EFFECTS OF HATHA YOGA TRAINING ON HEART RATE AND BLOOD
PRESSURE RECOVERY FROM EXERCISE

HUMBOLDT STATE UNIVERSITY

By
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ABSTRACT

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PURPOSE: The primary purpose of this study was to determine the effects of yoga training on heart rate (HR) and blood pressure (BP) recovery from a standardized exercise bout. The researchers also aimed to determine if there is modulation of autonomic function, specifically enhanced vagal nerve reactivation (i.e., enhanced parasympathetic activity) and concomitant withdrawal of sympathetic activity, resulting from the yoga training. A quasi-experimental design was used. METHODS: Two groups of 18-25 year old subjects (n = 8 yoga, with 3 males and 5 females; n = 7 stretch and relax [S&R], with 3 males and 4 females) were recruited from activity courses at Humboldt State University. Subjects were tested before and after 4 weeks (two times per week, at 50 min/session) of yoga or S&R class. A graded exercise test on a cycle ergometer was used to determine maximal oxygen uptake (VO_{2max}) pre-intervention. Recoveries (R) from two submaximal tests (at 40% of VO_{2max} and 85% HR_{max}), administered before and after the interventions were used to measure HR, systolic blood pressure (SBP) and diastolic blood pressure (DBP) at 0, 2, 4, and 6 minutes, as well as T30 and Delta 60 (measures of HRR and autonomic function). To determine if there were differences in the hemodynamic variables (HR, SBP, DBP, and rate-pressure...
product [RPP]) between pre- and post-intervention depending on group and time-period of recovery, four 2 X 2 X 4 mixed factorial ANOVAs were computed (time X group X time-period of recovery). Two 2 X 2 (time X group) mixed-factorial ANOVAs were computed to determine if there were differences in HRR. RESULTS: No significant interactions ($p > .05$) between time, group, and time-period of recovery were found for HR, SBP, DBP, or RPP. Similarly, no main effects for group were found with respect to these four dependent variables. As expected, there was a significant main effect for time-period of recovery (i.e., 0, 2, 4 and 6 minutes) for HR ($p = .000$), SBP ($p = .000$), and RPP ($p = .000$), but not for DBP ($p = .142$). A significant effect for time (pre- vs. post-intervention) was found for SBP ($p = .028$), but not for HR ($p = .622$), DBP ($p = .076$) and RPP ($p = .094$). No significant ($p > .05$) interactions or main effects between time and group were found with respect to either HRR variable. DISCUSSION/ CONCLUSION: Across all time-periods of recovery, the interventions collectively resulted in significantly lower mean SBP, with trends towards lower DBP and RPP post-intervention when compared to pre-intervention. Yoga training did not result in any better recovery from an exercise challenge than did S&R. No significant changes in autonomic function (HRR) were observed. Absence of a non-intervention control group, the short duration of the interventions, and measurement issues may have influenced the findings.
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CHAPTER ONE

Introduction/Literature Review

Yoga is an ancient discipline which promotes integration of spiritual, mental, and physical parts of one’s being (Coulter, 2001; Jayasinghe, 2004; Raub, 2002; Ross & Thomas, 2010a; Selvamurthy, Ray, Hegde, & Sharma, 1988). Yoga training can induce significant and broad-ranging health adaptations in both healthy and chronically-diseased subjects, as has been demonstrated in randomized controlled trials (Cohen et al., 2009; Cohen, Warneke, Fouladi, Rodriguez, & Chaoul-Reich, 2004; Garfinkel et al., 1998; Oken et al., 2004; Smith, Hancock, Blake-Mortimer, & Eckert, 2007). According to Patanjali’s codification of the sutras, the [health] benefits of the practice of yoga are from the physical action of the posture while holding focus of thought and smooth breath (Desikachar, 1999; Dunn, 2008; Iyengar, 2009).

Adherents to the science of yoga emphasize that all eight aspects of the discipline are important to the practice of yoga, and that yoga is much more than the physical postures alone (Goldberg, 2010; Jeste & Vahia, 2008). These eight “limbs” provide the foundation for the spiritual and ethical basis of yoga practice (Iyengar, 1979; Yogananda, 2000); they allow the yoga practitioner to accomplish physical postures (asanas) requiring balance, flexibility, strength, focus and concentration, harmonizing the body and mind to allow for breath practice (pranayama) and meditation (dharana—one pointed concentration) (Telles & Desiraju, 1992). While there are many forms of yoga (e.g., Bhakti, Janu, Mantra), Hatha yoga, which is considered to have a strong physical
component, has been one of most widely studied. Hatha yoga involves physical exercise, coupled with disciplined breathing and focused meditation. The practice of Hatha yoga may change the physiology of the practitioner. Specifically, it may affect the hypothalamus which regulates the autonomic nervous system (ANS) through the hypothalamic, pituitary, adrenal axis (i.e., the sympathetic branch of the ANS) and through action of the vagus nerve (i.e., the parasympathetic branch of the ANS) (Ross & Thomas, 2010a, 2010b). The ANS exerts control over thoracic and abdominal viscera, including the heart. Dysfunction in the ANS, more specifically a delay in sympathetic withdrawal in recovery from a bout of exercise has been demonstrated to be a risk factor for myocardial infarction (MI) (Azevedo & Parker, 1999; Binkley et al., 1993). Yoga training may restore the balance of the ANS through physiological changes in the hypothalamus and through biochemical and/or nervous system adaptations (Ross & Thomas, 2010a, 2010b).

In a complex and empirically supported neurophysiologic theory, Brown and Gerbarg (2005) elucidate the mechanisms and pathways by which a specific type of yogic breathing acts on the body. Central to this theory and other posited theories of yoga action is the idea that yoga adjusts imbalances in the autonomic system, primarily by its action in increasing parasympathetic stimulation and vagal activation (Pal, Velkumary, & Madanmohan, 2004; Parshad, 2004; Ross & Thomas, 2010a). According to Brown and Gerbarg (2005), acute yoga practice activates vagal afferents, which in turn influences
limbic/hypothalamic outflow of vagal efferents to increase parasympathetic and decrease sympathetic input to the sinoatrial node of the heart, resulting in a lowered heart rate.

Specific measures in which the practice of yoga affects the brain and autonomic nervous system have been reported. Cahn and Polich (2006) stated that the meditative state experienced by the disciplined practice of yoga breathing, postures, and focus changes the anterior cingulate cortex and dorsolateral prefrontal areas known to modulate the autonomic nervous system. Regularly practiced yoga training, like other relaxation techniques, may induce vagal (i.e., parasympathetic) activity and decrease the neurological hypersensitivity to physical and mental stressors, including exercise (Borresen & Lambert, 2008; Everly & Lating, 2002; Khattab, Khattab, Ortak, Richardt, & Bonnemeier, 2007; Ross & Thomas, 2010a, 2010b). Increased parasympathetic activity also has inhibitory effects on cardiac sympathetic activity (Azevedo & Parker, 1999; Coote, 2009). Enhancement of parasympathetic stimulation may cause a more rapid decrease of heart rate following a physical challenge, such as exercise (Hepburn, Fletcher, Rosengarten, & Coote, 2005; Otsuki et al., 2007; Raju, Prasad, Venkata, Murthy, & Reddy, 1997). Yoga training also may affect blood pressure responses during recovery from an exercise challenge due to its effects on the baroreflex (which is mediated by the vagus nerve) (Selvamurthy et al., 1998). Yoga training, but not aerobic exercise training, was shown by Bowman et al. (1997) to improve baroreflex sensitivity, measured by heart rate and blood pressure spectra, in elderly persons; the researchers
found that 6 weeks of yoga training decreased resting heart rate and increased vagal stimulation.

While the short-term modulation of autonomic function consequent to practicing a single bout of yoga exercise is well documented (Blank, 2006; Gopal, Anantharamn, Nishith, & Bhatnagar, 1974), there is less known about training adaptations to regular yoga practice. That said, there are some recent, well-controlled trials demonstrating improved autonomic balance consequent to yoga training (measured using heart rate variability) (Cheema, Marshall, Chang, Colagiuri, & Machliss, 2011). Furthermore, Vijayalakshmi, Mandanmohan, Bhavanani, Patil and Babu. (2004) studied the effect of yoga-based relaxation training on modulation of stress induced by an isometric handgrip test in hypertensive patients and found that after 4 weeks of supervised yoga training, there was optimization of sympathetic response and restoration of autonomic regulatory reflex mechanisms. Raju et al. (1997) showed that, after 4 weeks of intensive yoga training, subjects could complete a maximal treadmill exercise test with lower heart rate, reduced minute ventilation, reduced oxygen consumption per unit work, and a significantly lower respiratory quotient, with the authors suggesting that yoga may have different quantifiable physiological effects than other exercises.

Chronic yoga practice may dramatically alter the communication between the central nervous system (CNS) and the ANS (Henje Blom, Olsson, Serlachius, Ericson, & Ingvar, 2010). Such longer-term effects from yoga training may improve physiological resiliency, such as the ability to reduce heart rate and blood pressure after the stress of a
bout of exercise. Recovery of heart rate and blood pressure from exercise is important. Rapid and large cardiovascular changes following strenuous exercise may cause syncope, hypotension, and arrhythmias (Nakahara, Miyamoto, Nakanishi, & Kinoshita, 2006). Furthermore, myocardial oxygen demand (indexed by the rate pressure product) is highest in the immediate post-recovery from exercise, especially when a passive recovery is given. Lastly, large-scale studies reveal that delayed HR recovery has prognostic value as a predictor of mortality in cardiac patients (Buch, Coote, & Townend, 2002; Cole, Blackstone, Pashkow, Snader, & Lauer, 1999).

Statement of the Problem

There are limited studies on the effect of yoga training on heart rate and blood pressure recovery from exercise. Muralidhara and Ranganathan (1982) reported that yoga training is different than physical exercise which effects skeletal muscles and demonstrated 10 weeks of yoga training for one hour daily improved a cardiac recovery index in yoga trained male medical students compared to 10 matched controls. Cardiac recovery index was assessed following the Harvard Step Test. Although the methodology was not clearly stated, the yoga-trained subjects improvement in cardiac recovery index was statistically significant whereas the difference observed among the control group was not statistically significant (Mandanmohan et al., 2004). Mandanmohan et al., (2004) measured HR and BP recovery in 21 active 17- to 19-year old boys who practiced yoga daily (45 min/day) for 2 months. The exercise challenge in the study consisted of 5 minutes of stepping exercise (Harvard Step test); heart rate
recovery (HRR) and blood pressure recovery (BPR) measures were taken in the supine position over 10 minutes, with first measures taken at minute 1. No comparison group was used and, given the timing of measures and protocol used, it was impossible to ascertain the role of vagal reactivation, which is thought to be maximized in the initial 30 seconds of recovery (Otsuki et al., 2007). That said, Mandanmohan et al. (2004) did find that all of the recovery HR measures (min 1, 2, 3, 4, 5, 7 and 10), and some of the systolic blood pressure (SBP), diastolic blood pressure (DBP), and rate pressure product (RPP) measures were significantly lower following the yoga training intervention than at baseline. It is not clear if uncontrolled factors, such as the other “activity” done by the subjects who participated and the effect of testing itself, may have led to confounding. As such, there are no controlled/comparison studies on the effect of yoga training on HRR and BPR measures.

Therefore, the primary purpose of this study was to determine the effects of yoga training on the HRR and BPR from standardized exercise bouts. The researchers also aimed to determine if there is modulation of autonomic function, specifically enhanced vagal nerve reactivation (i.e., enhanced parasympathetic activity) and concomitant withdrawal of sympathetic activity, resulting from the yoga training. Stretch and relax was used as a comparison group because, although it involves the same physical stretching aspects as yoga, it does not involve the repetitive focused breathing coupled with the intense isometric contractions that characterize the effectiveness of yoga in
autonomic modulation (Bhargava, Gogate, & Mascarenhas, 1988; Tang et al., 2009; Telles & Desiraju, 1993).

Hypotheses

Four weeks of yoga exercise training will improve of HRR and BPR (i.e., result in a lower HR and BP recovery) from a submaximal bout of exercise, and will result in improved autonomic function when compared to stretch and relax.

Practical Applications

There is an increase in the use of complementary and alternative medicine and research into non-pharmaceutical interventions, which manifest changes in the ANS, and hold enormous potential for resolving health crises in humans.
CHAPTER TWO

Methodology

Research Design

A quasi-experimental design was used to answer the two research questions posed: (1) to determine the effects of yoga training on the HR and BP recovery from a standardized exercise bout, and (2) to determine if there is modulation of autonomic function, specifically enhanced vagal nerve reactivation (i.e., enhanced parasympathetic activity), and concomitant withdrawal of sympathetic activity, resulting from the yoga training. College-aged students from yoga and stretch and relax activity courses were recruited to participate in the study. Prior to and after a 4-week intervention, participants in each group were measured at rest and following two submaximal exercise bouts in sequence at 40% VO$_2$$_{max}$ and 85% HR$_{max}$ to determine if there were mean differences in HRR and BPR. The independent variables were: group (yoga or stretch and relax), time (pre and post intervention), and time of recovery (0, 2, 4, and 6 minutes). The dependent variables were recovery HR, SBP, DBP and RPP. In addition, two HRR measures were taken: T30 (an index of vagal-mediated HRR) and Delta 60. These are widely used recovery measures (Imai et al., 1994; Otsuki et al., 2007b; Sugawara, Murakami, Maeda, Kuno, & Matsuda, 2001).

Subjects

The principal investigator and the co-investigator received approval from the teaching staff (PE class instructors) to recruit and assess subjects from two physical
education courses at Humboldt State University, in Arcata, California. These courses were Yoga (PE 259) and Stretch & Relax Techniques (PE 144). Groups were balanced so that similar numbers of males and females were in each.

All subjects met study inclusion criteria listed in the recruitment flyer (Appendix A) that was distributed at a meeting during the first week of classes. To qualify for participation, subjects had to be: (a) 18 to 25 years of age; (b) nonsmokers; (c) participating in physical activity equivalent to brisk walking for a minimum of 30 minutes on at least 3 days a week for at least 3 months; (d) new to yoga or stretch and relax practice (less than 5 days per week for 1 year); (e) free from major illness; (f) willing to attend yoga or stretch and relax class 2 times a week for 4 weeks; (g) willing to maintain the same activity level for the 4-week study; and (h) aware of or willing to have resting blood pressure tested to qualify for the study. Blood pressure screening (according to standardized procedures) for those that did not know their blood pressure took place during open lab times in the Human Performance Lab (HPL) before pre-testing began. All subjects were classified as low-risk according to ACSM guidelines (American College of Sports Medicine, 2010). All testing took place in the HSU Human Performance Lab.

Each potential subject was required to complete an informed consent form (Appendix B) and a release of liability (Appendix C), as well as a screening and demographic information questionnaire (Appendix D). A total of 18 subjects initially met these criteria and were included in the study. However, one subject later revealed
that he had more experience in yoga than was allowed, so his data were eliminated prior to analysis. While multiple attempts, including four visits to health education classes, were made to recruit control subjects who did not participate in either of the physical education classes, only two control subjects were recruited. Furthermore, technical problems with data collection for these two control subjects necessitated elimination of this group from the study. Therefore, final results are presented for a total of 15 subjects in the two active intervention groups only.

A few days prior to each testing session, subjects were notified and asked to adhere to pretest conditions (Appendix E). Additionally, immediately prior to the posttest exercise measures, subjects were asked if there had been any changes to their responses to screening questionnaires. The investigators documented and reviewed these responses to insure subjects still qualified; i.e., subjects must not have had more than one risk factor and were excluded from participation if they were: pregnant; had an implantable electronic device; had any reported coronary, pulmonary or metabolic diseases; had signs/symptoms suggestive of these diseases; were on medication that may affect heart rate and blood pressure; had an uncontrolled medical condition; or had contraindications to exercise, according to ACSM guidelines (American College of Sports Medicine, 2010).

Measurement Protocols
Following, in order, are descriptions for each of the measures subjects were to undergo. Subjects were asked to adhere to standardized pretest conditions (Appendix E) prior to all visits to the Human Performance Lab for testing.

Demographics and yoga/stretch and relax background. Demographic information was collected on a self-report form (Appendix D). This form included questions regarding: (a) date of birth; (b) ethnicity; (c) current injury status; (d) medical history and risk factors for cardiovascular disease; and (e) participation in yoga or stretch and relax classes.

Measurement of height and mass. The HSU Human Performance Lab faculty, staff and trained students measured the mass and height of each participant with a calibrated scale (Health-o-Meter, Illinois). Subjects were asked to wear normal work out attire. Mass was measured to the nearest 0.5 kg with shoes off. Height was taken with participants standing, without shoes, with back, heels, and buttocks against the wall according to standardized procedures (Frisancho, 2008; Lohman, 1988). The measuring device was laid over the tallest point of the participant’s head. Height was measured to the nearest 0.5 cm.

Body composition. Body composition was determined using underwater weighing (UWW) (Exertech, Bradford Products LLC, Wilmington, NC). Subjects were asked to wear a one-piece spandex suit provided by the Human Performance Laboratory during this measure. Weighing procedures included three trials, each trial lasting 3 seconds in duration (with the subject being submerged between 7 and 10 seconds), and
were carried out according to Exertech body density measuring systems (Exertech, Bradford Products LLC, Wilmington, NC). Body fat percentage was taken as the value provided by the Exertech software.

Waist and hip circumference. Waist and hip circumference measurements were taken with a spring-loaded Gulick tape. Waist circumference was measured at the narrowest part of the torso. Hip circumference was measured at the widest part around the buttocks (American College of Sports Medicine, 2010).

Resting heart rate and blood pressure measures. Subjects were asked to sit calmly without speaking for 5 minutes prior to having their resting heart rate (HR) and blood pressure (BP) measured in the temperature controlled Human Performance Lab (70-74°Fahrenheit). Multiple Human Performance Lab technicians obtained the resting HR and BP measurements. The resting HR was obtained, via palpation for 15 seconds (multiplying the beats recorded by 4 to obtain the HR), while the subject was still seated. The resting SBP and DBP measurements took place under standard conditions (Pickering, 2004). The subject was seated comfortably with the left arm at heart level. Readings were taken with the arm slightly bent using a mercury sphygmomanometer. The correct-sized cuff was determined and recorded for reference in future testing, making sure that the cuff encircled 80% of the arm. The SBP and DBP were obtained twice and the lower of two BP measurements was used for data analysis.

Measurement of perceived stress and activity level. Level of physical activity over the previous week was measured via the Paffenbarger Physical Activity Questionnaire.
The Paffenbarger Physical Activity questionnaire was designed to identify activity level and is validated by 17 sources and used in six other studies (Paffenbarger et al., 1978). Stress was measured using the Perceived Stress Scale (Appendix G). The Perceived Stress Scale was chosen to measure the stress level of the subjects as it has been accepted as reliable in multiple scientific articles and has been validated (Cohen, Kamarck, & Mermelstein, 1983). These measures were taken as other activity and/or stress may influence hemodynamic recovery from exercise.

Maximal exercise test. In order to measure VO
max and HR
max, an incremental exercise test to volitional exhaustion was conducted on an Excalibur Sport (Lode, Groningen, Netherland) cycle ergometer. The protocol used was a modification of the standardized staged protocol used by Heffernan, Fahs, Shinsako, Jae, and Fernhall (2007). In this test, subjects briefly warmed up, and then the initial workload was set for 50 Watts. A 30-Watt increase in workload was made every 2 minutes until test termination criteria or volitional exhaustion (inability to maintain a 50-60 rpm cadence) was achieved. (Note: this protocol was modified by experienced ergometer technicians so that subjects would reach maximal oxygen uptake within 8 to 12 minutes from when the test commenced, by adjusting workload increments in middle stages of the test). At any point in time the participant had the freedom to end the test if they desired. No subject ended the test early. A 5-min recovery consisting of low-level exercise (0 resistance at a cadence of 25 repetitions per minute) continued until HR and BP stabilized. Maximal HR was
established as the highest HR achieved during the test. Gas exchange data was measured with a metabolic measurement system (True One 2400, ParvoMedics, Sandy, UT). \( \text{VO}_2\text{max} \) was determined when two of the following three criteria were met: 1) a respiratory exchange ratio >1.1, or 2) no change in HR with a change in workload, or 3) a plateau in \( \text{O}_2 \) (≤ 150 mL) uptake with an increase in workload. All subjects achieved \( \text{VO}_2\text{max} \) according to these criteria.

T30/Submaximal exercise test at 40% \( \text{VO}_2\text{max} \). The protocol for the first submaximal exercise test for the collection of T30 was identical to that of Otsuki et al. (2007), and included the monitoring of oxygen uptake during the submaximal test. A Polar RS800 CS HR monitor was placed on the chest at the level of the xiphoid process, tight enough to prevent movement or slippage of the monitor during exercise. A heart rate technician strapped the Polar watch receiver to the handlebar of the bike and stood in front of the bike and monitored the subject’s heart rate. The subjects started with a brief (5-min) warm-up period pedaling on an Excalibur Sport (Lode, Groningen, Netherland) cycle ergometer at a cadence of 50 rpm with minimal resistance. The subjects then performed approximately 8 minutes of steady-state exercise on the cycle ergometer at an intensity that equated to approximately 40% of maximal oxygen uptake (to insure that participants were working below ventilatory threshold). To insure that subjects were working at the desired intensity (40% \( \text{VO}_2\text{max} \)), oxygen uptake was monitored and the workload was adjusted on the Lode ergometer. At the end of the 8 minutes, the test was
terminated, and the subject remained seated and underwent a passive recovery while heart rate recovery (HRR) data was collected.

**T30.** The T30 measurement was used to assess vagal nerve reactivation (Imai et al., 1994; Otsuki et al., 2007a; Sugawara, Hamada, Nishijima, & Matsuda, 2001; Sugawara, Murakami, et al., 2001). Heart rate was measured using a Polar RS800 CS HR monitor in beat-by-beat data collection mode. The subject’s HR for the first 30 seconds after the cessation of cycle ergometer exercise at 40% VO$_2$ max was measured. Linear regression on the natural logarithm of the HR data for the first 30 s after exercise was performed using Excel software. The negative reciprocal of the slope of the regression line was then defined as T30, similar to methodology of previously validated measures of ANS using HRR (Imai et al., 1994; Otsuki et al., 2007).

Delta 60/Submaximal exercise test at 85% HR$_{max}$. The second submaximal test was used to obtain the Delta 60 HRR measurement. To standardize measurements for this test, an exercise stimulus of 85% of HR$_{max}$ was used, as this has been shown to be an appropriate intensity to obtain HRR (Borresen & Lambert, 2008). Heart rate was measured using a Polar RS800 CS HR monitor in beat-by-beat data collection mode. The HR monitor transmitter was placed on the chest at the level of the xiphoid process, tight enough to prevent movement or slippage of the monitor during exercise. A heart rate technician strapped the Polar watch receiver to the handlebar of the bike and stood in front of the bike and monitored the subject’s heart rate. The protocol to bring subjects to 85% of their HR$_{max}$ (established from the max test) began with an initial workload on the
cycle ergometer set at 50 W. Workload increased 30 W every 2-minutes (Heffernan et al., 2007). Once the participant reached 85% of maximal HR, the test was terminated and data collection for HRR began, with subjects doing a seated passive recovery. The 60-s HRR was then calculated as the difference between peak HR at the cessation of exercise, and HR after one minute of recovery

*Delta 60.* The Delta 60 measurement was calculated as the average of five HR measurements surrounding the HR at the cessation of exercise (i.e., approximately 85% of $HR_{\text{max}}$), minus the average of five HR measurements after one minute of recovery. It was used to measure the concept of vagally mediated HRR after exercise which also depends on sympathetic withdrawal, in the balance of the autonomic nervous system (Imai et al., 1994). Vagal reactivation rapidly decreases HR immediately after exercise (Otsuki et al., 2007). However, whereas the T30 measurement was independent of sympathetic nervous system activity, the Delta 60 measurement captures changes in sympathetic activity (Imai et al., 1994).

Recovery HR, SBP and DBP at 0, 2, 4, and 6 minutes. The second submaximal test was used to obtain the HRR and BPR measures at 0, 2, 4, and 6 minutes after a bout of exercise. The recovery of HR, SBP and DBP after exercise has been used to demonstrate physiological adjustments to yoga training interventions (Madanmohan et al., 2004). The protocol to bring subjects to 85% of their $HR_{\text{max}}$ started with the workload on the cycle ergometer set at 50 W. Workload increased 30 W every 2-minutes (Heffernan et al., 2007). Once the participant reached 85% of maximal HR, the test was terminated and
data collection for HRR began, with subjects doing a seated passive recovery. Recovery
BPs were obtained using an automated BP device (SunTech Tango, Morrisville, NC),
which was calibrated by the manufacturer and was again calibrated using a mercury
sphygmomanometer prior to testing. The Tango Stress Test BP Monitor (SunTech
Medical Instruments, Inc., Raleigh, NC) has been tested for validity in comparison to the
traditional mercury sphygmomanometer in three studies (Blank, 2006; Furtado, Ramos,
& Araújo, 2009; Roemmich et al., 2011; Simmons et al., 2010). Automated BP
assessment during exercise-ECG testing is feasible with the use of appropriate automatic
devices likely to be at least as accurate as manual BP auscultation. The Tango device is
tolerant to exercise and provides reliable automatic BP assessment with absolute
differences within an acceptable clinical range (Cameron et al., 2004). The National
Aeronautics and Space Administration (NASA) also established the validity of the Tango
Blood Pressure Monitoring System using Tango Blood Pressure Monitoring System to
monitor the cardiovascular and respiratory health of astronauts aboard the International
Space Station.

Intervention Protocols

Length of interventions. The yoga and stretch and relax interventions took place
over a time period of 4 weeks at the onset of the semester. There were a total of 8 classes
in each intervention; each class met two times per week, 50 minutes per session, for a
total of 100 minutes per week.

Yoga intervention. The yoga intervention consisted of the beginning yoga class
taught at HSU (PE 259). A certified instructor taught Anusara Yoga, a type of hatha yoga. Anusara yoga was chosen for the current research study as compared to other forms of yoga for convenience, as it is the type of yoga that is taught at Humboldt State University (HSU). Anusara yoga primarily emphasizes alignment and has a philosophy of looking for the good in all people and all things (Friend, 2007). Consequently, students of all levels of ability and yoga experience are honored for their unique differences, limitations, and talents in the practice of this type of yoga. The physical elements of yoga are to help people focus and meditate for long periods of time without putting undue stress on the body. Developing strength, flexibility and stamina, as well as an effective breathing practice is the main outcome goal. Anusara yoga postures (asanas) are not thought of as a “poses” but as “the place and manner in which you move” (Friend, 2007). Please refer to Appendix I for a more detailed description of what was taught in the yoga class.

Stretch and relax intervention. A common misconception is that yoga is only stretching; hence stretch and relaxation class was used as the comparison group. The comparison intervention was the Stretch and Relax Techniques class at HSU (PE 144). In this class students are taught a wide variety of methods to safely and effectively stretch and relax the muscles of the body. The main goal of the stretch and relax skill development is to prevent injury and maintain flexibility and agility. Techniques and instructions help students achieve more optimum fitness and help them define the muscle groups helped by each stretching exercise (Anderson, 1980). Please refer to Appendix J
for a more detailed description.

Procedures

After the Humboldt State University Internal Review Board (IRB) approved the study, all subjects reported to the HPL in room 254 of the KA Building on the HSU campus, and confirmed that they had adhered to pretest conditions. Demographic information, yoga and stretch and relax experience, as well as perceived stress and activity level, were obtained by questionnaires. Anthropometrics, body composition, and resting HR and BP were then measured. A maximal graded exercise test on a cycle ergometer was used to determine maximal oxygen uptake (VO$_{2\text{max}}$) pre-intervention; data from this test was used to determine 40% VO$_{2\text{max}}$ and 85 % HR$_{\text{max}}$ for submaximal exercise tests that followed.

After all initial tests were completed, subjects returned to the HPL the following weekend for two submaximal cycle ergometer tests (steady state at 40% VO$_{2\text{max}}$ and incremental to 85 % HR$_{\text{max}}$); data from these tests were used to determine HRR and BPR prior to the interventions. Subjects recovered from the first submaximal test prior to beginning the second test. These submaximal exercise tests for determination of recovery HR and BP measures and T30 and Delta 60 were then repeated at the same time of day for each subject, 4 weeks later, following the respective interventions.

Statistical Analysis

Four 2 x 2 x 4 (group x time x time period of recovery) ANOVAs were used to compare means of HR, SBP, DBP, and RPP in recovery at 0, 2, 4, 6 minutes. Two 2 x 2
(2 groups = yoga or stretch and relax; 2 times = pre and post-intervention) ANOVAs were used to compare means for T30 and Delta 60 between groups before and after the intervention. Independent groups $t$-tests were used to compare groups on descriptive and HRR measures and pre-intervention. Dependent $t$-tests, run separately for each group, were used to compare activity (Paffenbarger Physical Activity Questionnaire) and stress levels (Perceived Stress Scale) pre and post-intervention. Statistics were analyzed using SPSS (IBM Corp., Chicago, IL, USA) version 19, with the criterion for significance set at alpha level of $p \leq .05$.

Operational Definitions

1) Rest HR - determined by palpation at radial artery for 15 seconds. This number was multiplied by 4 to get the resting HR and was expressed in beats per minute (bpm). Multiple technicians in the HSU Human Performance Laboratory performed the measurement.

2) Rest SBP - obtained by manual auscultation using a mercury sphygmomanometer performed by multiple technicians in the HSU Human Performance Laboratory.

3) Rest DBP - obtained by manual auscultation using a mercury sphygmomanometer performed by multiple technicians in the HSU Human Performance Laboratory.

4) Rest Mean Arterial Pressure (MAP) - obtained by calculation $\left[ \frac{2}{3} \text{SBP} + \frac{1}{3} \text{DBP} \right]$. 
5) Recovery HR - obtained using the SunTech Tango Automated Blood Pressure Monitoring System; automated measures were taken at 0, 2, 4, and 6 min after recovery from 85% \( \text{HR}_{\text{max}} \) bout of exercise on a cycle ergometer.

6) SBP - obtained using the SunTech Tango Automated Blood Pressure Monitoring System; automated measures were taken at 0, 2, 4, and 6 min after recovery from 85% \( \text{HR}_{\text{max}} \) bout of exercise on a cycle ergometer.

7) DBP - obtained using the SunTech Tango Automated Blood Pressure Monitoring System; automated measures were taken at 0, 2, 4, and 6 min after recovery from 85% \( \text{HR}_{\text{max}} \) bout of exercise on a cycle ergometer.

8) RPP - calculated by multiplying the HR times the SBP divided by 100.

9) T30 - calculated, following recovery from 40% \( \text{VO}_{2\text{max}} \) submaximal bout of exercise, as the negative reciprocal of the slope of the rate of heart rate recovery taken for the first 30 seconds of recovery as per methodology described by Imai et al. (1994).

10) Delta 60 - five HRs were averaged (the two HRs before and the two heart rates after the desired HR) for the start HR (0 seconds) and the end HR (60 seconds) during recovery. The 60-second average was subtracted from the 0-second average to give the value for Delta 60.
Assumptions

For this study it was assumed that all subjects performed to the best of their abilities and adhered to pretest conditions. It was assumed that subjects did not participate in any outside yoga or stretch and relax programs other than the classes that they participated in at Humboldt State University.

Limitations

The following limitations are noted, as they may have affected the outcomes of this study:

1) Stress was measured, but not controlled for in the data analysis.

2) Unknown inter-tester reliability may have influenced the validity of measurements.

3) External factors such as talking during the recovery measures may have affected the HR and BP of the subjects.

4) Subjects had varied experience and skill level in both the yoga and stretch and relax groups.

5) Inadequate recruitment of control (non-intervention) subjects did not allow for determination of training effects alone, hence results may have reflected change due to history, testing, and other factors that could compromise internal validity.

6) The T30 measurement and the equipment used for the measurement were unfamiliar to the testers.
7) The technicians had a lack of technical experience in working with the Polar Heart Rate Monitor software, which may have created some error in the reported data.

8) Breath control in beginning yoga classes may have created increased levels of stress.

Delimitations

The following delimitations are noted as they may have affected the outcomes of this study:

1) Yoga and stretch and relax training took place for only 8 sessions.

2) Fewer male subjects than female subjects completed the study.

3) Only two control subjects completed the testing and their data was not usable.

4) Other more established measures of autonomic nervous system functioning, such as HRV and baroreflex sensitivity, were not measured.

5) Subjects’ responses to physical education classes were measured and these in-class interventions may or may not reflect what is done in other yoga or stretch and relax classes.
CHAPTER THREE

Results

This study was designed to compare heart rate and blood pressure recovery from a bout of exercise following either yoga or stretch and relax training in samples of young adults. Heart rate and blood pressure recovery at 0, 2, 4, and 6 minutes after a bout of exercise were taken before and after 4 weeks of the interventions. A secondary purpose of the study was to compare autonomic nervous system adaptations acquired as a result of the interventions by measuring T30 and Delta 60 HRR parameters prior to and following the interventions. All measurements were obtained for 17 subjects (n = 8 yoga, n = 7 stretch and relax, n = 2 non-intervention control). Technical problems with data collection for control subjects necessitated elimination of this group in final results analyses, therefore results are presented for 15 subjects in the two active intervention groups only; all of these subjects met inclusion criteria and completed the study. There was 100% attendance in class for the yoga and stretch and relax group.

Subject Descriptive Characteristics

The descriptive characteristics of the 15 subjects who successfully completed the entire study are presented in Table 1. Subjects ranged in age from 18 to 25 years. Subjects in the yoga group (M = 21.13 years, SD = 2.59) were not significantly different in age from subjects in the stretch and relax group (M = 20.57 years, SD = 1.81). Both groups included more women than men, but gender distribution was similar, with 5 women and 3 men in the yoga group, and 4 women and 3 men in the stretch and relax
group. All students in the yoga group were Caucasian, except one student who reported Latino and one who reported “other”. All students in the stretch and relax group were Caucasian, except for two who reported Latino, one who reported Asian, and one who reported African-American. One half of the subjects \((n = 4)\) in the yoga group had no experience in yoga; one male had six months of experience two times per week, two females had six months of experience (one two days per week and one five days per week), and one female had 12 months of experience two times per week. In the stretch and relax group two male subjects had 12 months of experience (4.5 and 5 days per week), and two female subjects had four months and half a month of experience two times per week, while the remaining three subjects had no prior experience. None of the mean values for the 14 variables related to anthropomorphic characteristics, cardiovascular endurance, perceived stress, and activity level were significantly different between yoga and stretch and relax groups at pretest, as revealed by dependent-groups \(t\) tests. That said, there was a trend towards the yoga participants having higher level of perceived stress than stretch and relax participants \((p = .066)\) at pretest. Dependent \(t\)-tests performed within each group revealed no significant differences between pre-intervention and post intervention stress and activity level.
### Table 1

**Subject Characteristics (N = 15)**

<table>
<thead>
<tr>
<th>Variable</th>
<th>M</th>
<th>SD</th>
<th>Range</th>
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<tr>
<td>Age (years)</td>
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<td>2.59</td>
<td>18-25</td>
</tr>
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<td>Stretch and Relax</td>
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<td>1.81</td>
<td>19-23</td>
</tr>
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<td>158.00-181.50</td>
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<td>6.93</td>
<td>159.50-181.50</td>
</tr>
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<td>7.50</td>
<td>158.00-177.50</td>
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<td>48.18-106.00</td>
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<td>48.18-82.70</td>
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<td>16.27</td>
<td>61.81-106.00</td>
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<td>7.81-45.89</td>
</tr>
<tr>
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<td>12.00</td>
<td>7.81-44.99</td>
</tr>
<tr>
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<td>21.95</td>
<td>13.09</td>
<td>8.96-45.89</td>
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<td>63.50-81.00</td>
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<td>68.00-126.00</td>
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<td>Hip Circumference (cm)</td>
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<td>14.09</td>
<td>86.00-145.00</td>
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<td>Yoga</td>
<td>93.31</td>
<td>4.48</td>
<td>87.00-98.50</td>
</tr>
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<td>Stretch and Relax</td>
<td>103.76</td>
<td>19.28</td>
<td>86.00-145.00</td>
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<tr>
<td>VO2max (mL/kg/min)</td>
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<td>15.30-55.60</td>
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<tr>
<td>Yoga</td>
<td>42.85</td>
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<td>31.40-55.60</td>
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<td>40.30</td>
<td>14.59</td>
<td>15.30-55.40</td>
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<td>40% VO2max (mL/kg/min)</td>
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<td>4.51</td>
<td>6.12-22.24</td>
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<td>12.56-22.24</td>
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<tr>
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<td>6.12-22.16</td>
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<td>HRmax (bpm)</td>
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<td>14.34</td>
<td>165.00-205.00</td>
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<td>180.00-207.00</td>
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<td>10.63</td>
<td>140.25-175.95</td>
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<td>Yoga</td>
<td>159.48</td>
<td>12.16</td>
<td>140.25-174.25</td>
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<tr>
<td>Stretch and Relax</td>
<td>164.04</td>
<td>8.85</td>
<td>153.00-175.95</td>
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<td>Pretest Perceived Stress</td>
<td>2.08</td>
<td>0.25</td>
<td>1.6-2.6</td>
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<tr>
<td>Yoga^a</td>
<td>2.18</td>
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<td>1.9-2.6</td>
</tr>
<tr>
<td>Stretch and Relax^a</td>
<td>1.98</td>
<td>0.20</td>
<td>1.6-2.2</td>
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<tr>
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<tr>
<td>---------------------------</td>
<td>-------</td>
<td>-----</td>
<td>--------</td>
</tr>
<tr>
<td>Posttest Perceived Stress</td>
<td>2.12</td>
<td>0.36</td>
<td>1.6-2.9</td>
</tr>
<tr>
<td>Yoga^a</td>
<td>2.28</td>
<td>0.37</td>
<td>1.8-2.9</td>
</tr>
<tr>
<td>Stretch and Relax^a</td>
<td>1.95</td>
<td>0.29</td>
<td>1.6-2.4</td>
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<td>Pretest Paffenbarger Score</td>
<td>8065.51</td>
<td>5024.22</td>
<td>168.00-14723.57</td>
</tr>
<tr>
<td>Yoga^b</td>
<td>9596.88</td>
<td>4628.24</td>
<td>3594.75-14723.57</td>
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<tr>
<td>Stretch and Relax^a</td>
<td>6789.38</td>
<td>5389.78</td>
<td>168.00-14602.00</td>
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<tr>
<td>Posttest Paffenbarger Score</td>
<td>8305.22</td>
<td>5339.79</td>
<td>336.00-16351.00</td>
</tr>
<tr>
<td>Yoga^b</td>
<td>9645.15</td>
<td>4889.40</td>
<td>3122.75-16351.00</td>
</tr>
<tr>
<td>Stretch and Relax^a</td>
<td>7188.61</td>
<td>5883.04</td>
<td>336.00-14602.00</td>
</tr>
</tbody>
</table>

Notes: ^a n = 6. ^b n = 5.

Resting Heart Rate and Blood Pressure Measures

Resting measures were compromised by having multiple technicians (with varied levels of experience) collect data across subjects both before and after the intervention period. These resting measures were not taken to answer the major research questions, but were exploratory. The resting HR, SBP, DBP, MAP, as well as RPP values are presented in Table 2. Independent-groups t-tests revealed no significant mean differences in these variables between yoga and stretch and relax groups at pretest.

In order to determine if there were mean differences in resting hemodynamic variables between pre- and post-intervention depending on group, five 2 X 2 mixed factorial ANOVAs were run (for HR, SBP, DBP, MAP, and RPP, respectively). No significant interactions (p > .05) between time and group were found for any of these outcome variables with the exception of SBP (p = .045). Significance values for all interactions and main effects for these resting hemodynamic variables are reported in Appendix M. Post-hoc paired t-tests revealed that there was not a significant difference in resting SBP pre- to post-intervention for the yoga group, t(7) = .100, p = .923, but the
post-intervention resting SBP in the stretch and relax group was significantly lower than at pre-intervention, $t (6) = 2.991, p = .024$. Again, confidence in accuracy of manually measured resting HR and BPs was not high, due to multiple (sometimes inexperienced) testers, hence these results are not discussed further.
Table 2

Resting Values ($N = 15$)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Pre</th>
<th>Post</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$M$</td>
<td>$SD$</td>
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<tr>
<td>HR (bpm)</td>
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<td>79.38</td>
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<td>15.32</td>
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<td>SBP (mmHg)</td>
<td>121.13</td>
<td>12.84</td>
</tr>
<tr>
<td>Yoga</td>
<td>118.50</td>
<td>12.58</td>
</tr>
<tr>
<td>Stretch and Relax</td>
<td>124.14</td>
<td>13.42</td>
</tr>
<tr>
<td>DBP (mmHg)</td>
<td>75.27</td>
<td>9.36</td>
</tr>
<tr>
<td>Yoga</td>
<td>74.13</td>
<td>8.20</td>
</tr>
<tr>
<td>Stretch and Relax</td>
<td>76.57</td>
<td>11.06</td>
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<tr>
<td>MAP (mmHg)</td>
<td>90.56</td>
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<tr>
<td>Yoga</td>
<td>89.92</td>
<td>8.48</td>
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<tr>
<td>Stretch and Relax</td>
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<td>RPP</td>
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<tr>
<td>Yoga</td>
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</tr>
<tr>
<td>Stretch and Relax</td>
<td>101.02</td>
<td>26.36</td>
</tr>
</tbody>
</table>

Note. For the yoga group, $n = 8$. For the stretch and relax group, $n = 7$.

Recovery Heart Rate and Blood Pressure Measures

The HR, SBP, DBP, and RPP measures at 0, 2, 4, and 6 minutes after recovery from a bout of exercise on the cycle ergometer at 85% $HR_{max}$, pre and posttest are presented in Table 3. No significant mean differences in these variables between yoga and stretch and relax groups were found at pretest (determined with independent-groups $t$-tests).

In order to determine if there were differences in the hemodynamic variables between pre- and post-intervention depending on group and time-period of recovery, four $2 \times 2 \times 4$ mixed factorial ANOVAs were run (time X group X time-period of recovery).
No significant interactions ($p > .05$) between time, group, and time-period of recovery were found for HR, SBP, DBP, or RPP. Similarly, no main effects for group were found with respect to these four dependent variables. As expected, there was a significant main effect for time-period of recovery (i.e., 0, 2, 4 and 6 minutes) for HR ($p = .000$), SBP ($p = .000$), and RPP ($p = .000$), but not for DBP ($p = .142$). A significant effect for time (pre-vs. post-intervention) was found for SBP ($p = .028$), but not for HR ($p = .622$), DBP ($p = .076$) and RPP ($p = .094$). Hence, across all time-periods of recovery, the interventions collectively resulted in significantly lower mean SBP, with trends towards lower DBP and RPP post-intervention when compared to pre-intervention. Lastly, there were no significant interactions between time and group, between time-period of recovery and group, and between time and time-period of recovery for any of these hemodynamic measures. The mean values for HR, SBP, DBP, and RPP across recovery time periods both pre- and post-intervention for yoga and stretch and relax groups are depicted in Figures 1, 2, 3, and 4, respectively.
Table 3

Recovery of Heart Rate and Blood Pressure at 0, 2, 4 and 6 Minutes After a Bout of Exercise (N = 15)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Pre</th>
<th></th>
<th>Post</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
<td>M</td>
<td>SD</td>
</tr>
<tr>
<td>0-min HR (bpm)</td>
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<td></td>
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<tr>
<td>Yoga</td>
<td>158.13</td>
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<td>156.88</td>
<td>14.96</td>
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<td>0-min SBP (mmHg)</td>
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<td>Yoga</td>
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<td>25.05</td>
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<td>58.00</td>
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<td>0-min RPP</td>
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<td>2-min SBP (mmHg)</td>
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<td>2-min DBP (mmHg)</td>
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Figure 1. Pre and Post HR Measures for the Yoga and Stretch & Relax Groups
Figure 2. Pre and Post SBP Measures for the Yoga and Stretch & Relax Groups
**Figure 3.** Pre and Post DBP Measures for the Yoga and Stretch & Relax Groups
Figure 4. Pre and Post RPP Measures for the Yoga and Stretch & Relax Groups
Autonomic Function

The pre- and post-intervention values for T30 and Delta 60, the two measures of autonomic function, are presented in Table 4. Independent groups $t$-tests showed no significant mean differences in these variables at pretest.

In order to determine if there were mean differences in T30 and Delta 60 between pre- and post-intervention depending on group, two 2 X 2 mixed factorial ANOVAs were run. No significant interactions ($p > .05$) between time and group were found with respect to either HRR variable. Furthermore, there were not any significant main effects for time or main effects for group for T30 or Delta 60. Significance levels for these mixed factorial levels are reported in subsections below. Mean values for T30 and Delta 60 pre- and post-intervention in each group are shown in Figures 5 and 6, respectively.

T30. No significant group x time interaction was found for T30 measures ($p = .216$). No significant main effect for time was found ($p = .343$). No significant main effect for group was found ($p = .448$). Data was available for fewer subjects due to technician measurement difficulty and lack of experience in transferring the data into the excel computer files.

Delta 60. No significant group x time interaction was found for Delta 60 measures ($p = .561$). No significant main effect for time was found ($p = .983$). No significant main effect for group was found ($p = .671$).
Table 4

T30 and Delta 60 (N = 15)

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Notes: \(^a n = 5. \(^b n = 4. \(^c n = 6.\)
Figure 5. Pre and Post T30 Measures in the Yoga and S&R Group.
Figure 6. Pre and Post Delta 60 Measures in the Yoga and Stretch & Relax Group
CHAPTER FOUR

Discussion

Yoga is increasing in popularity, with over 15 million practitioners in the United States, yet there is a lack of well-controlled studies to assert the physiological adaptations and benefits of yoga (Smith, Greer, Sheets, & Watson, 2011; Smith & Pukall, 2009). Specifically, there are limited studies on the effect of yoga training on heart rate and blood pressure recovery from exercise. The studies which exist are lacking standardized exercise tests or comparison subjects (Bhargava et al., 1988; Madanmohan et al., 2004; Muralidhara & Ranganathan, 1982). Researchers from India have asserted benefits to the nervous system from yoga (Joseph et al., 1981; Manjunath & Telles, 2003), and more recent studies in the United States indicated the positive effect of yoga on autonomic modulation using HRV and spectral analysis methodology (Cheema et al., 2011; Ross & Thomas, 2010a, 2010b). Still, researchers have failed to demonstrate conclusively in well-controlled studies that yoga training can in fact lower HRR and BPR measures after a bout of moderate exercise through autonomic system modulation. Therefore, this study was designed to investigate the effects of yoga training versus a comparison exercise training (stretch and relax) on the HR and BP recovery from a bout of submaximal exercise. A secondary purpose of this study was to investigate post-exercise autonomic nervous system function using validated measures (Imai et al., 1994; Otsuki et al., 2007; Sugawara et al., 2001).
With regard to the findings of the current study, 4 weeks of yoga exercise training did not improve HRR and BPR from a submaximal bout of exercise as compared to the physical intervention of stretch and relax. However, both interventions resulted in significantly lower SBP in recovery and trends towards lower DBP and RPP post-intervention when compared to pre-intervention. With regard to modulation of ANS function, measured using T30 and Delta 60, there were no significant interactions between time (pre and post-intervention) and group (yoga and stretch and relax). Although not statistically significant, it was of interest to note that the Delta 60 values for the groups changed in the opposite direction over time. That is, the stretch and relax group seemed to exhibit a decrease in sympathetic activation whereas the yoga group had an increased sympathetic response post training. Again, although not statistically significant these trends were contradictory to the hypothesis. Perhaps it due to the fact that breath control may be a stressor, particularly in students fairly new to yoga.

The current study went further to illustrate the effects of yoga training on recovery from a bout of exercise than did the research of Mandanmohan et al. (2004). In this study, all recovery measurements were obtained using the SunTech Tango automated BP machine, which added both reliability and validity to the BP measures, compared with manually determined BP. Additionally, unlike the Mandanmohan et al. (2004) study which had no comparison group, the current study included a group of stretch and relax intervention subjects and there was an attempt to have a non-intervention control group, so that threats to internal validity could be controlled. However, due to difficulty in
recruiting the control subjects, the current study could not rule out history, the effect of
repeat testing, and other threats to internal validity, similar to limitations of
Mandanmohan et al. (2004). Also, without this latter group, it was not possible to
determine the reliability of the HRR measures, which in turn influences validity.

The current research was consistent with the Mandanmohan et al. (2004) study, in
that recovery SBP improved from the pre to the posttests in the yoga group (as well as in
the stretch and relax group). However, in the current study, activity outside of yoga was
qualified using the Paffenbarger Activity Questionnaire (Paffenbarger, Wing, & Hyde,
1978, 1995) to account for all activity of the subjects during the study. Mandanmohan et
al. (2004) did not control for physical activity level, and thus the improvement in the
ability to recover from a bout of exercise in that study may have been due to other
activities completed by the 19-year-old military cadet subjects. In the current study, the
Paffenbarger activity questionnaire (Paffenbarger et al., 1978, 1995) precisely quantified
all activity of the subject participants, and therefore activities outside of the yoga and
stretch and relax classes were accounted for systematically.

With regard to methodology, Mandanmohan et al. (2004) measured the blood
pressure every minute after the Harvard Step Test, whereas the American Heart
Association recommends at least one minute of rest between blood pressure
measurements (Pickering, 2004). This may have invalidated the BP readings in the
Mandanmohan et al. (2004) study. Finally, the cycle ergometer submaximal exercise test
protocol used in the current study is considered more dependable and reliable as an
exercise test to use for determining subjects’ physiological response than is the Harvard Step Test that was used as the exercise stimulus in the Mandanmohan et al. (2004) study.

Just as in the Mandanmohan et al. (2004) study, results of the current study indicated that after yoga or stretch and relax training a given level of exercise results in faster BP recovery. The current study was not able to demonstrate a significant improvement in HR recovery after a bout of exercise as was shown by Mandanmohan et al., (2004). Also, there was a trend for lower recovery DBP following both activity interventions in the current study, as was reported in previous studies where the authors attributed this recovery to reduction in sympathetic activity (Mandanmohan et al., 2004; Ray et al., 2001; Uday Sankar Ray, Pathak, & Tomer, 2011). Both yoga and stretch and relax training interventions induced a decrease in SBP, indicating faster recovery of cardiovascular parameters. The findings of this study are similar to the findings of Muralidhara and Ranganathan (1982), who reported that physical exercise training changes cardiac recovery measures measured following the Harvard step test.

In the current study, it is interesting that a reduction in SBP was also seen in the stretch and relax group, similar to what was seen in the yoga group. Further acknowledging, as Ross and Thomas (2010) indicated, yoga is as effective as other physical exercise. However, the researchers were not able to demonstrate in a clear manner that yoga manifests different physiological changes than exercise which primarily works the skeletal muscle as was shown by Muraliharda and Ranganathan (1982). One primary reason for this may have been the location of the yoga class moved during the
intervention, which could have provided less relaxation than the stretch and relax class. Finally the length and intensity of the intervention remains as a probable reason why the researchers did not more dramatic alterations the BPR and HRR in the yoga group.

With regard to measures of autonomic function, the mean T30 value increased in the yoga group and decreased slightly in the stretch and relax group, yet there was not a significant interaction between time and group with respect to T30. Due to the isolated information that the T30 measurement discloses it is not possible to say if there is any direct effect on activation of the parasympathetic nervous system. With regard to Delta 60, which assesses the sympathetic aspect of vagal reactivation in HRR, there is a trend that suggests the stretch and relax intervention may help blunt the flight or fight response that accelerates heart rate, and that the HRR is quicker in the stretch and relax intervention group. The opposite trend occurred with the yoga group, showing greater Delta 60; hence there was more activation of the sympathetic response. After the 4-week training, there was no significant interaction between time and group with respect to Delta 60. The investigator’s confidence in the HRR values is low, given measurement/testing issues such as: lack of experience in the T30 measurement protocol, lack of statistical power due to loss of subject data from technician error downloading the data, and talking during the recovery measures. That said, the direction of changes suggest that a favorable autonomic modulation could have occurred in the in the stretch and relax group. It is of interest that although the subjects in the control group had to be eliminated, the data from one control subject remained exactly the same; over the 4-week
intervention; that is, the Delta 60 measurement of change in heart rate remained 41.2 bpm from the pre to the post measures.

Debate surrounding ANS mechanisms has propagated investigation into sympathetic withdrawal and parasympathetic activation. It has been demonstrated that HRR after exercise is delayed in patients with chronic heart failure (Klein & Ferrari, 2010). Furthermore, a delayed withdrawal of the sympathetic nervous system has been shown to increase the risk of myocardial infarction (heart attack) (Azevedo & Parker, 1999). Manifesting balance between the sympathetic and parasympathetic nervous system, specifically parasympathetic dominance, in harmony with the circadian rhythms of normal human functioning (Bonnemeier et al., 2003), is a goal of modern-day physicians, yet has been a focus of yoga science for 5000 years (Patañjali, 2002).

Although the results indicate that one of the dependent variables (i.e., SBP in recovery and trends for DBP and RPP) was changed in the direction of superior health in the autonomic nervous system, there was no predominance or superior advantage to the yoga intervention as compared with the stretch and relax intervention. The enigma is that a sizable amount of scientific evidence concludes that yoga can in fact regulate the autonomic balance and restore factors of the nervous system that have been shown to lead to hypertension (D. L. Cohen et al., 2009; Field, 2011; Ross & Thomas, 2010b).

Opposite to the hypothesis in the current study, Vijayalakshmi et al. (2004) showed that yoga training enhanced the sympathetic response to stressful stimuli such as the isometric handgrip test; the yoga training reinstated the autonomic regulatory reflex
mechanism in hypertensive patients. Further research has linked improvement in parasympathetic dominance directly to yoga interventions (Cheema et al., 2011; Joseph et al., 1981; Khanam, Sachdeva, Guleria, & Deepak, 1996; Udupa, Madanmohan, Bhavanani, Vijayalakshmi, & Krishnamurthy, 2003). Ultimately it has to be acknowledged that a substantial amount of yoga research is demonstrating some kind of change in the physiology of the body that modulates the autonomic nervous system (Bhargava et al., 1988; Cheema et al., 2011; Tang et al., 2009; Telles & Desiraju, 1993), but direction of PNS and SNS changes might depend on subject population (e.g., clinical vs. healthy) or time since last bout of yoga practice in which measures are made. Despite the literature, this study found that neither yoga or stretch and relax had an effect on either parasympathetic dominance (T30) or sympathetic withdrawal for accelerated HRR as measured in a limited number of subjects.

Reasons for the lack of statistical significance in the results may be due to environmental conditions affecting the test results such as talking during the recovery measures and the wide range of experience between the different testers obtaining the measurements. In particular, any talking amongst the technicians was likely to be reflected in the data of the T30 measurements, as this measure followed low-level exercise. Silence and consistent administration of the Delta 60 measurement also proved to be a challenge at certain times of the day for rotating sets of technicians. Even more of a concern than the T30 data was that HRR measured by Delta 60 appeared to indicate opposite effects on the ANS, although these measures do capture slightly different
aspects of ANS function. This may raise questions about the validity of the measures used. These were new techniques in the field of ANS research, and they may still need refining.

Why then are the adaptations created through the practice of yoga in the ANS not visible in recovery measures in this study? Perhaps eight sessions is not long enough to manifest changes in the autonomic nervous system, particularly changes in parasympathetic activity. Other researchers have demonstrated physiological changes that show cardiac vagal control, sympathetic withdrawal and parasympathetic dominance depends on intensity of the exercise intervention and longer interventions (Coote, 2010; Hautala et al., 2008; Hepburn et al., 2005). A study with no control subjects determined yoga training one hour daily for 3 months decreased HR and BP at rest and indicated a shift in the autonomic balance towards relative parasympathodominance (Joseph et al., 1981) Telles (1993) reported physiological changes after 3 months of daily yoga training manifests optimum autonomic function. Pal et al. (2003) also noted that 3 months of daily yoga breathing exercises increased parasympathetic activity and decreased sympathetic activity as compared to no change in the control group. In all of the studies that so show an outcome effect, the intensity and duration of yoga training was greater than in the current study.

Although both class interventions were almost identical with regard to the exercises that were taught, the way in which they were taught was very different. The classes did not have the same instructor and the manner of verbal instructions and the
way in which the exercises (either asanas or stretches) were presented were not uniform and may have greatly influenced how the subjects practiced the exercises and hence the way the exercises effected their physiology, especially the nervous system. In the same way, the students may have different reactions to the instructor. Instructors who are calm and consistent may manifest different class conditions with different effects than instructors who are excited or have various or inconsistent class routines.

The dynamic interrelationship between the heart and the brain, or as yoga terms it, the body and the mind, is determining the balance of excitement and catecholamine release as well as vagus nerve stimulation; as well as the balance of parasympathetic and sympathetic dominance within the autonomic nervous system. Darwin and Ekman (1872) acknowledged the neural relationship of the heart and the brain:

when the heart is affected it reacts on the brain; and the state of the brain again reacts through the same pneumo-gastric-vagus nerve on the heart; so that under any excitement there will be much more mutual action and reaction between these two most important organs of the body (p. 40).

How the brain interpreted the surrounding environment and/or the instructor may have influenced the conditioning of the ANS. The reactivation of the parasympathetic and the activation or lack of activation in the sympathetic branch specifically influences HRR and BPP in both the contraction and expansion of the smooth muscle tissue differently in the two groups.
Implications

The major implication of this research is that yoga training may be as effective as stretch and relax training in improvement of BP recovery measures from submaximal bouts of exercise. The T30 and Delta 60 measurements may need to be used more and administered by professional paid technicians to increases the reliability. Further these tests may need to be correlated to other measures of the autonomic nervous system such as heart rate variability and spectral analysis in order to confirm their accuracy as measures of parasympathetic dominance and sympathetic withdrawal respectively. Finally, the difficulty in recruitment of control subjects must be acknowledged and considered as an important challenge to overcome for more valid future research, as these subjects may be less willing to participate in extracurricular activities such as research experiments.
Future Research

Future research recommendations are to focus a tremendous amount of effort, time, and money in the recruitment of control subjects. Furthermore, grant funding may allow for more consistency in the technicians. Above all, a longer intervention period with more classes per week could better illustrate the changes yoga and stretch and relax may have on the ANS. Despite numerous inconsistencies that threaten the internal validity, the overall results show that both interventions help to modulate lower HR and BP from a submaximal bout of exercise which demonstrates that even eight sessions of yoga or stretch and relax have a remarkable effect on the physiological adaptation of the human body.

Conclusion

Contrary to the hypothesis, yoga training did not significantly affect HR or BP recovery differently than was found for stretch and relax training. Furthermore, neither intervention affected HRR measures reflecting autonomic function. Due to lack of control group subjects, no conclusions can be stated that the interventions were the cause of the lower recovery BP, however the researchers note the results of improved recovery hemodynamic measures with interest, as the interventions may result in improvements in cardiovascular functions, specifically recovery BP from a submaximal bout of exercise stimulus.
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APPENDICES

Appendix A: Informational Flyer

ARE YOU INTERESTED IN BEING INVOLVED IN A RESEARCH STUDY OF THE EFFECTS OF DIFFERENT TYPES OF EXERCISE ON HEART RATE AND BLOOD PRESSURE?

You must:
- Be 18-25 years of age
- Be a non-smoker
- Participate in physical activity equivalent to at least brisk walking at least 30 minutes on at least three days of the week for at least three months
- Be new to yoga or “stretch & relaxation” practice less than 5 days a week for 1 year
- Have no major illness
- Be willing to attend “yoga” or “stretch and relax” class two times a week for four weeks or be recruited for a non-exercise group
- **Be willing to maintain the same activity level for the four to five week study duration**
- Know or have blood pressure tested (Free testing this Friday in 254 KA, Human Performance Lab, from 10 am to 3 pm...just show up)
Appendix B: Informed Consent

EFFECTS OF YOGA TRAINING ON HEART RATE AND BLOOD PRESSURE RECOVERY FROM EXERCISE

INFORMED CONSENT FOR PARTICIPATION
Please read the following as it provides information about this research study. Please understand that you are being asked to volunteer in this study and it is your choice to participate. By signing this form you are indicating that you have been informed of the nature of the study, including the risks and benefits of its association, and want to participate.

Principal Investigator:
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Trinidad, CA 95570
707-677-5227
bradleyrichmond@yahoo.com

Project Description:
The purpose of this study was to investigate the effects of yoga exercise training, stretch and relax exercise, and no intervention on heart rate and blood pressure recovery from exercise. This research may help to show the effects of certain types of exercise training on the autonomic nervous system.

Consent:
You must be at least 18 years old to participate in this study.

Your participation in this study is voluntary.

You may choose not to participate at all, or you may refuse to participate in certain procedures or answer certain questions or discontinue your participation at any time without penalty or loss of benefits.
Procedures:
If you agree to participate in this study, you:

Will participate in health/fitness testing that will take place over the course of approximately two days before and again after a 4 to 5 week period of yoga classes (PE 259), stretch and relax classes (PE 144), or no exercise class.

Will report to the Human Performance Laboratory, room 254 Kinesiology and Athletics Building, Humboldt State University, for all testing, having adhered to pretesting conditions including ample rest and avoidance of substances such as caffeine and tobacco immediately prior to testing.

Must be cleared for participation in exercise testing by being stratified as “low risk” based on responses to a medical screening questionnaire, a physical activity questionnaire and, if your blood pressure is unknown, resting blood pressure measurements. These screening procedures will take approximately 20 minutes at the beginning of the study.

Are willing to be selected to one of three groups (i.e., Yoga Group, Stretch and relax Group, or no exercise class group). If in the Yoga or Stretch and relax groups you agree to attend and fully participate in these classes for the duration of the study.

Will be asked to maintain current physical activity levels, with the exception of participation in the above-mentioned classes, over the time period from the beginning of testing to completion of post-testing approximately 4 to 5 weeks later.

Will have measures taken for resting blood pressure, resting heart rate, height, weight, body circumferences, and body composition by underwater weighing. The underwater weighing procedure (which will only be done once at beginning of the 4 to 5 week study period) involves being completely submerged in a tank of warm water. An accurate measurement of underwater weight requires a complete exhalation of air while submerged. You dictate the amount of time spent underwater. These tests will take approximately 30 minutes at the beginning of the study and 15 minutes at the end of the study.

Will have your maximal oxygen consumption measured (VO₂max) and maximal heart rate determined from an exercise test on a cycle ergometer. During this test there will be progressive increases in the resistance that you will pedal against until you are unable to continue. The test itself will last about 12 minutes. Plan to spend approximately 60 minutes in total for this assessment (inclusive of time for set up, warm-up, test and recovery) at the beginning of the study and again at the end of the study.
Will have your heart rate and blood pressure recovery determined after two different submaximal exercise tests that will be administered in the same testing session using a cycle ergometer protocol. Plan to spend approximately 60 minutes in total for these tests (inclusive of time for set up, warm-up, test and recovery) at the beginning of the study and again at the end of the study.

Possible Risks and Discomforts:
This study involves the administration of two maximal graded exercise tests, in which all-out effort will be required to complete the test. You also will be asked to take two sets of submaximal exercise tests, with each of these followed by a resting (passive) recovery. You also will have your weight taken while you are underwater.

( ) You may experience discomfort that is associated with these types of maximal and submaximal exercise tests.
( ) You will be required to be completely submerged in a tank of warm water for a few seconds in order to obtain a body composition measurement. You may experience discomfort while being submerged under water. You may inhale or swallow water while being submerged. You may slip while entering and exiting the tank.
( ) There is a possibility of injuring yourself while performing any of these activities.
( ) As is true for any exercise, you might experience abnormal heart rate, blood pressure and, in rare instances, death.
( ) Proper supervision and instruction during maximal and submaximal exercise tests will be provided to attempt to avoid injury. Standardized procedures for testing will be followed. Emergency equipment and trained personnel will be available to respond to any unusual situations should they arise.

Benefits:
The only direct benefits to you from participating in this study include receiving your scores for the various tests. The value you get for your VO$_{2\text{max}}$ will allow you to understand how your aerobic fitness is ranked compared to others of your age and sex. All subjects participating in this study will also receive scores for their measured body composition, blood pressure, height, weight, and waist and hip circumferences. The results from these tests may help you to determine your individual health/fitness strengths and weaknesses. In total this testing is valued at approximately $160.

Responsibilities You Have as a Participant in this Research:
Information you possess about your health status, and current or previous experiences of unusual feelings with physical effort may affect the value and safety of the exercise you will do as part of this research study. You agree to report this information to the principal
investigator, staff, or student assistant(s) conducting the tests. You also agree to promptly report to the investigator, staff or student assistant(s) any abnormal feelings you have during the exercise tests (e.g., excessive fatigue, shortness of breath, light-headedness, chest discomfort or similar occurrences). Finally, you agree to inform the investigator, staff, or student assistant(s) of any changes in medical status or medication use.

You understand that the primary investigator, lab staff, or student assistant test administrator(s) may reduce or stop the exercise test or training program if they deem that any abnormal responses to the exercise are occurring.

Confidentiality/Anonymity:
You understand that participation in this study is completely voluntary. Confidentiality will be protected by the following ways: (a) results will be presented as group data in any presentations and publications; (b) all testing data, once collected, will be stored in password-protected computers that are only accessible by the Principal Investigator and primary student assistant; (c) all non-electronically stored information will be kept in a locked drawer in the office of the Principal Investigator; and (d) all data will be kept for five years. Five years after project completion, data will be destroyed via a paper shredder and electronic information will be permanently removed from computer memory. The demographics, background information, medical history, and other data collected will be treated as privileged and confidential as described in the Health Insurance Portability and Accountability Act of 1996. The Principal Investigator and primary student assistant only have access to your demographics, background information, and medical history, and other data. Participation in this research project will not involve any costs that you must pay. You understand that no compensation will be awarded for participating in this study. Authorized persons from Humboldt State University and the Institutional Review Board have the legal right to review research records and will protect the confidentiality of those records to the extent permitted by law. Otherwise, all research records will NOT be released without your consent, unless required by law or court order. Results of testing will be confidential and will not be released unless individual participant consent is given; otherwise your name will be assigned a number to analyze data for anonymity purposes.

Inquiries:
Any questions about the procedures used in this research are encouraged. If you have any concerns or questions, please ask us for further explanations.

Freedom of Consent:
Your participation in this research is voluntary. You are free to stop any test at any point, if you so desire.
Contacts:
For questions regarding this study, please contact the Principal Investigator using the contact information above. If you have questions regarding your rights as a participant, any concerns regarding this project, or any dissatisfaction with any part of this study, you may report them—confidentially, if you wish—to the Dean for Research & Sponsored Programs, Dr. Rhea Williamson at Rhea.Williamson@humboldt.edu or (707) 826-4189.

I understand that the Investigator will answer any questions I may have concerning the investigation or the procedures at any time. I also understand that my participation in any study is entirely voluntary and that I may decline to enter this study or may withdraw from it at any time without jeopardy. I understand that the investigator may terminate my participation in the study at any time.

Signature:
Your signature below states your understanding of and willingness to participate in this study.
I_______________________________________ have read and agree to participate in this study described above.

(Print your full name here) ____________________________________________

(Sign your full name here) ____________________________________________

____/___/______ (Date)
Appendix C: Release of Liability

HUMBOLDT STATE UNIVERSITY RELEASE OF LIABILITY, PROMISE NOT TO SUE, ASSUMPTION OF RISK AND AGREEMENT TO PAY CLAIMS

I have read this form, and I understand the tests and exercise training procedures that I will perform and the attendant risks and discomforts. Knowing these risks and discomforts, and having had an opportunity to ask questions that have been answered to my satisfaction, I consent to participate in these tests, and these training programs (if a participant in the Yoga or Stretch and relax Techniques classes).

In consideration for being allowed to participate in this Activity, on behalf of myself and my next of kin, heirs and representatives, I release from all liability and promise not to sue the State of California, the Trustees of The California State University, California State University, Humboldt State University and their employees, officers, directors, volunteers and agents (collectively “University”) from any and all claims, including claims of the University’s negligence, resulting in any physical or psychological injury (including paralysis and death), illness, damages, or economic or emotional loss I may suffer because of my participation in this Activity, including travel to, from and during the Activity.

I am voluntarily participating in this Activity. I am aware of the risks associated with traveling to/from and participating in this Activity, which include but are not limited to physical or psychological injury, pain, suffering, illness, disfigurement, temporary or permanent disability (including paralysis), economic or emotional loss, and/or death. I understand that these injuries or outcomes may arise from my own or other’s actions, inaction, or negligence; conditions related to travel; or the condition of the Activity location(s). Nonetheless, I assume all related risks, both known or unknown to me, of my participation in this Activity, including travel to, from and during the Activity.

I agree to hold the University harmless from any and all claims, including attorney’s fees or damage to my personal property that may occur as a result of my participation in this activity, including travel to, from and during the Activity. If the University incurs any of these types of expenses, I agree to reimburse the University. If I need medical treatment, I agree to be financially responsible for any costs incurred as a result of such treatment. I am aware and understand that I should carry my own health insurance.

Date:_______ Signature of Subject:___________________________________________

Date:_______ Signature of Witness:__________________________________________
Appendix D: Demographic and Medical History Questionnaire

Demographic and Medical History Questionnaire

Descriptive and Medical History Questionnaire

Name: _______________________________________________ Date: ____________

Address: _______________________________________________________________________________________

Home Phone: _________________________ Work Phone: ______________________

Age: ________ Date of Birth: _______________ Sex: ______________________

Emergency Contact

Name: ____________________ Phone: __________________

Student (  ) Staff/Faculty (  ) Community (  ) Athlete (  )

Please circle/mark ONE of the following:

1. Which ONE of the following ethnicities BEST represents you:
   a. African American
   b. Asian
   c. Caucasian
   d. Latino
   e. Middle Eastern
   f. Native American
   g. Pacific Islander
   h. Other

2. Are you currently participating in a collegiate athletic sport?  Yes (  ) No (  )
   If Yes, what sport are you participating in? ______________________

Please describe your experience in practicing yoga prior to beginning of this semester.
   How many months have you participated? _____
   How many times per week on average have you participated? _____
   On average, how has each yoga session lasted? _____

Please describe your experience in practicing stretch and relax exercises prior to
beginning of this semester.
   How many months have you participated? _____
   How many times per week on average have you participated? _____
   On average, how has each yoga session lasted? _____

It is extremely important for us to know if you have any medical conditions which may
affect your testing process or your progress in our program. Please take the time to
answer these questions accurately.

Medical History

YES NO In the past five years have you had:

( ) ( ) 1. Pain or discomfort in chest, neck, jaw, or arms

( ) ( ) 2. Shortness of breath with mild exertion (e.g., walking)

( ) ( ) 3. Dizziness or fainting

( ) ( ) 4. Ankle edema (swelling)
5. Heart palpitations (forceful or rapid beating of heart)

YES NO In the past five years have you had:

6. Pain, burning, or cramping in leg with walking

7. Heart murmur

8. Unusual fatigue with mild exertion

Have you ever had:

11. Heart disease, heart attack, and/or heart surgery

12. Abnormal EKG or rhythm disturbance

13. Stroke

14. Metabolic disease (e.g., DIABETES, thyrotoxicosis, or myxedema)

15. Asthma or any other pulmonary (lung) condition

16. Heart or blood vessel abnormality (e.g., suspected or known aneurysm)

17. Liver or kidney disease

18. Thyroid disorder

19. Severe osteoporosis

20. Seizure

21. Do you have a pacemaker, cardiac defibrillator, or other electronic device?

22. Do you have a systemic infection, a fever, or swollen lymph glands?

23. Do you have an infectious disease (e.g. mononucleosis, hepatitis, AIDS)?

24. Do you have a neuromuscular, musculoskeletal, or rheumatoid disorder that is made worse by exercise?

25. Do you know of any reason why you should not do physical activity, or are there any particular exercises that make conditions worse?

If you answered yes to any of these questions, please explain.

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

________________________

Risk Factors

YES NO DON’T KNOW

1. Are you a male 45 years of age or older?

2. Are you a female 55 years of age or older?

3. Do you have a father or brother who had a heart attack or heart surgery before age 55?
4. Do you have a mother or sister who had a heart attack or heart surgery before age 65?

5. Do you smoke or have you smoked in the past 6 months?

6. Do you have high blood pressure (>140/90mmHg) or are you taking blood pressure lowering medication?

7. Do you have high total cholesterol (>200 mg/dL)?

8. Do you have high LDL cholesterol (>130 mg/dL)?

9. Are you taking cholesterol lowering medication?

10. Do you have low HDL cholesterol (< 40 mg/dL)?

11. Is your HDL cholesterol ≥60mg/dL?

12. Is your fasting blood glucose >100 mg/dL (diabetic or pre-diabetic)?

13. Do you have, or within the last 8 weeks had, an exercise regimen?

14. Have you ever practiced yoga before?

15. Do you exercise regularly? If so, describe:
   Frequency: __________ days/week
   Average Workout Time: __________ min.
   Intensity (circle): Low Moderate High
   How many months have you been active: __________

If you answered yes to any of these questions, please explain.
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

Health-Related Questions

YES  NO

1. Have you had any major surgery, serious illness, or serious injury in the last five years?

2. Are you currently under the care of a physician?

3. Are you pregnant?

4. Are allergic to isopropyl alcohol (rubbing alcohol)?

5. Do you have any allergies to medications, bees, foods, etc.? If so please list

6. Do you have any skin problems?
8. Do you have any other illness, disease, or medical condition (beyond those already covered in this questionnaire)?
( ) ( )

9. Have you had any caffeine, food, or alcohol in the past 3 hours?
( ) ( )

10. Have you exercised today?
( ) ( )

11. Are you feeling well and healthy today?

If you answered yes to any of these questions, please explain.
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

Medications

Please Select Any Medications You Are Currently Using:

| □ Diuretics | □ Other Cardiovascular |
| □ Beta Blockers | □ NSAIDS/Anti-inflammatories (Motrin, Advil) |
| □ Vasodilators | □ Cholesterol Lowering |
| □ Alpha Blockers | □ Diabetes/Insulin |
| □ Calcium Channel Blockers | □ Other Drugs (record below). |

Please list the specific medications that you currently take:
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

I certify that the information I have provided is complete and accurate to the best of my knowledge.

Date _______________ Signature of Subject __________________________________

Date _______________ Signature of Witness __________________________________

Office Use Only:
____BP  ____waist circumference  ____BMI
____ Low Risk  ____Moderate Risk  ____ High Risk
Appendix E: Pretest Instructions Given Prior to Lab Testing Days and General Participation

Instructions
The two days of submaximal exercise testing (one before and one after the 4 to 5 week intervention period) will be scheduled for the same time of day.

Please adhere to the following conditions for your participation in this research. Testing sessions will be held in the Human Performance Laboratory at HSU, room 254 KA.

Please do not alter your diet during the course of the study.
Please maintain your physical activity levels for the duration of the study.
Please do not ingest any drugs, other than those prescribed to you and previously disclosed, during the course of the study.
Please refrain from exercise in the 48 hours prior to lab test days.
Please do not consume alcohol in the 24-hour period preceding the test.
Please do not eat, drink caffeine, or use tobacco for at least 3 hours prior to each test session.
Drink ample fluids over the 24-hour period preceding the tests to insure normal hydration.
Please arrive at the designated testing location (254 KA, HSU) at least 5 minutes early on scheduled testing days.
Please wear loose fitting exercise attire (e.g., tee-shirt and shorts; woman may prefer to wear a sports bra) and athletic shoes to exercise testing sessions. Please bring a bathing suit and towel to the session in which you will be underwater weighed.
Appendix F: Physical Activity Questionnaire

Fassebarger Physical Activity Questionnaire:

1. How many city blocks or their equivalent do you usually walk each day? ______ blocks/day
   (1600 feet = 1 mile)
2. What is your usual pace of walking? (Please check one.)
   a. Casual or strolling (less than 2 mph)  b. Average or normal (2 to 3 mph)
   c. Fairly brisk (3 to 4 mph)  d. Brisk or strolling (4 mph or faster)
3. How many flights of stairs do you climb up each day? ______ flights/day (Let 1 flight = 10 steps)
4. List any sports or recreation you have actively participated in during the past year:
   Please remember seasonal sports or events.

<table>
<thead>
<tr>
<th>Sport, Recreation, or Other Physical Activity</th>
<th>Number of Time/episode</th>
<th>Hours</th>
<th>Minutes</th>
<th>Years Participation</th>
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<tbody>
<tr>
<td>a</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b</td>
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</tr>
<tr>
<td>f</td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

5. Which of these statements best expresses your view? (Please check one.)
   a. I take enough exercise to keep healthy.  b. I ought to take more exercise.  c. Don't know
6. At least once a week, do you engage in regular activity such as brisk walking, jogging, bicycling,
   swimming, etc. long enough to work up a sweat, get your heart thumping, or get out of breath?
   No Why not? ______ Yes How many times per week? ______ Activity ______
7. When you are exercising in your usual fashion, how would you rate your level of exertion (degree of
effort)? (Please circle one number.)
<table>
<thead>
<tr>
<th>0</th>
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<th>2</th>
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<th>4</th>
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<td>light</td>
<td>work</td>
<td>Work</td>
<td>Moderate</td>
<td>walking</td>
<td>walk</td>
<td>Jogging</td>
<td>Running</td>
<td>Very</td>
</tr>
<tr>
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<td>very</td>
<td>very</td>
<td>very</td>
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<td>very</td>
<td>very</td>
<td>very</td>
<td>very</td>
<td>very</td>
<td>very</td>
</tr>
</tbody>
</table>


Appendix G: Perceived Stress Scale

**Perceived Stress Scale**

Sheldon Cohen

The *Perceived Stress Scale* (PSS) is the most widely used psychological instrument for measuring the perception of stress. It is a measure of the degree to which situations in one's life are appraised as stressful. Items were designed to tap how unpredictable, uncontrollable, and overloaded respondents find their lives. The scale also includes a number of direct queries about current levels of experienced stress. The PSS was designed for use in community samples with at least a junior high school education. The items are easy to understand, and the response alternatives are simple to grasp. Moreover, the questions are of a general nature and hence are relatively free of content specific to any subpopulation group. The questions in the PSS ask about feelings and thoughts during the last month. In each case, respondents are asked how often they felt a certain way.

**Evidence for Validity:** Higher PSS scores were associated with (for example):
- failure to quit smoking
- failure among diabetics to control blood sugar levels
- greater vulnerability to stressful life-event-elicited depressive symptoms
- more colds

**Health status relationship to PSS:** Cohen et al. (1983) show correlations with PSS and: Stress Measures, Self-Reported Health and Health Services Measures, Health Behavior Measures, Smoking Status, Help Seeking Behavior.

**Temporal Nature:** Because levels of appraised stress should be influenced by daily hassles, major events, and changes in coping resources, predictive validity of the PSS is expected to fall off rapidly after four to eight weeks.

**Scoring:** PSS scores are obtained by reversing responses (e.g., 0 = 4, 1 = 3, 2 = 2, 3 = 1 & 4 = 0) to the four positively stated items (items 4, 5, 7, & 8) and then summing across all scale items. A short 4 item scale can be made from questions 2, 4, 5 and 10 of the PSS 10 item scale.

**Norm Groups:** L. Harris Poll gathered information on 2,387 respondents in the U.S.

<table>
<thead>
<tr>
<th>Category</th>
<th>N</th>
<th>Mean</th>
<th>S.D.</th>
</tr>
</thead>
<tbody>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>928</td>
<td>12.1</td>
<td>5.9</td>
</tr>
<tr>
<td>Female</td>
<td>1406</td>
<td>13.7</td>
<td>6.6</td>
</tr>
<tr>
<td>Age</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18-29</td>
<td>645</td>
<td>14.2</td>
<td>6.2</td>
</tr>
<tr>
<td>30-44</td>
<td>750</td>
<td>13.0</td>
<td>6.2</td>
</tr>
<tr>
<td>45-54</td>
<td>285</td>
<td>12.0</td>
<td>6.1</td>
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<tr>
<td>55-64</td>
<td>282</td>
<td>11.9</td>
<td>6.9</td>
</tr>
<tr>
<td>65 &amp; older</td>
<td>296</td>
<td>12.0</td>
<td>6.3</td>
</tr>
<tr>
<td>Race</td>
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<td></td>
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</tr>
<tr>
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<td>12.0</td>
<td>6.2</td>
</tr>
<tr>
<td>Hispanic</td>
<td>98</td>
<td>14.0</td>
<td>6.9</td>
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<tr>
<td>black</td>
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<tr>
<td>other minority</td>
<td>50</td>
<td>14.1</td>
<td>5.0</td>
</tr>
</tbody>
</table>

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Perceived Stress Scale

The questions in this scale ask you about your feelings and thoughts during the last month. In each case, you will be asked to indicate by circling how often you felt or thought a certain way.

Name _____________________________________________ Date ____________
Age ______ Gender (Circle): M  F  Other ____________________________

0 = Never  1 = Almost Never  2 = Sometimes  3 = Fairly Often  4 = Very Often

1. In the last month, how often have you been upset because of something that happened unexpectedly? ........................................ 0 1 2 3 4

2. In the last month, how often have you felt that you were unable to control the important things in your life? ................................. 0 1 2 3 4

3. In the last month, how often have you felt nervous and “stressed”? .......... 0 1 2 3 4

4. In the last month, how often have you felt confident about your ability to handle your personal problems? ........................................ 0 1 2 3 4

5. In the last month, how often have you felt that things were going your way? .............................................................................. 0 1 2 3 4

6. In the last month, how often have you found that you could not cope with all the things that you had to do? ................................. 0 1 2 3 4

7. In the last month, how often have you been able to control irritations in your life? ................................................................. 0 1 2 3 4

8. In the last month, how often have you felt that you were on top of things?..... 0 1 2 3 4

9. In the last month, how often have you been angered because of things that were outside of your control? ................................. 0 1 2 3 4

10. In the last month, how often have you felt difficulties were piling up so high that you could not overcome them? ................. 0 1 2 3 4

Please feel free to use the Perceived Stress Scale for your research. The PSS Manual is in the process of development, please let us know if you are interested in contributing.

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Redwood City, CA 94061 USA
Phone: (650) 261-3500  Fax: (650) 261-3505
e-mail: mindgarden@msn.com
www.mindgarden.com

References
Appendix H: Data Collection Form

EFFECTS OF YOGA TRAINING ON HEART RATE AND BLOOD PRESSURE RECOVERY FROM EXERCISE

Code________________________________

Date_________________________________ □ Pretest □ Post-test

Time___________ am/pm

_______Resting HR
_______Resting BP
_______Mass (nearest .25 kg)
_______Height (nearest 0.5 cm)
_______Waist circumference (nearest mm)
_______Hip circumference (nearest mm)
_______Body fatness (%) (pretest only)
_______VO₂ max criteria reached?
_______VO₂ max (ml/kg/min)
_______max HR
_______40% VO₂max
_______85% HRₘₐₓ
Appendix I: Yoga Class Format

YOGA CLASS FORMAT

Opening: Anusara Yoga is a type of hatha yoga, which emphasizes alignment. Anusara yoga philosophy looks for the good in all people and all things. Consequently, students of all levels of ability and yoga experience are honored for their unique differences, limitations, and talents (Health & Fitness, 2011). Developing strength, flexibility and stamina, as well as an effective breathing practice is the main outcome goal. Please think of an asana not as a "pose", but as "the place and manner in which you move", in order to develop strength, flexibility and stamina.

Important! Doing "the pose" is not your goal. Rather than focusing on "achieving the pose", focus on how the stretch is achieved; what is being stretched; what is being strengthened and the exact manner in which this is done. Precision, and alignment in your asanas will deliver you more benefits than simply trying to "do a pose". Even more importantly, it will keep you safe and prevent injury.

Breathe! Our breath is a barometer that reflects our state of mind, our well being and our experience in any given moment. Diaphragmatic breathing calms and soothes the nervous system and can counteract the stress reactivity cycle before we begin to experience its negative effects. The adage "Take a deep breath!" when under stress is sound, wise advice.

Philosophy: In yoga, the breath and the life force energy within the breath can be controlled and directed in certain ways affecting mind, body and spirit. When we pay attention to our breath and the sensations of our body breathing, our awareness is drawn into the body and the mind shifts from focusing on its usual distractions to focusing on the breath. As this happens the mind and body move into integration and balance.

Beginners: Beginners should not be in a hurry to do any pose in its perfect position. It is important that each individual practice to his or her own capacity and not strain in any pose. Deep breathing must always be prioritized before depth in the posture. If the breath becomes short or strained back out of the pose until they are able to breathe.

Time: It is important to wait at least two hours after eating before practicing yoga, six hours after eating before practicing pranayama.

Start:
Tadasana. Stand with the bases of your big toes touching, heels slightly apart. Lengthen your tailbone toward the floor and lift the pubis toward the navel. Press your shoulder blades into your back, then widen them across and release them down your back. Without
pushing your lower front ribs forward, lift the top of your sternum straight toward the ceiling. Widen your collarbones, arms beside the torso. Balance the crown of your head directly over the center of your pelvis, with the underside of your chin parallel to the floor, throat soft, and the tongue wide and flat on the floor of your mouth. Soften your eyes. Tadasana is usually the starting position for all the standing poses.

_Trikonasana._ Stand upright, with feet together. With an exhalation, step 4 feet apart. Raise your arms parallel to the floor and reach them actively out to the sides, shoulder blades wide, palms down. Turn your left foot in slightly to the right and your right foot out to the right 90 degrees. Align the right heel with the left heel. Exhale and extend your torso to the right directly over the plane of the right leg, bending from the hip joint, not the waist. Anchor this movement by strengthening the left leg and pressing the outer heel firmly to the floor. Rotate the torso to the left. Let the left hip come slightly forward and lengthen the tailbone toward the back heel. Rest your right hand on your shin, ankle, or the floor outside your right foot, whatever is possible without distorting the sides of the torso. Stretch your left arm toward the ceiling, in line with the tops of your shoulders. Reverse the feet and repeat for the same length of time to the left.

_Vrikshasana._ Stand upright feet together. Shift your weight slightly onto the left foot, keeping the inner foot firm to the floor, and bend your right knee. Reach down with your right hand and clasp your right ankle. Draw your right foot up and place the sole against the inner left thigh, press the right heel into the inner left groin, toes pointing toward the floor. Lengthen your tailbone toward the floor. Press your hands together. Repeat for the same length of time with the legs reversed.

_Bhujangasana._ Lie prone on the floor. Stretch your legs back, tops of the feet on the floor. Spread hands on the floor under your shoulders. Hug the elbows back into your body. Press the tops of the feet and thighs and the pubis firmly into the floor. On an inhalation, begin to straighten the arms to lift the chest off the floor.

_Dhanurasana._ Lie on your belly with your hands alongside your torso, palms up. (You can lie on a folded blanket to pad the front of your torso and legs.) Exhale and bend your knees, bringing your heels as close as you can to your buttocks. Reach back with your hands and take hold of your ankles. Keep your knees hip width for the duration of the pose. Inhale and strongly lift your heels away from your buttocks and, at the same time, lift your thighs away from the floor. Draw the tops of the shoulders away from your ears.

_Usttrasana._ Kneel on the floor with your knees hip width and thighs perpendicular to the floor. Press your shins and the tops of your feet firmly into floor. Rest your hands on the back of your pelvis, bases of the palms on the tops of the buttocks, fingers pointing down. Now lean back against the firmness of the tailbone and shoulder blades. For the time being keep your head up, chin near the sternum, and your hands on the pelvis. When
ready go back, touch the hands to the feet simultaneously while keeping the thighs perpendicular to the floor.

*Pachimotthasana.* Sit on the floor with your legs straight in front of you. Press actively through your heels. Draw the inner groins deep into the pelvis. Inhale, and keeping the front torso long, lean forward from the hip joints.

*Gomukhasana.* Sit with straight legs, then bend your knees and put your feet on the floor. Slide your left foot under the right knee to the outside of the right hip. Then cross your right leg over the left, stacking the right knee on top of the left, and bring the right foot to the outside of the left hip. Sit evenly on the sitting bones. Inhale and stretch your right arm sweep the arm behind your torso and tuck the forearm in the hollow of your lower back, parallel to your waist, with the right elbow against the right side of your torso. Roll the shoulder back and down, then work the forearm up your back until it is parallel to your spine. The back of your hand will be between your shoulder blades. Inhale and stretch your left arm forward, pointing toward the opposite wall, parallel to the floor. Turn the palm up and, with another inhalation, stretch the arm straight up toward the ceiling, palm turned back. Repeat with the arms and legs reversed for the same length of time. Remember that whichever leg is on top, the same-side arm is lower.

*Bhadrasana.* Stretch out both legs in front of you close together. Bend your legs at the knee and bring the feet towards the body. The knees should be pointed outwards. Join the soles of the two legs with the toes and heels close together. Using the thumb, forefinger and middle finger clasp the toes and fore part of both feet together. Bring the feet closer to your body while bending the elbows outward. Widen your thighs and gently bend the knees downwards. Sit straight up.

*Sarvangasana.* Lay your arms on the floor alongside your torso, then bend your knees and set your feet against the floor with the heels close to the sitting bones. Exhale, press your arms against the floor, and push your feet away from the floor, drawing your thighs into the front torso. Walk your hands up your back without letting the elbows slide too much wider than shoulder width. Inhale and straighten the knees, pressing the heels up toward the ceiling. When the backs of the legs are fully lengthened, lift through the balls of the big toes so the inner legs are slightly longer than the outer. Soften the throat and tongue. Gaze softly at your chest.

*Halasana.* From Sarvangasana exhale and bend from the hip joints to slowly lower your toes to the floor above and beyond your head. As much as possible, keep your torso perpendicular to the floor and your legs fully extended. With your toes on the floor, lift your top thighs and tailbone toward the ceiling.

*Padmasana.* Sit on the floor with the legs crossed. Carefully slide the left leg over the right, snuggling the edge of the left foot deep into the right groin. Again swivel into
position from the hip joint, pressing the heel against the lower belly, and arrange the sole perpendicular to the floor. Draw the knees as close together as possible. Use the edges of the feet to press the groins toward the floor and lift through the top of the sternum.

_Savasana_. Lay supine with palms facing upward, heels touching, the toes fall open. Training the mind and body to release tension and sink deeply into Savasana takes practice.

1. Tadasana
2. Trikonasana
3. Dandasana
4. Bhujangasana
5. Dhanurasana
6. Ustrasana
7. Pachimotthasana
8. Gomukhasana
9. Bhadrasana
10. Sarvangasana
11. Halasana
12. Padmasana
13. Savasana
Appendix J: Stretch and Relax Class Format

STRETCH & RELAXATION CLASS FORMAT

Opening: Stretch and relax is a quite guided exercise designed to stretch the muscles and relax the body. Students of all ages and levels breathe in various stretches using a mat, Bender ball and Versa Tube (both made by Power Systems). Developing range of motion, functional flexibility, and relaxing deeply are the main outcome goals. The dark room with no lights and soft background music and simple instructions to inhale and exhale help foster a safe environment for deep stretching as well as time for students to relax in each stretch.

Important! Courtesy to others requires a quite environment free of distractions. Also each person knows their own body best and individual modification is encouraged to find the most comfort and deepest stretch for each individual.

Breathe! Each stretch relaxation requires a deep inhale and exhale. Move slowly from forward bend inhales to extension exhales. Make sure each breath is long and slow and coordinated with the movement of your body.

Philosophy: Stretching the muscles and relaxing are important to maintain flexibility, full range of motion and help to prevent injury as well as to maximize the efficiency of human movement.

Beginners: All levels of ability are welcome and a “beginner’s mindset” is valuable for every student, particularly when exploring the ability of the body to stretch and relax. Beginning students must take particular caution not to overstretch and also must take care to notice the difference between a hurt that is “good” and opening versus and hurt that is sharp or “bad” and creating pain. Whenever there is doubt or question, back off and balance the depth of stretch with deep relaxation.

Time: Stretch and relax is most effective after vigorous exercise and is warmed up and sweat is present.

Start: Sitting cross-legged with the coccyx on the green versa ball to help level the hips begin breathing inhale arms up reaching to the ceiling and exhale arms down. Repeat 3 times. Next arms circle back one at a time in large circles. First circle the left arm then the right arm. Repeat 3 times. Now, still sitting cross-legged, forward bend inhale and sit up straight for the exhale. Repeat 3 times.

Versa Tube. Seated. Stretch band out in front of chest horizontal, extending arms towards the sides of the room.
Standing. Stretch band up and overtop of head again horizontal, extending arms toward the sides of the room. Inhale up over the head to back. Exhale overhead to the front. Repeat 3 times.

Lift the hand holding band over the right shoulder to stretch the triceps. Inhale look up to the left, exhale look down to the right.

Lift the hand holding band over the left shoulder to stretch the triceps. Inhale look up to the right, exhale look down to the left.

Next, take a wide stance (remove socks off) stretch band horizontal behind back, and bend forward.

**Standing forward bend twist.** Drop bands down, clasp elbows in front while hanging to stretch the backside of the legs and then swing side to side. Place the left hand on the floor and reach the right arm up toward the ceiling. Switch sides. Place right hand on the floor and reach the left arm up toward the ceiling. The torso twists while the biceps femoris is lengthened. Please roll back up to standing.

**Feet stretch.** Right big toe is planted, and then the little toe is planted. Now alternate from the big toe to the little toe. Next, circle ankle pivoting on the ball of the foot. Switch feet.

**Toe lift.** Stand on the toes and hold for balance. Inhale up. Exhale forward bend with legs shoulder width apart. Round up.

**Quad stretch.** Lift right leg and grab foot. Now reach out in front with opposite arm. Other side lift left leg and grab foot. Now reach out with opposite arm.

**Butterfly stretch.** Sit down and pull feet together. Use elbows to press legs down. Create resistance, while pressing legs down. Inhale up, exhale forward over long spine.

**Wide legged stretch.** Extend right leg, then left. Lift body up from behind pushing hands down to floor behind back. Extend forward and flex toes to stretch calves. Lean forward. If it is effective bring hands forward. Bring hands forward or backward depending on where it presents a straighter spine.

**Hip circles.** The right inner elbow cradles left leg. Rock back and forth. Repeat on the other side.

**Spine twist.** Bend left knee, cross up and over and place left foot flat of the floor on outside of right leg (or knee if leg is bent). Place both hands at the base of the spine. Inhale and extend spine, reach right arm up. Twist and place outside of right elbow on the outside of the left knee. Look back behind left shoulder and exhale. Do other side. Bend right knee, place sole of the right foot flat on the floor. Inhale place both hands
behind back on floor and extend spine up straight. Then reach left arm up over and place left elbow on the outside of the left knee, twist and exhale. Look back as far as you can behind the right shoulder.

**Figure 4 Seated.** Reach left leg crossed over right knee while sitting upright. Roll shoulders back and rock knee from side to side. Deep breath. Hug around bent leg and cradle knee back and forth. Hug knee close to body, then twist to the left. Other side. Reach right leg crossed over left knee. Roll shoulders back and rock left knee from side to side. Deep breath. Hug around bent leg and cradle knee back and forth. Hug knee close to body and then twist to the right.

**Supine Butterfly.** Recline on back and bring feet together. Inhale expand chest, exhale push knees down.

**Supine Wide-legged stretch.** Extend both legs out. Flex toes up, rotate top of thighs to point up towards ceiling. Exhale gently forward.

**Cat stretch.** On all fours, shoulders roll back as much as possible, exhale, arch spine back. Inhale, pull abdominal muscles in as much as possible, round the back. Repeat 5 times. Curl back up.

**Transition to Child’s pose.** Look up, back arches (backward bend). Then inhale forward. Now exhale curl up then push back into child’s pose. Repeat 5 times, and then stay in child’s pose.

**Shoulder reach.** On knees with shoulders down reach on arm extended out with fingers reaching out and fingers turned up. Extend through the hand. Repeat other side.

**Extended Cobra.** Lay on stomach, push up the chest with thighs on the floor. Next tuck the toes and rock back to child’s pose.

**Supine extended one leg stretch.** Lay on the back, use a versa tube band over right foot. Begin with the left knee bent and then extend left leg and flex left foot so the calf is flat on the floor while the right leg is extended with the versa tube band offering resistance. Circle the ankle. Cross the right leg over the body, stretching the IT (Iliotibial) band, then open up and let that leg go up and out in half circles. Lower the leg all the way towards the floor. Finish that leg up and switch legs.

**“Always listen to your body”**

**Supine Rest.** Everyone rest supine. Some may bend the knees for low back relief. Rest a few minutes.
*Butterfly supine with resistance.* Bend knees into the butterfly stretch, pulling feet together in toward the body but also pushing away at the same time. Reach over the feet and open them out extend through the legs. Roll up.

*Transition to sitting.* Sit with the legs spread wide apart. Pull feet in back to the butterfly seated upright.

*Foot massage.* Massage the right foot. Massage the left foot. Take a deep breath and knead the bottom of the foot till it hurts. Switch feet.

*Finishing Breath.* Inhale expand, Exhale release. Slowly class dismisses.

1. Versa Tube
2. Standing forward bend twist
3. Feet stretch
4. Toe lift
5. Quad stretch
6. Butterfly stretch
7. Wide legged stretch
8. Hip circles
9. Spine twist
10. Figure 4 Seated
11. Supine Butterfly
12. Supine Wide-legged stretch
13. Transition to Child’s pose
14. Shoulder reach
15. Extended Cobra
16. Supine extended one leg stretch
17. Supine Rest
18. Butterfly supine with resistance
19. Transition to sitting
20. Foot massage
21. Finishing breath
Appendix K: Checklist for Investigators

Checklist for Investigators

Projected schedule of testing that will take place in the HSU Human Performance Lab:

**Pre Testing:**
Recruitment in classes
Telephonic review of nature of study and description of elements of informed consent;
potential participants invited to ask questions
Informed Consent, Release of Liability
Physical Activity Questionnaire, Resting BP Measure, Medical History filled out and returned to co-investigators and risk stratified
Balance groups with regard to sex of the participants
Reminder email of pre-test instructions and phone call

**Testing Day 1:** Resting Measures, Descriptive Tests, Maximal Testing
Mass and Height
Circumferences
Resting Blood Pressure and HR measure #2 (if 2\text{nd} time BP \geq 140/90, S must be dropped)
Body Composition via underwater weighing
VO_{2max} Cycle ergometer test

**Testing Day 2:** Submaximal Testing to Determine Heart Rate and Blood Pressure
Recovery

**Training for 4 to 5 Weeks**

**Testing Day 3:** Repeat tests from Testing Day 1 (except underwater weighing)

**Testing Day 4:** Repeat tests from Testing Day 2
Appendix L: Schedule

Pretest Day 1 (approximately 90 min)
- resting HR measure
- resting BP measure
- completion of Perceived Stress Scale (Cohen et al., 1983) (Appendix G)
- Completion of the Paffenbarger Physical Activity Questionnaire (Appendix E)
- Height
- Weight
- Waist/Hip circumference measures
- Underwater weighing
- Cycle ergometer VO$_{2\text{max}}$ test (requiring 60 of the 90-min test time on this day)

Pretest Day 2 (approximately 60 min)
- Two submaximal tests performed sequentially. Workloads for these tests began at 50 Watts and increased 30 watts every 2 minutes until 8 minutes at a VO$_2$ (or corresponding HR) equivalent to 40% to 85% of initial VO$_{2\text{max}}$, and HR$_{\text{max}}$, respectively.

Yoga or Stretch and relax Class Attendance (approximately 100 minutes/week)
- 4 weeks of regular class attendance and participation

Posttest Day 1 (approximately 75 min)
- resting HR measure
- resting BP measure
- completion of Perceived Stress Scale (Cohen et al., 1983) (Appendix G)
- completion of the Paffenbarger Physical Activity Questionnaire (Appendix E)
- Weight
- Waist/Hip circumference measures
- Underwater weighing
- Cycle ergometer VO$_{2\text{max}}$ test (requiring 60 of the 75-min test time on this day)

Posttest Day 2 (approximately 60 min)
- Two submaximal tests performed sequentially. Workloads for these tests will be determined subsequent to pilot testing, but are likely to be at 4 to 8 minutes at a VO$_2$ (or corresponding HR) equivalent to 40% to 85% of initial VO$_{2\text{max}}$ and HR$_{\text{max}}$, respectively.
Appendix M: 2 X 2 Mixed-Factorial ANOVA Results for Resting Hemodynamic
Variables

Resting Heart Rate and Blood Pressure Measures: Mixed-Factorial ANOVAs
were used to determine differences between the yoga and stretch and relax groups before
and after a 4-week intervention for HR, SBP, DBP, MAP, and RPP. No significant
groups x time interactions were found, with the exception of those for the resting SBP
measures. Full results for each ANOVA are reported below.

  Resting heart rate. No significant group x time interaction was found for rest
HR measures ($p = .777$). No significant main effect for time was found ($p = .903$). No
significant main effect for group was found ($p = .729$).

  Resting systolic blood pressure. A significant group x time interaction was
found for rest SBP measures ($p = .045$). Similarly, a significant main effect for time was
found ($p = .035$). While the SBP measures for the yoga group remained fairly stable
between the pre and post tests (pre = 118.5 mmHg, post = 118.0 mmHg), the resting SBP
measures for the stretch and relax group changed noticeably from the pretest to the
posttest (pre = 124.1 mmHg, post = 106.7 mmHg). However, no significant main effect
for group was found ($p = .670$).

  Resting diastolic blood pressure. No significant group x time interaction was
found for rest DBP measures ($p = .286$). No significant main effect for time was found ($p
= .538$). No significant main effect for group was found ($p = .886$).
Resting mean arterial pressure. No significant group x time interaction was found for MAP measures ($p = .075$). No significant main effect for time was found ($p = .125$). No significant main effect for group was found ($p = .776$).

Resting rate pressure product. No significant group x time interaction was found for RPP measures ($p = .229$). No significant main effect for time was found ($p = .157$). No significant main effect for group was found ($p = .892$).