875	72.21429	64	62.625			
6J	141.9333333	126.8571	138.9286	77.53333	76.14286	82.35714	85.73333	88.92857	91.78571			
7D	112.3571429	120.9286	122.4286	66.35714	64.28571	69.21429	60.57143	63.14286	61			
9HO	143.9333333	134.8571	149.1333	76.06667	64.85714	69.76923	81	60.78571	57.58333			
Average	124.0340278	119.4534	124.7936	73.55962	70.49289	72.74462	75.51284	76.02735	70.49995			

Table 6. Class p-values calculated from Table 5, based on Student's t-test. Comparison between the measurement dates (intervals M1-M2, M2-M3, or M1-M3). Night-time measurements were not statistically different (data not shown).

Interval	Systolic (day)	Diastolic (day)	Pulse
M1-M2	0.230697047	0.055190276	0.262689
M2-M3	0.03138921	0.312511116	0.612311
M1-M3	0.664280844	0.570820386	0.239294

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Table 7. P-values for individual students. Statistical significance of positive changes in BP values of individual study participants, comparing between measurement dates: 1st and 2nd measuring date (M1-M2), or 1st and 3rd measuring date (M1-M3): Day-Systolic BP (average), Day-Diastolic BP (average), and Day -Heart Rate (average). P-value is a measure of statistically significant difference, based on Student's t-test; .05 threshold for statistical significance. ns = not significantly different; n/a = values not able to be calculated. Student IDs correspond to those in Table 4.

Student ID	Measurement		P-Value	P-Value	P-Value
	Date Comparison	(M1 - M2, M1-M3)			
1A	M1 - M2		ns	ns	ns
	M1 - M3		ns	ns	0.00301159
2S	M1-M2		0.00658598	0.0064357	ns
	M1 - M3		ns	ns	ns
3W	M1-M2		0.00064873	ns	ns
	M1 - M3		0.013362	ns	ns
4B	M1-M2		ns	ns	0.003011593
	M1 - M3		ns	0.024728	0.002342451
5H	M1-M2		n/a	n/a	n/a
	M1 - M3		0.035941	ns	ns
6J	M1-M2		0.000793057	ns	ns
	M1 - M3		ns	ns	ns
7D	both		n/a	n/a	n/a
8T	both		n/a	n/a	n/a
9HO	both		ns	ns	ns
10K	both		n/a	n/a	n/a
11B	both		n/a	n/a	n/a

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APPENDICES

Appendix A: Entrance Interview Questionnaire

Appendix B: Exit Interview Questionnaire

Appendix C: Class Practice Examples: First Practice, Sixth Week Practice, Twelfth Week Practice; and home practice.

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Date: _____

Appendix A: ENTRANCE INTERVIEW QUESTIONNAIRE

Yoga and Blood Pressure Study Participants

Thank you for contacting us again with the clearance from your physician. As I mentioned during our previous conversation, I have a few more questions for you to decide on your eligibility to participate in this study. This conversation will take about 20 minutes. You could terminate this call at any time. If you elect not to continue, your continued care at UC Davis will be unaffected. If you wish additional details you could also contact Dr. C.T. Kappagoda on his pager (916 762 5791).

Name:

Age:

Gender:

Occupation:

Reasons for participating in this study:

Health Information:

Are you under treatment for any condition by a doctor?

Do you consider your appetite to be:(Circle one): Excessive Normal Low Very low

Do you have any problems with sleeping? Sleep Onset _____ Sleep Continuity _____

What is your overall energy level? (Circle one): High Average Low Very low

Are you taking medication for high blood pressure? (Y/N)

Do you exercise regularly? (Circle one) Daily 2-3 times/week Once/week

Duration of a session: (Circle one) 30 min 30-60 > 60 min

Other Life Activities or hobbies:

Do you know your blood pressure?

Date:

Blood pressure _____

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Would you be willing to try a daily ten minute practice?

If so, what time of day would you do this?

Thank You!

That concludes the interview. We will contact you within a few days about your eligibility to participate in this study. If you are eligible and still willing to participate, it would be necessary for you to meet me (Name.....) to go over the consent form and sign it.

If you are not eligible for the study or if you decide not to continue with the study when we contact you again, your involvement with the project will be over and no information about you will be retained. In the meantime, any information you have provided will be maintained in a secure place accessible only to the investigators.

I want to advise you that there is no compensation offered for participating in this study.

Instructor Observations

Appendix B: EXIT INTERVIEW QUESTIONNAIRE

1. Has this class helped you? How?

2. Was the combination of breath and movement helpful?

3. Do you have plans to continue your personal practice? How?

4. Have you noticed any change in your level of stress or ability to cope with stress?

5. Change in your overall energy level? Have your sleep patterns changed? Other physical or mental changes?

6. How often on average did you practice between sessions? We have your practice logs, but please describe in a few words how you did a practice between sessions? Did you use the class tools in other ways (breathing/moving; chair yoga; etc.)?

7. Were any aspects of the practice particularly difficult or easy for you:
(Practicing in daily life, specific physical movements, understanding inhale and exhale, other)?

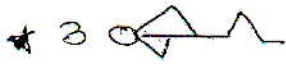
8. Additional comments:

8¹⁰ - 11 First Class


1. Intro-circle time





★ 2.  IN Ex FREE



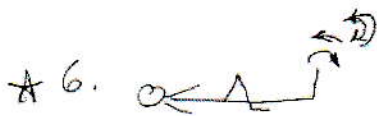
⑤ 11.  REST 

4.  PELVIC TILT
→ EX
← IN

② 12.  → EX
← IN 


★ 5.  → IN
← EX  ONE ARM AT A TIME


★ 13. 



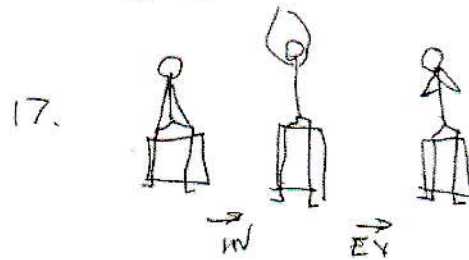
① 14.  PALMING





★ 7.  shoulder rolls

★ 16.  NYASA
4 X FREE

★ 8.  Head Nod



9.  → IN
← EX 

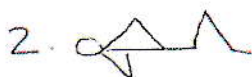
THANK YOU

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8-10-11 TAKE HOME PRACTICE AFTER FIRST CLASS



INHALE & EXHALE FREE 8 BREATHS



HAND ON HEART
HAND ON STOMACH 8 BREATHS

3A



SHOULDER ROLLS

3B. OPTIONAL - FAVORITE MOVEMENT FROM CLASS

4.



TOUCH THUMB TO INDEX ONE BREATH

" " " MIDDLE " "

" " " RING " "

" " " PINKY " "

ONE ROUND IS FOUR BREATHS

REPEAT FOR TWO ROUNDS TOTAL

9-14-11 SIXTH PRACTICE

PAGE ONE

1. INTRO

- Possible Recording
- MONITOR SCHEDULE
- HOME PRACTICE GOING WELL
- BREATHING TIPS
- BASE OF SUPPORT REVIEW

TJ AB



TJ



TJ

6x EXHALE LONGER THAN INHALE
NOTICE PAUSE AT END OF EXHALE



AB

PELVIC TILT 6x



TJ

6 BREATHS EACH POSITION



AB

→ IN



→ EX

pelvic tilt



6x

last 3 x
alternate



TJ



AB



6x EACH SIDE



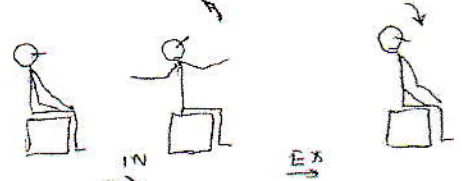
AB



9-14-11

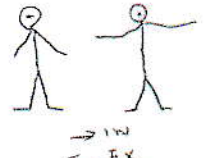
SIXTH PRACTICE

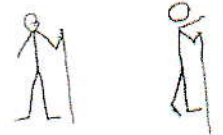
PAGE TWO

10.  6x

11.  6x

12.  IN FREE EX AL LO HA 3x
IN FREE EX "AAA" 1x


13.  IN PALMS UP 6x
EX PALMS DOWN

14.  6x

15.  REST

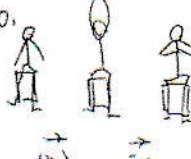
16.  6x EACH SIDE

17. 

18.  6x EACH POSITION
EXHALE LONGER THAN INHALE
NOTICE PAUSE AT END OF EXHALE


19. 

NYASA
IN FREE EX "AAA" 8 BREATHS (2 ROUNDS)
IN FREE EX SILENT 4 BREATHS (1 ROUND)


20.  IN EX

9-14-11 SIXTH HOME PRACTICE

1.  INHALE & EXHALE 6 BREATHS

2.  6 BREATHS HANDS ON STOMACH
 6 BREATHS HANDS ON HEART
 6 BREATHS HANDS ON EYES
 6 BREATHS HANDS MOST COMFORTABLE PLACE (FLOOR, STOMACH, ETC.)

EXHALE LONGER THAN INHALE IN ALL POSITIONS

3.  INHALE: PELVIS ROLLS FORWARD, BACK ARCH ^(SOFT)
 EXHALE: NAVEL TOWARDS SPINE, BACK ROUN ^(SOFT)
 6 REPETITIONS

TOUCH THUMB TO INDEX ONE BREATH

4.  " " " MIDDLE " "
 " " " RING " "
 " " " PINKY " "

ONE ROUND IS FOUR BREATHS ^{CHANT (ALoud OR SILENT)}

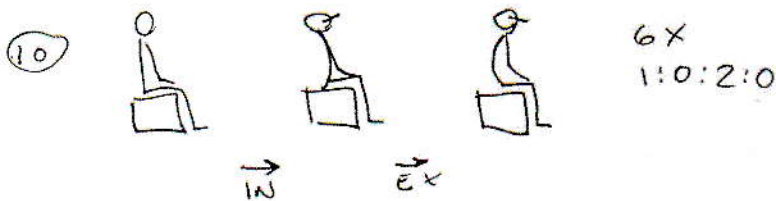
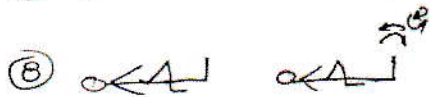
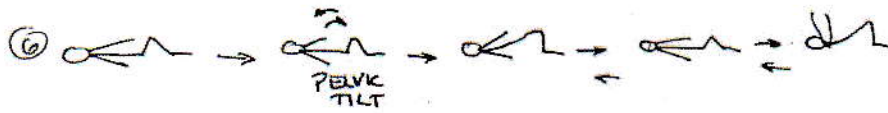
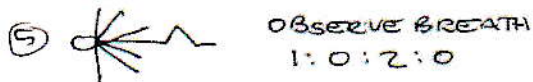
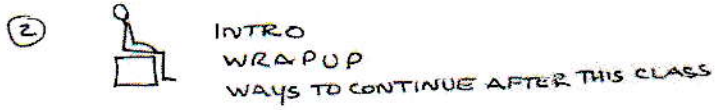
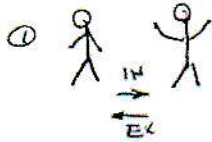
FIRST & SECOND ROUNDS: FREE INHALE, "AAA" ON EXHALE

THIRD ROUND: FREE INHALE, FREE EXHALE

DAY	PRACTICE (Y/N)	SELF-OBSERVATIONS
		At home? At work? AM/PM? Chair-yoga? Breathing practice? Bringing awareness?
Wed	Y (Class practice)	
Thu		
Fri		
Sat		
Sun		
Mon		
Tue		
Wed		

10-26-11 TWELFTH PRACTICE

PAGE ONE




10-26-11


TWELFTH PRACTICE

PAGE TWO


11  6x
FREE IN, FREE EX


→ IN
← EX

12  Balanced Weight
1:0:1:0 6x


13  6x EACH SIDE

→ IN
← EX


14  UMPIRE


15  REST
OBSERVE NATURAL BREATH

16  4x EACH SIDE

17  REST

18  FREE INHALE BOTH NOSTRILS OPEN
BOTH HANDS ON LAP
EXHALE ONE NOSTRIL BLOCKED
ALTERNATE SIDES EXHALE

19  NYASA FREE INHALE
AA LO HA EXHALE

20 

Yoga Therapy Project: Effect of Yoga Practice on Blood Pressure

10-26-11



Gy



INHALE & EXHALE
FIND NORMAL BREATH RHYTHM



6 BREATHS HANDBON STOMACH
" " " HEART
" " " EYES
" " " MOST COMFORTABLE PLACE



Gx

5: MOVEMENT OF CHOICE Gx



ALTERNATE NOSTRIL
FREE IN
EXHALE LEFT NOSTRIL CLOSED
FREE IN
EXHALE RIGHT NOSTRIL CLOSED

THESE 4 STEPS
ARE ONE
ROUND



NYASA TOUCH THUMB TO INDEX
" " " MIDDLE
" " " RING
" " " PINKY

ONE ROUND

FIRST AND SECOND ROUNDS INHALE SILENT EXHALE "AAA"
THIRD ROUND EXHALE TWICE AS LONG AS INHALE
FOURTH ROUND FREE INHALE, FREE EXHALE

OBSERVATIONS :

Effect of Yoga Practice on Blood Pressure

Yoga Therapy Project Report

by

Alison Berry and Terri Wegener

Submitted to the Krishnamacharya Healing Yoga Foundation

North America Batch, Yoga Therapy Training Program

February 29, 2012