ACUTE EFFECTS OF BIKRAM YOGA ON AMBULATORY BLOOD PRESSURE

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ABSTRACT

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PURPOSE: The primary purpose of this study was to determine the acute effects of Bikram yoga on 24-hour ambulatory blood pressures (ABP) by comparing measures on a Bikram yoga (BY) day to a non-Bikram yoga (NBY) day. A secondary purpose was to investigate the effects of Bikram yoga on state anxiety and perceived stress. Measures were done to relate differences in ambulatory blood pressures between NBY and BY days with perceived stress, initial resting blood pressure, and Bikram yoga experience. **METHODS**: Sixteen healthy normotensive and prehypertensive subjects (M = 46.3, SD = 12.4 yr) were randomized and counterbalanced to repeat (1 week apart) two conditions of 24-hour ABP monitoring following BY and NBY control, which was ≥ 48-hours after the last bout of yoga. Subjects completed the State Trait Anxiety Inventory (STAI) before and after the BY session, and the Perceived Stress Scale (PSS) after both 24-hour ABP monitoring conditions. **RESULTS**: Factorial ANOVAs were used to analyze differences in ambulatory systolic blood pressure (SBP), diastolic blood pressure (DBP), and mean arterial pressure (MAP) on BY versus NBY days across daytime (1200-2200 h), nighttime (2200-0600 h), and next day (0600-1200 h) time periods. The $M \pm SE$ for SBP was significantly lower on BY versus NBY days for daytime (131 ± 4 vs 144 ± 3 mm Hg) and nighttime (115 ± 3 vs 122 ± 3 mm Hg) time periods, but not for next day (126 ± 3 vs 131 ± 3 mm Hg) time period. DBP was significantly lower for BY versus

NBY days for daytime (80 ± 2 vs 86 ± 3 mm Hg), nighttime (64 ± 2 vs 69 ± 2 mm Hg), and next day (74 ± 3 vs 81 ± 2 mm Hg) time periods. MAP was significantly lower for BY versus NBY days for daytime (97 ± 3 vs 106 ± 3 mm Hg), nighttime (81 ± 2 vs 87 ± 2 mm Hg), and next day time (92 ± 3 vs 98 ± 3 mm Hg) time periods. Paired t-tests revealed that state anxiety was significantly lower after Bikram yoga (24.7 ± .9), than before Bikram yoga (31.9 ± 2.5); perceived stress was not significantly different over the 24-hour ABP measurement period between BY (6.3 ± .9) and NBY (7.7 ± 1.3) days. No significant correlations were found between differences in 24-hour ABP between the BY and NBY days and perceived stress, initial resting blood pressure, or Bikram yoga experience. **CONCLUSION**: Bikram yoga may be an effective alternative to traditional forms of exercise in reducing ABP in normotensive and prehypertensive individuals, with effects persisting across 24 hours.

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INTRODUCTION

Nearly one in three men and women in the US has hypertension (systolic blood pressure [SBP] ≥ 140 and/or diastolic blood pressure [DBP] ≥ 90 mm Hg) (Roger et al., 2013). The occurrence of hypertension increases with age, and individuals over 55 with normal blood pressure have a 90 percent risk of developing hypertension (Chobanian et al., 2004). The risk of cardiovascular disease (including coronary artery disease, stroke, and renal disease) increases progressively with higher levels of blood pressure, making hypertension the number one attributable risk factor for premature death worldwide (Chobanian et al., 2004; Durstine, Moore, Painter, & Roberts, 2009). Medications are available for the treatment of hypertension. In addition to medications, lifestyle modifications are recommended in order to aid in blood pressure control for hypertensive patients (Chobanian et al., 2004). Most normotensive and prehypertensive individuals require lifestyle modifications to prevent hypertension. Lifestyle modifications include weight reduction, adopting a DASH (Dietary Approaches to Stop Hypertension) eating plan, dietary sodium reduction, moderation of alcohol consumption, and increasing physical activity (Chobanian et al., 2004). Exercise, both aerobic (Brandao-Rondon et al., 2002; Cox, Puddey, Morton, Burke, Beilin, & McAleer, 1996; Wallace, Bogle, King, Krasnoff, & Jastremski, 1999) and to a lesser effect, resistance training (Melo, Filho, Tinucco, Mion, & Forjaz, 2006), has been shown to decrease blood pressure acutely. An effective means of measuring the acute effects of exercise on blood pressure is through 24-hour ambulatory blood pressure monitoring.

Ambulatory blood pressure. Ambulatory blood pressure measures can be used

to predict cardiovascular risk and have been shown to be more closely related to predicting target-organ damage and left ventricular hypertrophy than clinical resting blood pressure measures (Mancia & Parati, 2000; Marchiando, D., & Elston, 2003; Ohkubo et al., 2005; Ozawa et al., 2009; National Blood Pressure Advisory Committee, 1995). Ambulatory blood pressure is recognized as one of the most reliable methods of monitoring blood pressure, and can be used to evaluate white coat hypertension, masked hypertension, efficacy of anti-hypertensive drug therapy, changes in diet and daily routine on blood pressure, hypotensive symptoms, blood pressure variability, night-time blood pressure dipping, and morning blood pressure surge (Chavanu, Merkel, & Quan, 2008; Chobanian et al., 2004; Eguchi et al., 2011; Ohkubo et al., 2005; National Blood Pressure Advisory Committee, 1995). Ambulatory blood pressure monitoring has been widely used in the assessment of blood pressure changes from both acute and chronic exercise.

Exercise and Yoga. It has been established that acute aerobic exercise, such as running and cycling, reduce ambulatory blood pressure (Brandao-Rondon et al., 2002; Cox et al., 1996; Hamer, 2006; Pescatello, Fargo, Leach, & Sherzer, 1991; Pescatello et al., 2004; Pescatello et al., 1999). In a landmark study, Pescatello et al. (1991) reported significant reductions in blood pressure of hypertensive men after cycling for 30 minutes at moderate intensity for up to 12.7 hours during awake ambulatory blood pressure readings. More recently, Bhammar, Angadi, and Gaesser (2012) studied the effects of fractionalized and continuous exercise on 24-hour ambulatory blood pressure in a repeated measures design. Eleven prehypertensive sedentary men and women were each

randomly assigned to complete three conditions (non-exercise control day, one continuous 30-minute exercise session, and three 10-minute exercise sessions performed 4 hours apart throughout the testing day). Ambulatory blood pressure monitoring was performed using a Suntech Oscar 2 ambulatory blood pressure monitoring device. The researchers found that 24-hour ambulatory SBP, including daytime (1300- 2300 h), nighttime (2300- 0800 h), and next day (0800- 1200 h) hours, was significantly lower following fractionalized exercise as compared with control. Reductions in SBP for continuous exercise was significantly lower for daytime (1300- 2300 h) and nighttime (2300- 0800 h) hours. Neither fractionalized exercise nor continuous exercise had any effect on 24-hour DBP (Bhammar et al., 2012).

Although many researchers have found significant reductions in ambulatory blood pressure following acute aerobic exercise, especially in hypertensive individuals, the findings have been less consistent following acute bouts of resistance exercise (Queiroz, Gagliardi, Forjaz, & Rezk, 2009; Roltsch, Mendez, Wilund, & Hagberg, 2001). While the majority of evidence for the beneficial effects of exercise on blood pressure is based on these traditional forms of exercise, there is increased interest in the effect of non-traditional exercise modalities, such as yoga, tai chi, and qigong. Yoga is a mind-body therapy that combines both spiritual and physical practice. Researchers have suggested that practicing yoga is beneficial for both physical and mental health (Ross & Thomas, 2010; Smith, Hancock, Blake-Mortimer, & Eckert, 2007; Hart & Tracy, 2011; West, Otte, Geher, Johnson, & Mohr, 2004). Consequently, yoga has grown in popularity in the US as an exercise modality (Austin, 1998; Barnes, Bloom, & Nahin, 2007).

Practicing yoga can improve strength, flexibility, and physiological conditions such as blood pressure, heart rate, respiration, and improve overall exercise capacity (Raub, 2002). Also, researchers have demonstrated that yoga interventions can decrease feelings of anxiety and stress in both males and females across different age groups (Smith et al., 2007; West et al., 2004). Stress management techniques are recognized by the Canadian Hypertension Society for their role in lowering blood pressure (Khan et al., 2009; Spence, Barnett, Linden, Ramsden, & Taenzer, 1999). Yoga has consistently been shown to reduce resting blood pressure in hypertensive subjects (Cohen et al., 2011; McCaffrey, Ruknui, Hatthakit, & Kasetsomboom, 2005; Murugesan, Govindrajulu, & Bera, 2000; Patel and North, 1975), and prehypertensive subjects (Blumenthal, Siegel, & Appelbaum, 1991; Cohen et al., 2011; Mananmohan, Udupa, Bhavanani, Shatapathy, & Sahai, 2004; Schmidt, Wijga, Von Zur Muhlen, Brabant, & Wagner, 1997), but there is a lack of research on the effect of yoga on blood pressure in normotensive subjects. In addition, only two studies (Cohen et al., 2011; Montfrans et al., 1990) and one unpublished thesis (Mulvey, 2011) assess the effects of yoga on blood pressure and appear to have been conducted using ambulatory blood pressure as an outcome measure.

The first of these studies, Montfrans et al. (1990), conducted a study comparing hypertensive subjects randomized to either a 1-year relaxation therapy intervention or a control group. The relaxation therapy involved training in muscle relaxation, yoga exercises, and stress management for one hour a week for 8 weeks. Subjects in the relaxation therapy group continued exercising twice daily for the remainder of the year. Control subjects adhered to the same attendance schedule and were asked to sit and relax

twice a day. All subjects were asked not to change their diet or physical activity for the duration of the study. The researchers did not find significant changes in mean daytime and mean nighttime ambulatory blood pressure in either the yoga or control group. The researchers identified certain behavioral measures that were difficult to control in the study, such as the type of therapy, clinical skills of the therapist, and patient characteristics that may have contributed to the lack in relevant effect of relaxation therapy on ambulatory blood pressure.

In the second study examining the effects of yoga training on ambulatory blood pressure, Cohen et al. (2011) studied the effect of a 12-week Iyengar yoga training compared to enhanced usual care (EUC) on 24-hour ambulatory blood pressure in yoga naive subjects with either prehypertesion or Stage 1 hypertension. Subjects were randomized into either Iyengar yoga training (n = 26) or EUC (n = 31). The Iyengar yoga protocol included timed postures and breathing techniques. EUC was based on a dietary adjustment including sodium reduction, alcohol restriction, and increased intake of fruits, vegetables, and low-fat foods. Subjects in the Iyengar yoga group demonstrated reductions in 24-hour ambulatory SBP (-6 mm Hg), DBP (-5 mm Hg), and MAP (-5 mm Hg) compared to baseline measures after 12 weeks of training. There were no differences in ambulatory blood pressures between the Iyengar yoga and EUC groups at 6 and 12 weeks. The Iyengar yoga group did not demonstrate significant change in 24-hour ambulatory blood pressure at 6 weeks compared to baseline. Decreases in blood pressure in the EUC group failed to reach statistical significance at 12 weeks. Cohen et al. (2011) did not include when the ambulatory blood pressure measures were taken

relative to the last bout of yoga, therefore, it is difficult to discern if the effects at post-test were from acute effects of the last bout of yoga in these trained practitioners or simply the result of 12 weeks of training.

In a master's thesis, Mulvey (2011) researched the effects of 9 weeks of Hatha yoga practice on 24-hour ambulatory blood pressure in one subject with prehypertension. Mulvey's single-subject study involved a young, sedentary, non-smoking, prehypertensive male who was naive to yoga at the beginning of the 9-week yoga training. The subject demonstrated reductions in 24-hour SBP (- 8 mm Hg) and DBP (- 7 mm Hg) as a result of acute measures immediately following the first yoga session compared to baseline measures. Over the 9-week training, the mean 24-hour and awake ambulatory blood pressures were similar between those following an acute bout of yoga and that on the comparable non-yoga day. That said, throughout the 9-week study, the asleep ambulatory blood pressure measures following an acute bout of yoga were consistently lower than in the control period. This may be due to the fact the yoga training took place in the evening at 17:00 hours (Mulvey, 2011). Because this was a single subject case study it was not possible to determine if this reduction in blood pressure was significant. However, this lends credence to the idea that acute yoga practice may have daytime blood pressure lowering effects if yoga is practiced early in the day. Thus, greater emphasis should be placed on lifestyle modifications and alternative therapies for the prevention and treatment of hypertension.

Many aspects of a set of yoga exercises are important to consider for the prevention and treatment of hypertension. A multitude of effective forms of yoga

practices are available, which draw from thousands of yoga postures that exist. The order of the postures, variation of the postures, duration that each posture is held, total duration practiced, intensity, and other details all differ from method to method. Popular yoga methods practiced in the United States include Ashtanga yoga, Iyengar yoga, Anusara yoga, and Bikram yoga. Bikram yoga offers a controlled, consistent, systematic method to perform yoga postures and breathing exercises.

Bikram Yoga. Bikram yoga is a standardized method of yoga established in the United States by Bikram Choudhury in the 1970's, that was designed to focus specifically on the Western body and lifestyle (Choudhury, 2007). The practice of Bikram yoga was designed to reverse the negative effects of daily living for the prevention and treatment of disease. Interestingly, no studies have effectively examined the effect of Bikram yoga practice on risk factors for disease, including blood pressure. Hart and Tracy (2011) published a controlled study on the effect of Bikram yoga training on strength, steadiness, and balance in healthy men and women. Subjects with little or no yoga experience were randomized into either a Bikram yoga training group (n = 10) or control group (n = 11). Each subject in the training group participated in an average of three Bikram yoga classes per week during the 8-week training period. Measures were taken before and after training, and included maximum voluntary contraction (MVC), force of the elbow flexors and knee extensors, steadiness of isometric elbow and knee contractions, steadiness of concentric and eccentric knee contractions, and timed balance. Significant improvements were found in all of the aforementioned measures except MVC for elbow flexors, and steadiness of concentric and eccentric contractions. Hart and Tracy (2011) concluded

that an 8-week Bikram yoga program improved balance substantially, produced modest improvements in leg strength, and improved leg muscle control in young adults (Hart & Tracy, 2011).

In what looks to be the same subject group as studied by Hart and Tracy (2011), Tracy and Hart (2013) explored the effects of Bikram yoga training on measures of physical fitness, including isometric deadlift strength, handgrip strength, lower back/hamstring and shoulder flexibility, resting heart rate and blood pressure, maximal oxygen consumption, and body composition. The subjects improved in all measurements after training except for handgrip strength, maximal oxygen consumption, resting heart rate, and resting blood pressure. Of importance to the current study was that no change in resting blood pressure was found from pre-test to post-test in the Bikram yoga or control group. The authors did not report when blood pressure measures were taken in relation to the last bout of Bikram yoga, thus, it is not clear if blood pressure measures reflect responses to an acute bout of Bikram yoga or to the 8 weeks of Bikram yoga training. Tracy and Hart (2013) noted, due to the greater cardiovascular and metabolic demand of Bikram yoga compared to other forms of yoga, cardiovascular adaptations were expected. However, the authors found it possible that the subjects experienced metabolic adaptations to training that improved submaximal exercise tolerance not measured in this study.

Hewett, Ransdell, Gao, Petlichkoff, and Lucas (2011) studied the effect of an 8-week Bikram yoga program on mindfulness, perceived stress, and physical fitness. Subjects (n = 51) included men and women who had not engaged in Bikram yoga in the

last 2 years, or not at all in the 3 months prior to the study. The subjects were varied with regard to Bikram yoga experience, with 27% of participants having practiced Bikram yoga previously. Most participants in the study had meditative or other yoga practice experience. There was no control group. The researchers found that a total of 20 sessions of Bikram yoga in 8-weeks improved mindfulness measured by the Five-Facet Mindfulness Questionnaire, perceived stress measured by the Perceived Stress Scale (PSS), cardiorespiratory endurance measured by a 1-mile walk, flexibility measured by sit-and-reach and body rotation, and balance measured by the single-leg balance. Additionally, Hewett et al. (2011) randomly selected three subjects to wear a Polar heart rate monitor during two Bikram yoga sessions and found these subjects worked at a moderate to vigorous intensity training zone (50-85% heart rate reserve). The researchers concluded that 8-weeks of Bikram yoga improved mindfulness, perceived stress, cardiorespiratory endurance, flexibility and balance (Hewett et al., 2011). Unfortunately, blood pressure measures were not reported in the study (Hewett et al., 2001).

In a master's thesis, Abel (2011) examined the effects of a 60-day Bikram yoga program on selected cardiopulmonary and psychological measures. Subjects included males and females (n = 22) participating in at least 80% of a daily Bikram yoga practice over 60 days. Subjects had an average of 1.79 years of prior Bikram yoga experience. Blood pressure category was not specified for the subjects, but were all considered low risk according to the American College of Sports Medicine (ACSM) guidelines (ACSM, 2014). Subjects were asked to maintain diet and refrain from participating in any other form of exercise. Pre-intervention measures were taken before starting the 60-day

program and post-intervention measures were taken within 1-week of completing the 60-day program. Significant improvements were found in resting heart rate and DBP as well as intrinsic motivation, life satisfaction, and core-self evaluations (Abel, 2011). Specifically, resting DBP decreased by 7.23%, while resting SBP did not statistically change. Abel (2011) argued that the magnitude of improvement in resting blood pressure following Bikram yoga training was not as great as reported in studies done on the effect of other styles of yoga, because those studies used older individuals or hypertensive individuals. Since Abel's subjects showed no improvements in cardiovascular function, improvements in resting DBP were attributed to relaxation and breathing techniques that affected autonomic balance, rather than improvements in aerobic fitness (Abel, 2011).

Only a handful of studies have specifically used Bikram yoga as an exercise intervention (Abel, 2011; Hart & Tracy, 2011; Hewett et al., 2011; Tracy & Hart, 2013), and only two of these studies reported on blood pressure as an outcome variable (Abel, 2011; Tracy & Hart, 2013). Tracy and Hart (2013) found no reductions in blood pressure following an 8-week Bikram yoga training in a controlled study using yoga naïve subjects; whereas, Abel (2011) found reductions in only DBP following a 60-day Bikram yoga program in an uncontrolled study using subjects experienced in Bikram yoga.

Conclusions. Bikram yoga is a unique style of yoga, with standardized postures, breathing exercises, and timing, practiced in a consistently hot and humid studio environment. Bikram yoga has been shown to result in heart rates corresponding to moderate and vigorous exercise intensities (Hewett et al., 2011), which is within in the exercise intensity range recommended for hypertension (ACSM, 2014). However,

Bikram yoga is relatively un-studied.

Hewett et al. (2011) found meaningful improvements in perceived stress in an 8-week Bikram yoga training that included subjects with varied yoga experience. Only two studies addressed the effect of Bikram yoga on blood pressure. Tracy and Hart (2013) did not find meaningful changes in resting blood pressure following a randomized and controlled study on the effects of an 8-week Bikram yoga training in subjects with little or no prior yoga experience. Abel (2011) did find significant decreases in resting DBP following a 60-day yoga program in subjects who had an average of 1.79 years of Bikram yoga experience. However, no control was used to compare with the yoga intervention. Among the current Bikram yoga studies, only resting blood pressures have been measured, and ambulatory blood pressure monitoring has never been used.

Only a few research studies address the effect of yoga of any type on ambulatory blood pressure. Montfrans et al. (1990) did not find significant changes in ambulatory blood pressure after one year of yoga practice. However, Cohen et al. (2011) and Mulvey (2011) did find meaningful effects of yoga on ambulatory blood pressure. Cohen et al. (2011) demonstrated clinically meaningful reductions in ambulatory SBP and DBP at 12 weeks compared to baseline. A limitation in the Cohen et al. (2011) study is that the researchers did not include when, relative to the last bout of yoga, the blood pressure measures were taken. Therefore, it is difficult to report if the effects at post-test were from acute effects of the last bout of yoga or the result of training. Mulvey (2011) demonstrated that an acute bout of Hatha yoga in the evening can reduce average evening ambulatory blood pressure in a previously sedentary prehypertensive male. A limitation

of this study is that the results can not be generalized to the larger population based on one subject, and the effects of other distinct styles of yoga on ambulatory blood pressure are unknown. More research is needed on the acute effect of a systematized style of yoga, such as Bikram yoga, to determine if preliminary results relating to ambulatory blood pressure found by Mulvey (2011) can be replicated. Furthermore, there is need for research on the effect of yoga on ambulatory blood pressure at a different time of day than was studied by Mulvey (2011). Therefore, more systematic, randomized, and controlled research is needed to demonstrate the effect of Bikram yoga, specifically on blood pressure and psychological parameters.

Although research on the effects of yoga on blood pressure have been conducted, no specific study has used Bikram yoga as an intervention and focused on the effects of Bikram yoga on ambulatory blood pressure. Therefore, the primary purpose of this study was to examine the acute effects of Bikram yoga on 24-hour ambulatory blood pressure for daytime (1200- 2200 h), nighttime (2200- 0600 h), and next day (0600- 1200 h) hours. A secondary purpose of this study was to examine the effects of Bikram yoga on stress and anxiety and to ascertain if these psychological effects are related to blood pressure measures. It was hypothesized that acute ambulatory blood pressure following Bikram yoga would be lower than the non-Bikram yoga control day; perceived stress would be lower in the 24-hour period following Bikram yoga compared to that for the non-Bikram yoga control day; and, Bikram yoga would acutely reduce state anxiety. Lastly, we hypothesized that changes in ambulatory blood pressure would be directly related to perceived stress.

METHODS

Design. A repeated measures design was used in order to compare 24-hour ambulatory blood pressure responses immediately following a single Bikram yoga (BY) intervention to that on a non-Bikram yoga (NBY) control day. Testing took place over a 3-week timeframe. Each participant received informed consent and had anthropometric and resting measures taken. Over the subsequent two weeks, each participant was tested on two days, on the same day of the week at the same time of day. The order of BY and NBY control day measures were counterbalanced and randomly assigned to each subject.

Participants. Subjects were recruited from the privately owned Bikram yoga studios in Farmington Hills and Troy, Michigan. Recruitment Flyers (Appendix A) were posted in the studio, announcements were made in the Bikram yoga classes, and personal verbal contact was made before and after classes by certified Bikram yoga instructors and the Primary Investigator to promote participation in the study. Inclusion criteria were that subjects were 18 years of age and older, had been practicing Bikram yoga regularly (3 or more classes per week) for a minimum of 3 months, not pregnant, were non-smokers, were not on blood pressure medications, and had no chronic medical conditions. The subjects were screened and selected based on meeting the inclusion criteria, and their availability to attend specified yoga practice sessions.

Procedures. Prior to reporting for the initial visit, subjects were contacted and asked not to eat or drink, ingest caffeine or alcohol, or use tobacco products 3 hours prior to their appointment for the initial day of measures. Subjects were also instructed to avoid significant exertion or exercise before their appointment on the day of the initial

visit. Subjects met the Primary Investigator for initial day of measures at either Bikram yoga studio location and were given informed consent (Appendix B), both verbally and in writing. At this visit, subjects also filled out a Participant Questionnaire (Appendix C) and the International Physical Activity Questionnaire (IPAQ) (Appendix D). Subjects received a checklist (Appendix E) to keep track of what was involved during the two weeks of testing. Resting heart rate, blood pressure, mass, height, and waist circumference were measured and recorded (Appendix F) using the procedures described below. Subjects were instructed in and familiarized with using the ambulatory blood pressure monitor on this initial visit.

Following the initial visit, subjects were assigned to one of two groups. On the first week, the BY group had 24-hour ambulatory blood pressure measures recorded immediately following Bikram yoga class. The NBY control group had ambulatory blood pressure measures recorded at the same time of day, but on a day in which subjects had refrained from Bikram yoga for at least 48 hours. For the second week, the groups switched in order for the second round of ambulatory blood pressure measures.

Bikram yoga classes were instructed by certified Bikram yoga teachers trained by Bikram Choudhury himself and senior yoga instructors through Bikram yoga College of Indian World Headquarters in Los Angeles, CA. The certified Bikram yoga teachers adhered to a strict dialogue to instruct the yoga series at authorized studios. The Bikram yoga classes included the standard beginning series of 26 postures, including two breathing exercises, performed at a room temperature of 105˚ F and 40% humidity. The yoga postures and breathing exercises are known as the beginning series and were

performed in the same order and for the same duration of time for a total of 90 minutes.

Refer to Figure 1 for a summarized description of the study design and procedures. All equipment used, including balance scale, stadiometer, and ambulatory blood pressure monitors were calibrated prior to and throughout testing as needed per manufacturers' directions.

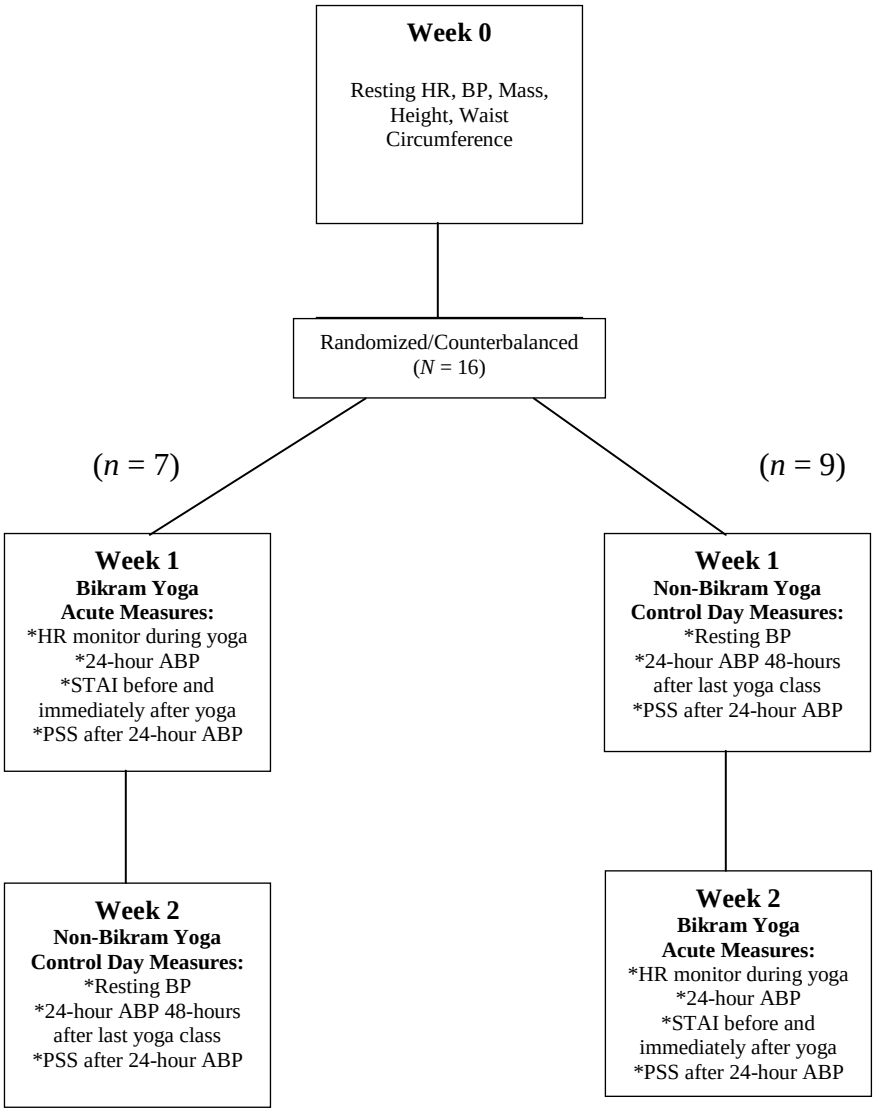

Figure 1. Study flow diagram.

Measures. *IPAQ*. The short version of the IPAQ was used to obtain measures of physical activity among participants. The IPAQ is a valid and reliable instrument to measure physical activity levels (Craig et al., 2003). The IPAQ was scored according to

protocol in the test guidelines. Scores were used as a descriptive measure for participants in the study.

Resting HR and BP measurements. All blood pressure measurements were done according to standardized procedures (ACSM, 2014). Subjects were asked to sit quietly for 5 minutes prior to having their blood pressure and resting heart rate measured. Seated resting blood pressure was measured on two separate occasions, during the day of preliminary screening for subjects and prior to the Bikram yoga session. Resting blood pressure was taken 3 times at each assessment day via auscultation with a mercury sphygmomanometer and stethoscope with at least a 1-minute rest between readings. Measurements all fell within 5 mm Hg. Resting blood pressures were determined by averaging the six total resting blood pressure measurements and used to categorize subjects as either normotensive, prehypertensive, or hypertensive. Resting heart rate was obtained during the day of preliminary screening for subjects by palpating the radial artery for 60 seconds.

Mass and height measurements. Mass and height of each participant was measured with a calibrated scale and stadiometer. Mass was measured to the nearest 0.5 pound with shoes off and converted to kilograms. Height was taken with participants standing, without shoes, with back, heels, and buttocks against the wall. The measuring device was laid over the tallest point of the head of the participant. Height was measured to the nearest 0.5 inch and converted into meters. Body mass index (BMI) was calculated using mass and height of each subject.

Circumference measurements. Circumference measures were used to assess

distribution of body fat. Using a Gulick tape measure, waist circumference was measured according to procedures in ACSM's Guidelines for Exercise Testing and Prescription (ACSM, 2014).

Ambulatory blood pressure. An Oscar 2 ambulatory blood pressure monitor (Suntech; Morrisville, NC) was used to measure heart rate, SBP, and DBP according to the procedures in the manufacturer's manual. The Oscar 2 ambulatory blood pressure monitor has been validated for use in an adult population by both the British Hypertension Society protocol and the International Protocol for the validation of blood pressure measuring devices (Goodwin, Bilous, Winship, Finn, & Jones, 2007; Jones, Bilous, Winship, Finn, & Goodwin, 2004). In addition, Viera, Lingley, and Hinderliter (2011) researched the tolerability of the Oscar 2 ambulatory blood pressure monitor and concluded the device is straightforward to use, but can interfere with sleep and cause adverse effects including pain, skin irritation, and bruising**.**

Subjects were given verbal and written instruction on how to use the ambulatory blood pressure monitor (Appendix G) and signed an ambulatory blood pressure monitor check out form (Appendix H). The cuff was fitted to the upper arm according to the manufacturer guidelines. Upper arm circumference was measured on the non-dominant arm (in cm) in order to fit the subject with either of the two cuff sizing options, adult (25-35 cm) and adult plus (33-40 cm). The cuff was fitted with the microphone placed down over the brachial artery (3-5 cm from the elbow) of the non-dominant arm. Participants were instructed to let the arm hang extended at their side during each blood pressure measurement and to refrain from any other movements during cuff inflation.

Ambulatory blood pressure monitors were pre-programmed to take measurements automatically every 20 min during the daytime (1200-2200 h) and next day (2200-0600 h) time periods, and every 30 min during the nighttime (2200-0600 h) time period as per procedures similar to those used by Bhammar et al. (2012). The subjects were prevented from reading the display monitor. The subjects were given log instructions (Appendix I) and an activity log (Appendix J) and asked to document the (1) time of each blood pressure reading during waking hours, (2) body position during the blood pressure reading (standing, sitting, lying down), (3) activity immediately before the blood pressure reading, and (4) sleep and wake up time. In addition, subjects were asked to document diet during ambulatory blood pressure monitoring, including the time, food or drink, and amount consumed (Appendix K). The log instructions for subjects are similar to those used by previous investigators (Lehmkuhl, Park, Zakutansky, Jastremaski, & Wallace, 2005; Wallace et al., 1999).

Participants were allowed 10 minutes to shower and change clothes at the yoga studio facilities following the Bikram yoga session before the first acute ambulatory blood pressure measures were taken, as per procedures similar to those used by Jones, Pritchard, George, Edwards, and Atkinson (2008). Subjects were fitted with the ambulatory blood pressure monitor to begin measures within 30 minutes from the end of the Bikram yoga session. In order to insure valid measures and minimize chances for damage to the equipment, the subjects were instructed: (1) not to exercise, (2) not to take a shower or bath, (3) not to nap, and (4) to relax and straighten out the arm during the recording interval for the waking hours of the entire 24-hour post-exercise period as was

done in previous studies (Lehmkuhl et al, 2005; Wallace et al., 1999).

Ambulatory blood pressure researchers have not reported on any accommodation procedures prior to collecting data. Further support for the idea that accommodation is not required was obtained in a pilot study for the current research. No significant difference in awake or asleep ambulatory blood pressures measures were found between consecutive days in subjects (n = 7) who wore monitors for up to 5 consecutive days under conditions similar to that proposed in the current study (i.e., p values on paired t-tests ranged from .068 to .874, with exception only of day 3 to day 4 awake SBP values, where p was .042. In addition day-to-day reliability coefficients (via Pearson r) were all above .90, with exception of day 2 to day 3 SBP measures, where r was .80. Lastly, according to Lehmkuhl et al. (2005), ambulatory blood pressure measurements are reproducible post exercise for all SBP and DBP variables including mean daytime, mean nighttime, and mean 24-hour averages. Therefore, in the current study, the 24-hour ambulatory blood pressure measures were taken only once directly following a single Bikram yoga session to obtain acute measures. Similarly, 24-hour ambulatory blood pressures were only taken once, at least 48-hours after a Bikram yoga session to obtain non-Bikram yoga day measures (in order to avoid the influence of post-exercise hypotension). Liu, Goodman, Nolan, Lacombe, and Thomas (2012) used similar one-time measuring procedures in studying the acute effects of exercise on ambulatory blood pressure.

In order to control for diurnal variations in blood pressure, all subjects began Bikram yoga classes at either 9:30 or 10:00 am and ended at 11:00 or 11:30 am,

respectively. The ambulatory blood pressure measures began within 30 minutes of ending class and were taken on the same day of the week in two consecutive weeks. For each subject this was done in order to reduce variability of activity between measurement days. The subject was asked to repeat diet, patterns of activity, and sleep/wake time on the second day of ambulatory blood pressure recording.

Several investigators have reported on protocol used for editing ambulatory blood pressure recordings, based on the exclusion criteria of Staesson et al. (1991) (Lehmkuhl et al., 2005; Padilla, Wallace, & Park, 2005;Wallace et al., 1999). Similarly, in the current study, this protocol was followed. Readings were excluded if: (1) SBP < DBP, or > 240 or < 50 mm Hg; (2) DBP > 140 or < 40 mm Hg; (3) pulse pressure < 10 % of SBP; or (4) pulse rate > 150 or < 40 beats per minute (Staesson et al., 1991). Ambulatory blood pressure data were analyzed for mean daytime (1200- 2200 h), mean nighttime (2200- 0600 h), and mean next day (0600-1200 h) periods for SBP, DBP, and mean arterial pressure (MAP), similar to the ambulatory blood pressure analysis done by Bhammar et al. (2012).

Heart Rate. Similar to Hewett et al. (2011), subjects wore a Polar RS800CX heart rate monitor (Polar Electro Inc., 2008) during a 90-minute Bikram yoga class to enable researchers to report on the exercise intensities, recognizing that these values may have been affected by heat and postural changes. The heart rate monitors were programmed to record heart rate in 2-second intervals during the Bikram yoga intervention. The heart rate information was used to compare Bikram yoga to traditional forms of exercise that have been previously studied. For example, Hewett et al. (2011)

found subjects training at moderate to vigorous intensity (50-85% heart rate reserve) while participating in a 90-minute Bikram yoga class.

Psychological Measures. Two questionnaires were used to assess the subject's state anxiety and perceived stress. In order to assess state anxiety, subjects completed the State Trait Anxiety Inventory (STAI) (Spielberger et al., 1983) (Appendix L) before and after participation in Bikram yoga; these procedures are similar to procedures done by Wei, Kilpatrick, Naquin, and Cole (2006) who used the STAI to assess state anxiety after an acute yoga session. The STAI is a valid and reliable for measuring state and trait anxiety (Quek, Low, Razack, Loh, & Chua, 2004). In order to assess perceived stress, subjects completed the Perceived Stress Scale (PSS) at the end of 24-hour ambulatory blood pressure monitor for NBY and BY days. The PSS is a reliable psychological measure for perceived stress (Cohen, Kamarck, & Mermelstein, 1983) (Appendix M). The PSS was amended to ask about feelings and thoughts "in the last 24-hours" rather than "in the last month" in order to relate to acute BY and NBY day 24-hour ambulatory blood pressure readings. In published research, West et al. (2004) used the PSS to assess stress after an acute yoga session. Both psychological measures were scored according to the instructions provided by each test. High scores indicated a higher level of perceived stress (PSS) and anxiety (STAI).

Statistical Analysis. Descriptive statistics (mean $\pm$ *SD*) were calculated for all subject characteristics. Mean $\pm$ *SE* were calculated for all study parameters. Mean differences in blood pressure (SBP, DBP, and MAP) between conditions (NBY control and BY intervention) and across time periods (daytime, nighttime, and next day) were

analyzed using a 2x3 repeated measures factorial ANOVA with simple effects tests conducted post hoc. Mean differences in perceived stress measures corresponding to the 24-hour time period which the ambulatory blood pressure measures were taken were compared for NBY and BY conditions using paired t-tests. Mean differences in state anxiety before and immediately following the Bikram yoga class were analyzed using paired *t*-tests. Exploratory post hoc analyses were done to determine if there was a relationship between perceived stress and/or post-Bikram anxiety measures and the ambulatory blood pressure measures, as well as between regular current Bikram yoga experience (i.e., weeks) and difference in blood pressures observed under the two different conditions. Finally, mean differences in 24-hour ambulatory SBP, DBP, and MAP from NBY to BY days were compared between normotensive and prehypertensive subjects using independent *t*-tests. All statistical analyses were performed using the Statistical Package for the Social Sciences (SPSS) for Windows (version 20.0, SPSS Inc., Chicago, IL) with $p < .05$ as the criteria for statistical significance.

Limitations and Delimitations. There are several limitations that may have interfered with the results. The assumption was made that subjects adhered to 24-hour ambulatory blood pressure measurement instructions (Appendix G), and maintained the same diet, physical activity level, and sleep/wake times for the duration of the study. Because blood pressure is labile, there was concern the physical activity level on NBY and BY 24-hour ambulatory blood pressure days may not be equivalent, which would affect mean differences observed between the days, although heart rate data and log entries informed on this potential confounder. In addition, the time frames for daytime

(1200-2200 h), nighttime (2200-0600 h), and next day (0600-1200 h) time periods were standardized for each subject and did not necessarily match individual wake and sleep patterns. Phase of the menstrual cycle was not recorded or controlled for as was done by Pescatello et al. (1999). Finally, there may have been blood pressure "responders" and "non-responders" to the yoga treatment, which may have influenced results obtained (Hagberg, Park, & Brown, 2000; Liu et al., 2012; MacDonald, 2002).

Delimitations, which could have influenced generalizability of results, included that the subjects were not randomly selected from all Bikram yoga practitioners, but only involved volunteer subjects who practiced at Bikram yoga studios in Farmington Hills and Troy, MI. It was difficult to find prehypertensive subjects in Bikram yoga practitioners (i.e., ≥ 120/80 mm Hg) for the study. Results only related to Bikram yoga practice in early morning, as the acute 24-hour ambulatory blood pressure measures were following a 9:30 am or 10 am Bikram yoga class.

RESULTS

A total of 22 subjects were screened for the study, of which 21 met the participation inclusion criteria. Two subjects dropped out prior to the beginning of testing due to personal circumstances; 2 subjects were excluded because of failure to record ambulatory blood pressure measures on the same day of the week; 1 subject was excluded because a larger cuff size was used for the second 24- hour day of ambulatory blood pressure measures. Consequently, data from 7 normotensive and 9 prehypertensive participants were used in the data analysis. Participants (N=16) were male (n = 3) and female (n = 13) who were of Caucasian (n = 10), African American (n = 4), and Asian (n = 2) decent. Based on the IPAQ, subjects overall physical activity level was generally high (n = 12), with a few subjects categorized as having moderate (n = 2) and low (n = 2) physical activity level. Subject characteristics are summarized in Table 1.

During the 90-min Bikram yoga intervention, the average heart rate of the subjects was 118 $\pm$ 21 bpm, corresponding to 68% of age-predicted maximal heart rate. Heart rates obtained using ambulatory blood pressure monitors were compared via paired t-tests in order to roughly index physical activity levels for the two 24-hour periods during which the ambulatory blood pressure monitor was worn (NBY and BY days). On average, participants had significantly greater heart rates in beats per minute (bpm) on BY days (M = 78.54, SE = 2.60), than NBY days (M = 71.37, SE = 1.53, $t(15)$ = -3.88, p = .001) during the daytime period; no significant difference was found between heart rate on NBY days (M = 64.38, SE = 1.68) versus BY days (M = 64.34, SE = 2.06, $t(15)$ = .03, p = .980) during the nighttime period; and, no significant difference was found between

NBY days (M = 68.60, SE = 1.71) versus BY days (M = 69.83, SE = 2.04, $t(15)$ = -.96, p = .354) during the next day period.

Ambulatory blood pressures were recorded for each subject every 20 min during daytime (1200-2200 h) and next day (0600-1200 h) time periods and every 30 minutes during nighttime (2200-0600 h) time period. The mean SBP, DBP, and MAP plotted as a function of time over the 24-hour period for both the NBY and BY conditions are shown in Figures 2, 3, and 4, respectively. The 24-hour SBP, DBP, and MAP for each of the 16 subjects is shown in Figures 5, 6, and 7, respectively; these findings illustrate the variability of the treatment response across the different subjects.

Descriptive data for SBP, DBP, and MAP for the 24-hours and each of the three time periods (1200- 2200 h, 2200- 0600 h, and 0600- 1200 h) are shown in Table 2. Difference and percent change in blood pressure between NBY and BY conditions for subjects classified as normotensive and prehypertensive are shown in Table 3. Paired t-tests show significant differences between NBY and BY 24- hour SBP (t = 4.45, p = .000), DBP (t = 4.32, p = .001), and MAP (t = 5.21, p = .000); in all three analyses the blood pressure was lower in the BY condition. Three 2 x 3 repeated measures ANOVAs were conducted to compare mean differences in blood pressure (SBP, DBP, and MAP) between conditions (NBY control and BY intervention) and across time periods (daytime, nighttime, and next day). Graphic representations of the factorial ANOVAs are shown in Figures 8, 9, and 10 respectively. Mauchly's Test of Sphericity was significant only for the interaction term for SBP, hence a Greenhouse Geisser adjustment was made to the degrees of freedom. With regard to SBP, there was a significant interaction between

condition and time period, $F(1.44, 21.57) = 4.17$. This indicates that differences in SBP between NBY and BY conditions depended upon which time period the ambulatory blood pressure measures were taken. A simple effects test was done to determine if there were differences in SBP between NBY and BY at 1200- 2200 h, 2200- 0600 h, and 0600-1200 h. Significantly lower SBP was found for BY condition at the daytime ($p = .001$) and nighttime ($p = .035$) time periods. No significant differences in mean SBP were found between NBY and BY for the next day ($p = .075$) time period.

With regard to DBP, there was no significant interaction between condition and time period, $F(2, 30) = .11$. There was a significant ($p = .001$) main effect for condition $F(1, 15) = 16.53$; overall, across time periods, BY resulted in lower DBP than NBY. Marginal means ($M \pm SE$) for condition of NBY was 78.7 ± 2.0 mm Hg and for BY was 73.1 ± 1.9 mm Hg. There was also a significant main effect for time $F(2, 30) = 60.32$. Marginal means for daytime were 83.3 ± 2.2 mm Hg, for nighttime were 66.4 ± 1.7 mm Hg, and for next day were 77.9 ± 2.2 mm Hg. Post hoc pairwise comparisons using the Bonferroni correction revealed significant differences between each of the time periods, as expected given the diurnal variation in blood pressures between daytime and nighttime.

With regard to MAP, there was no significant interaction between condition and time period, $F(2,30) = .56$. There was a significant main effect for condition $F(1, 15) = 16.80$; overall, across time periods, BY resulted in lower MAP than NBY. Marginal means for condition of NBY was 96.7 ± 2.2 mm Hg and BY was 90.0 ± 2.2 mm Hg. There was also a significant main effect for time $F(2, 30) = 51.93$. Marginal means for

daytime were 83.3 ± 2.2 mmHg, for nighttime were 66.4 ± 1.7 mm Hg, and for next day were 77.9 ± 2.2 mm Hg. Post hoc pairwise comparisons using the Bonferroni correction revealed significant differences between each of the time periods, as expected given the diurnal variation in blood pressures between daytime and nighttime.

On average, subjects experienced significantly lower state anxiety after Bikram yoga (M = 24.73, SE = .86), than before Bikram yoga (M = 31.87, SE = 2.49; $t(14)$ = 2.88, p = .012). No differences in perceived stress on a NBY day (M = 7.7, SE = 1.3) versus a BY day (M = 6.33, SE = .87) were found ($t[14]$ = 1.44, p = .173). There were no significant relationships between perceived stress and the differences in 24- hour ambulatory blood pressure between NBY to BY days for SBP, r = .261, p = .328 , DBP, r = .233, p = .385, and MAP, r = .285, p = .285. There was no significant relationship between initial resting SBP or DBP and differences in 24-hour ambulatory SBP, DBP, and MAP from NBY to BY days. There was no significant difference in 24-hour ambulatory SBP, DBP, and MAP from NBY to BY days between normotensive and prehypertensive subjects.

Table 1. Demographic information of subjects (mean ± *SD*)

Sex (Men/Women)	**(3/13)**
Age (years)	46.3 ± 12.4
Weight (kg)	69.8 ± 11.0
Height (cm)	165.9 ± 7.7
BMI ($kg \cdot m^{2}$)	25.3 ± 2.7
Waist Circumference (cm)	
Men	88.5 ± 15.8
Women	78.2 ± 7.8
Resting SBP* (mm Hg)	117.6 ± 7.8
Resting DBP* (mm Hg)	79.6 ± 5.7
Resting Heart Rate (bpm)	73.2 ± 7.6
Bikram Yoga Experience (months)	30.8 ± 27.6

* Average of six screening BPs.

Table 2. Ambulatory SBP, DBP, and MAP (mm Hg) during NBY and BY days, for 24 h and during the periods of 1200- 2200 h, 2200- 0600 h, and 0600- 1200 h

Time	**NBY**	**BY**
Ambulatory SBP (mm Hg)		
24 h	135 ± 3	125 ± 3
1200- 2200 h	144 ± 3	131 ± 4
2200- 0600 h	122 ± 3	115 ± 3
0600-1200 h	131 ± 3	126 ± 3
Ambulatory DBP (mm Hg)		
24 h	80 ± 2	74 ± 2
1200- 2200 h	86 ± 3	80 ± 2
2200- 0600 h	69 ± 2	64 ± 2
0600-1200 h	81 ± 2	74 ± 3
Ambulatory MAP (mm Hg)		
24 h	99 ± 2	91 ± 2
1200- 2200 h	106 ± 3	97 ± 3
2200- 0600 h	87 ± 2	81 ± 2
0600-1200 h	98 ± 3	92 ± 3

All values are mean ± *SE*.

Table 3. Difference and percent change in blood pressure between NBY and BY conditions for subjects classified as normotensive and prehypertensive.

Subjects (*N* = 16)	**SBP NBY – BY**	**%**	**DBP NBY – BY**	**%**	**MAP NBY – BY**	**%**
Normotensive (*n* = 7)						
1	4	3	9	12	7	8
2	8	6	7	8	8	8
3	18	14	13	16	14	14
4	25	19	12	15	16	16
5	5	4	-3	-4	0	0
6	0	0	-2	-3	-1	-1
7	34	24	9	12	17	18
Average	13	10	6	8	9	9
Prehypertensive (*n* = 9)						
8	8	6	15	18	13	13
9	9	6	0	0	3	3
10	1	1	1	2	1	1
11	9	6	7	8	7	6
12	7	5	2	3	4	4
13	7	6	3	4	5	5
14	12	9	10	12	11	11
15	6	4	5	6	6	6
16	5	3	5	5	5	4
Average	7	5	5	6	6	6
Total Average	10	7	6	7	7	7

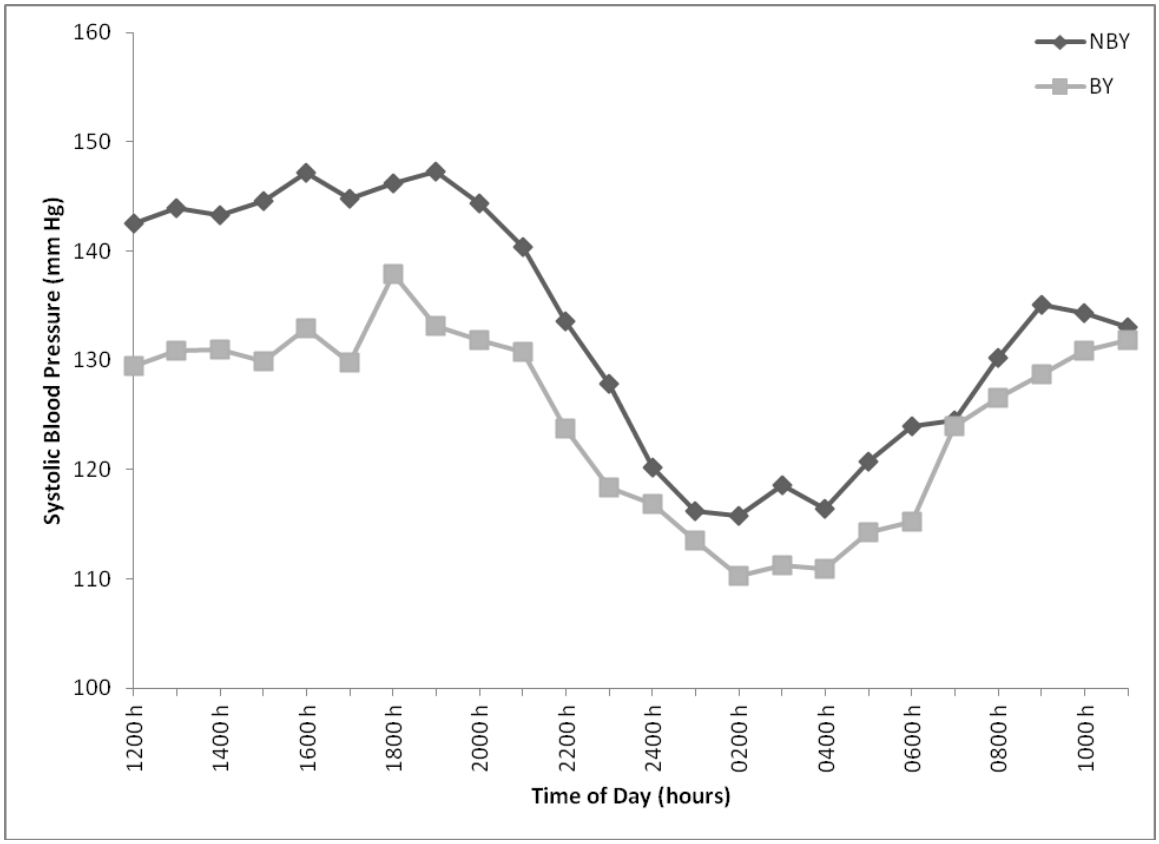

Figure 2. Pattern of ambulatory SBP means across 24 hours comparing NBY with BY days. Twenty-four hour SBP was significantly lower after BY as compared with after NBY.

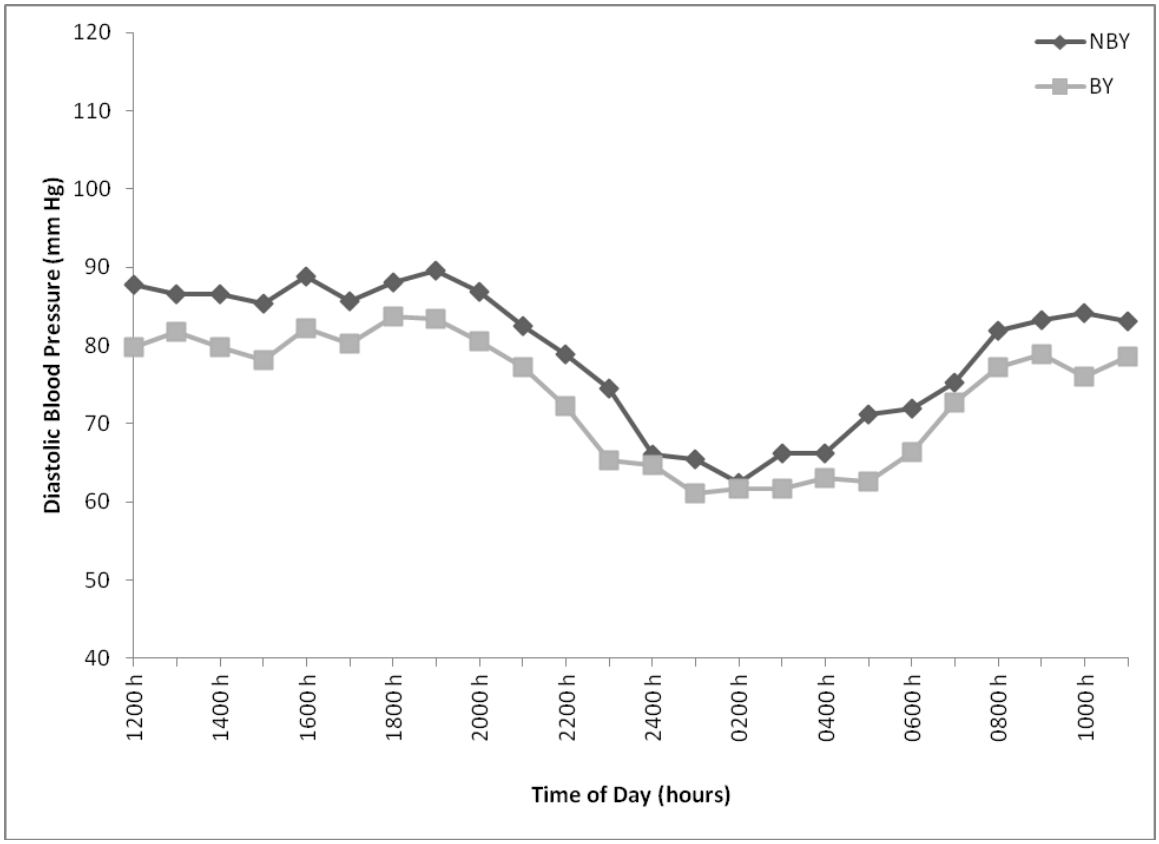

Figure 3. Pattern of ambulatory DBP means across 24 hours comparing NBY with BY days. Twenty-four hour DBP was significantly lower after BY as compared with after NBY.

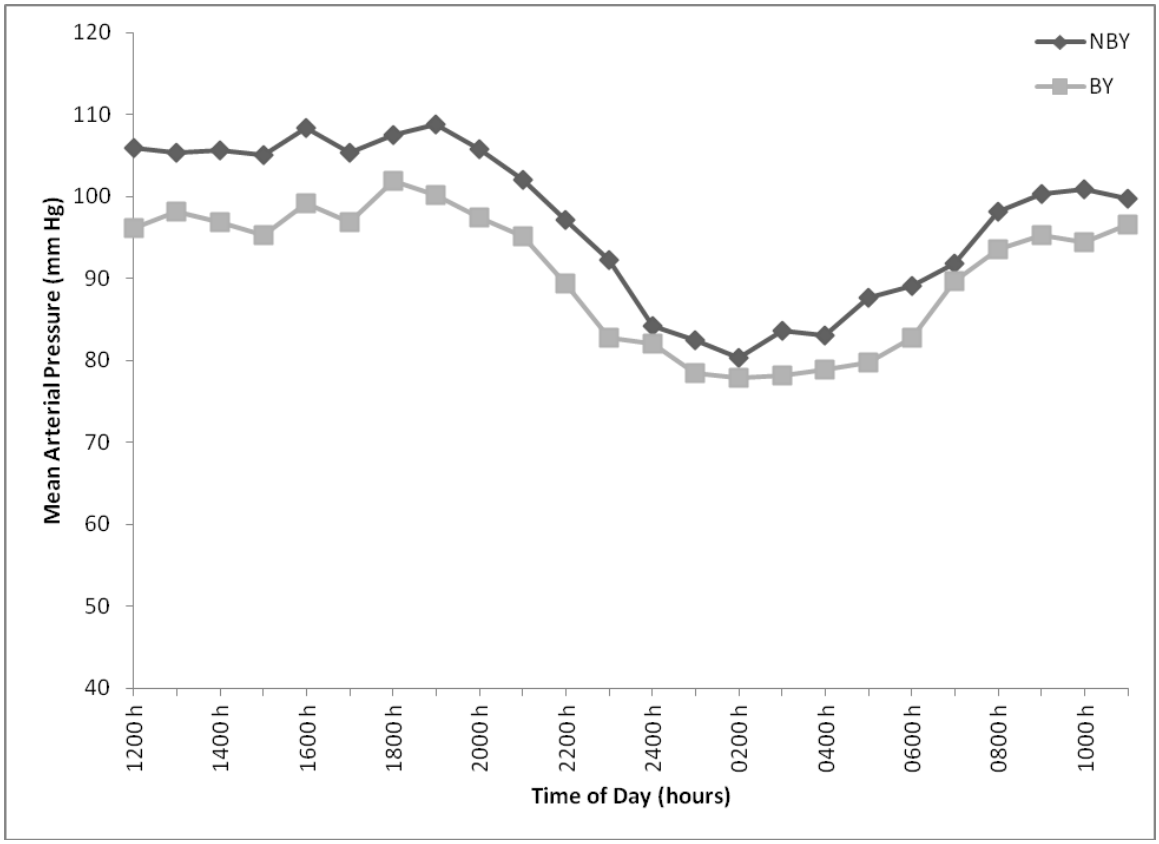

Figure 4. Pattern of ambulatory MAP means across 24 hours comparing NBY with BY days. Twenty-four hour MAP was significantly lower after BY as compared with after NBY.

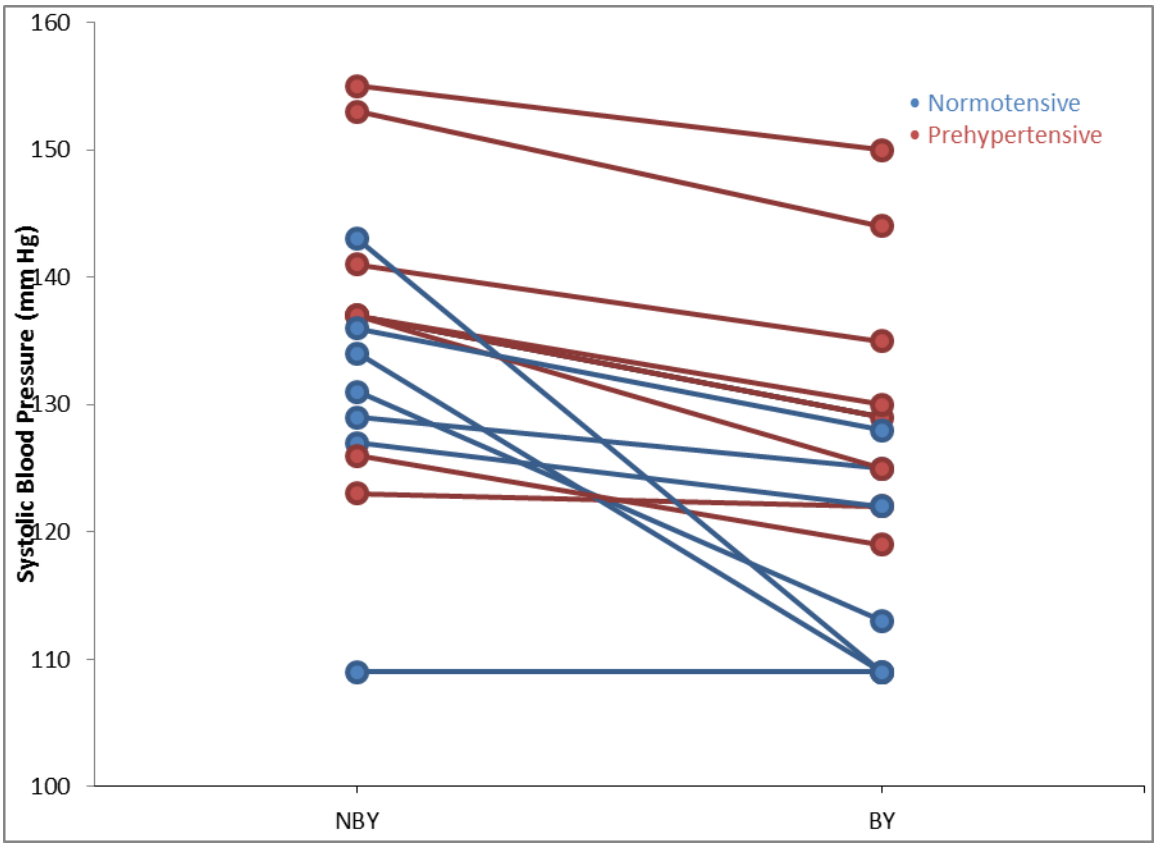

Figure 5. The 24-hour ambulatory SBP of participants classified as normotensive or prehypertensive on NBY and BY days.

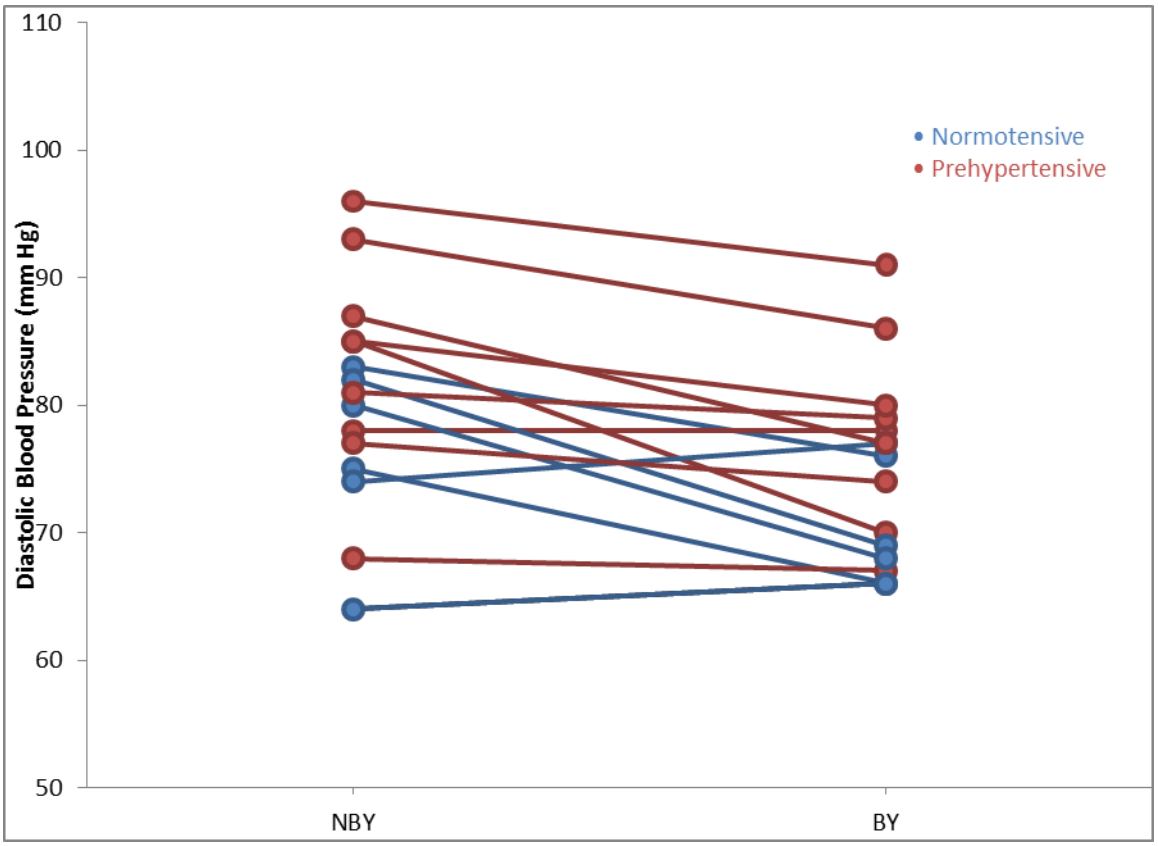

Figure 6. The 24-hour ambulatory DBP of participants classified as normotensive or prehypertensive on NBY and BY days.

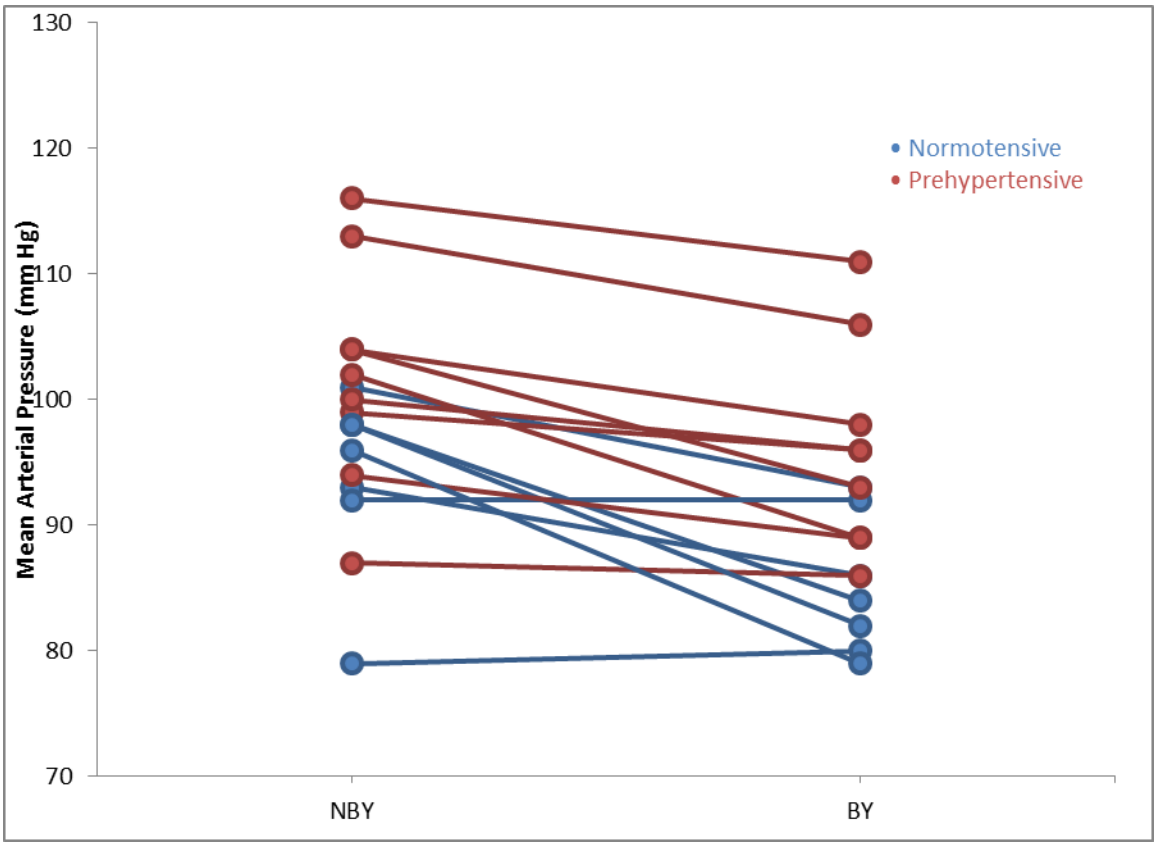

Figure 7. The 24-hour ambualtory MAP of participants classified as nomotensive or prehypertensive on NBY and BY days.

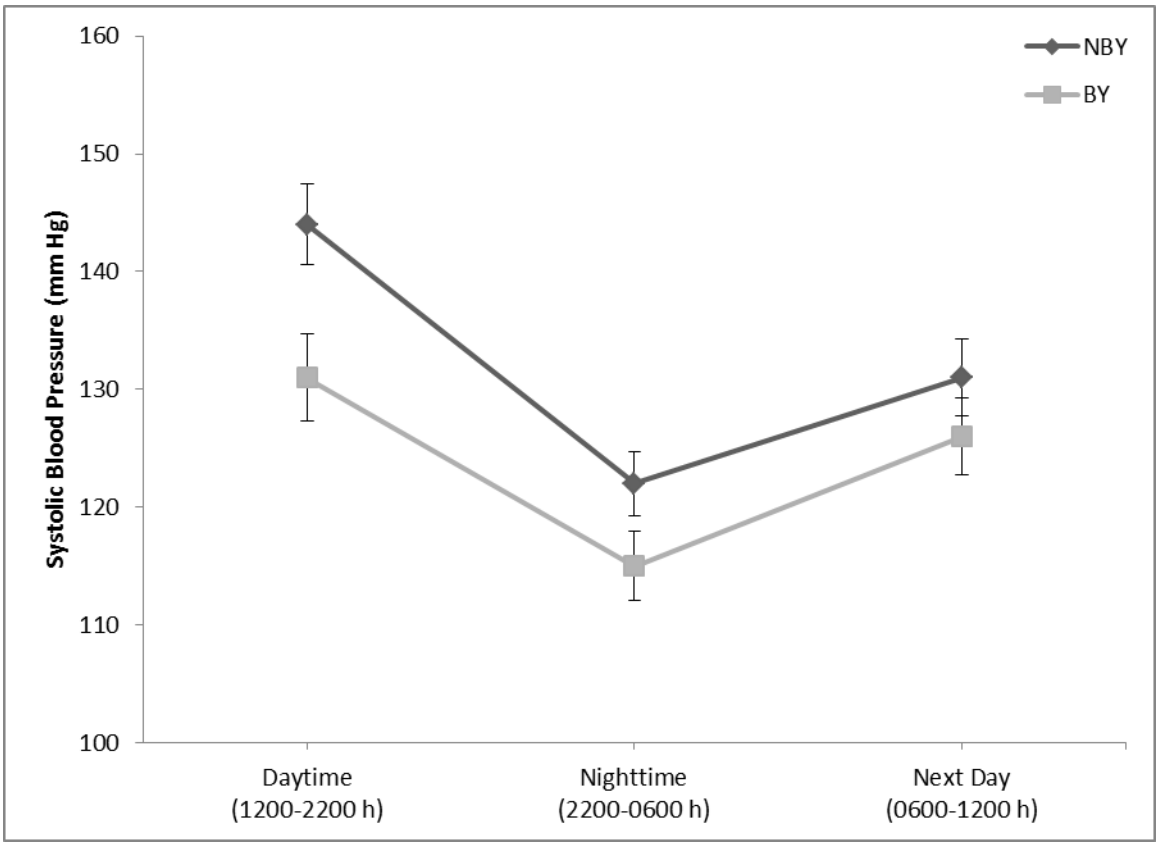

Figure 8. The pattern of ambulatory SBP between NBY vs. BY days across time of day. Ambulatory blood pressure was significantly lower for SBP on BY days compared to NBY days only for daytime and nighttime hours. Values are mean ± *SE*.

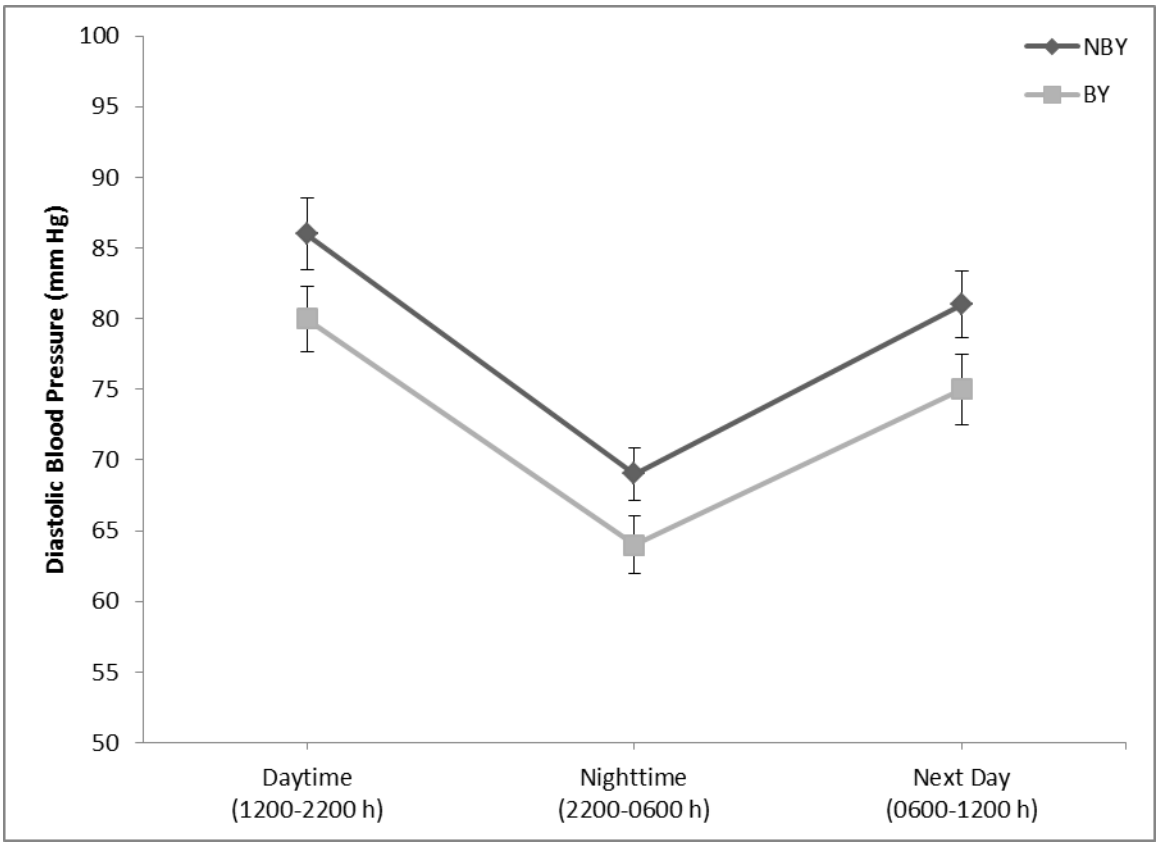

Figure 9. The pattern of ambulatory DBP between NBY vs. BY days across time of day. Ambulatory blood pressure was significantly lower for DBP on BY days compared to NBY days for daytime, nighttime hours, and next day hours. Values are mean ± *SE*.

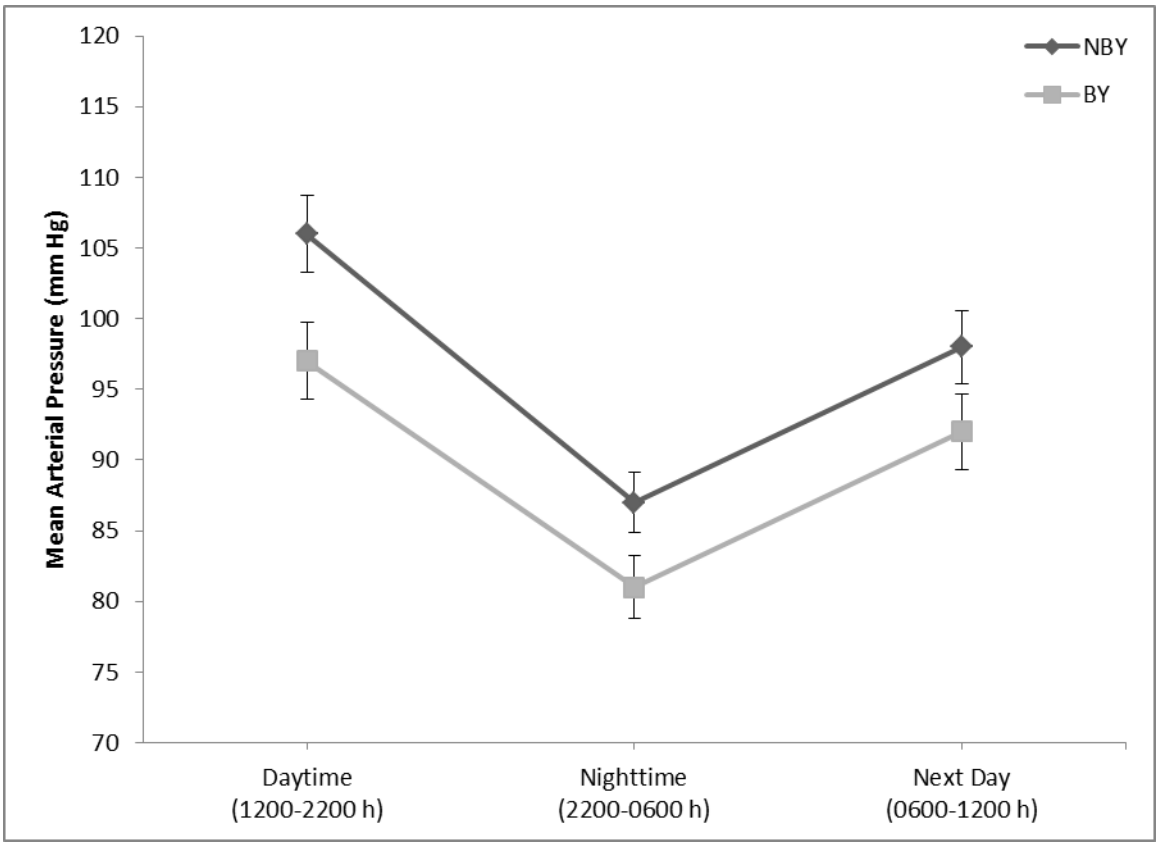

Figure 10. The pattern of ambulatory MAP between NBY vs. BY days across time of day. Ambulatory blood pressure was significantly lower for MAP on BY days compared to NBY days for daytime, nighttime hours, and next day hours. Values are mean ± *SE*.

DISCUSSION

The purpose of this study was to examine the acute effects of a single 90-minute bout of Bikram yoga on 24-hour blood pressure in normotensive and prehypertensive subjects for daytime (1200 – 2200 h), nighttime (2200- 0600 h), and next day (0600- 1200 h) hours. A secondary purpose of this study was to examine the effects of Bikram yoga on stress and anxiety. Exploratory analyses were conducted on possible relationships between differences in 24-hour ambulatory blood pressure on BY and NBY days with initial resting blood pressure, Bikram yoga experience, and perceived stress. The main finding of this study was that SBP was significantly lower on BY days compared to NBY days for an 18 hour period across daytime (1200- 2200 h) and nighttime (2200- 0600 h) time periods, but not significantly lower during the next day (0600- 1200 h) time period in normotensive and prehypertensive individuals. DBP and MAP were significantly lower on BY days compared to NBY days for a 24 hour period during daytime (1200- 2200 h), nighttime (2200- 0600 h), and next day (0600- 1200 h) time periods. These blood pressure results are even more impressive considering heart rates were significantly higher during daytime BY days, than NBY days. Ambulatory blood pressure for both NBY and BY days followed the expected circadian pattern, in which blood pressure dips at night, begins to rise in the morning, and peaks sometime in the late afternoon (Ernst, 2013). Overall, subjects demonstrated meaningful reductions in 24-hour blood pressures on BY days compared to NBY days for SBP (- 10 mm Hg), DBP (- 6 mm Hg), and MAP (- 7 mm Hg). These findings are comparable to other researchers on the acute effects of traditional forms of aerobic exercise, who found meaningful

reductions in SBP (- 9 mm Hg), DBP (- 9 mm Hg), and MAP (- 7 mm Hg) (Cardoso et al., 2010; Pescatello et al., 1991; Pescatello et al., 1999; Quinn et al., 2000). In the general population, reductions in SBP and DBP as small as 2 mm Hg is associated with a 9% and 6% lower risk of coronary artery disease and 14% and 17% lower risk of stroke, respectively (Pescatello et al., 2004).

The main findings in the current research can be related to those in Pescatello et al. (1991) who reported significant reduction in DBP and MAP for a longer duration (12.7 hours) than significant reductions in SBP (8.7 hours) in hypertensive, but not normotensive, men following cycling. Subjects in the Pescatello et al. (1991) study only wore the ambulatory blood pressure monitors for about 13 hours in the study, rather than a full 24-hours as in the current study. Also, significant reductions in blood pressure post-exercise were compared only to pre-exercise resting blood pressure measures, rather than comparable blood pressures on a non-exercise day, as was done in the current study. Bhammar et al. (2012), similar to the current study, compared 24-hour ambulatory blood pressure on an exercise day to a comparable non-exercise day. The researchers studied prehypertensive men and women and demonstrated that 30 minutes of acute continuous cardiovascular exercise resulted in significantly lowered ambulatory blood pressure for daytime hours compared to a non-exercise control day, but ambulatory blood pressure reductions were limited to SBP. Reductions in SBP were significantly lower when the 30-minute exercise was divided into three 10-minute bouts; the SBP was lower than a non-exercise control period for daytime (1300-2300 h), nigttime (2300-0800 h), and next day (0800-1200 h) time periods. In addition, there were no reductions in DBP from

either the continuous or fractionalized exercise when compared to a non-exercise control day (Bhammar et al., 2012).

In the current research, there were reductions in both SBP and DBP in normotensive and prehypertensive trained men and women following an acute bout of Bikram yoga. Most researchers have shown reductions in ambulatory blood pressure for prehypertesnive or hypertensive subjects (Brandao-Rondon et al., 2002; Cox et al., 1996; Pescatello et al., 1991; Pescatello et al., 2004; Pescatello et al., 1999) as a result of an acute bout of traditional cardiovascular exercises, such as cycling or treadmill running. Studies in which both ambulatory blood pressure between normotensvie and hypertensive individuals are measured, often reported significant reductions in blood pressure only for the hypertensive subjects (Brandao-Rondon et al., 2002; Pescatello et al., 1999; Quinn, 2000; Wallace et al., 1999). The occurance of lowered blood pressure in normotensive subjects following an acute bout of exercise is inconsistent (Bermudes, Vassallo, Vasquez, & Lima, 2003). Blood pressure response to an acute exercise bout and to exercise training can vary between individuals (Hagberg, Park, & Brown, 2000). Hagberg et al. (2000) reports that 75% of hypertensive individuals elicit a blood pressure response to exercise training; hence, as many as 25% of hypertensive individuals are “nonresponders” to exercise. The relationship between blood pressure response to an acute exercise bout or exercise training is still unclear. It has been suggested that further research is needed to examine if there is a genetic predisposition to have a blood pressure lowering response to exercise in normotensive individuals (MacDonald, 2002).

In the current research, Bikram yoga, a non-traditional form of exercise, was

shown to have significant blood pressure lowering effects in *both* normotensive and prehypertensive individuals. Differences in blood pressure between NBY and BY days were found to be unrelated to initial resting blood pressure categories (see Figures 4, 5, and 6). Normotensive subjects had equivalent differences in 24-hour ambulatory SBP, DBP, and MAP compared to prehypertensive subjects. Interestingly, this may be unique to Bikram yoga and not seen in other studies which use traditional forms of exercise as an intervention. This is inconsistent with previous notions that the magnitude of blood pressure reductions due to exercise are greater for hypertensive and prehypertensive individuals compared to normotensive individuals (MacDonald, 2002). It may be that a non-traditional form of exercise like BY can have equal, if not greater, blood pressure lowering effects than traditional forms of exercise, yet, the effects of Bikram yoga on blood pressure is under-researched. This is the only published study known in which the acute effects of Bikram yoga on ambulatory blood pressure are reported. Previous Bikram yoga researchers that reported on blood pressure used training studies, and blood pressure was only a secondary variable in the analyses.

Tracy and Hart (2013) previously reported no change in resting blood pressure from pre- to post-training as a result of an 8-week Bikram yoga training in normotensive and prehypertensive individulas with little or no previous yoga experience. Similarly, Abel (2011) found significant changes only in resting diastolic blood pressure in individuals practicing Bikram yoga daily for almost 9 weeks. In the Abel (2011) study, it is unclear if subjects were normotensive, prehypertensive, or hyptertensive. In each of these two Bikram yoga studies, the authors do not discuss when blood pressure measures

were taken in relation to the last bout of Bikram yoga. Therefore, it is not clear if blood pressure measures reflect responses to an acute bout of Bikram yoga or the Bikram yoga trainings. In addition, resting blood pressures are being measured as opposed to ambulatory blood pressure as in the current study. A few yoga researchers, that use styles of yoga other than Bikram yoga, have reported on amubulatory blood pressures.

Montfrans et al. (1990) did not find significant changes in ambulatory blood pressure after 8 weeks of relaxation therapy, which included yoga. The absence of significant blood pressure reduction in this study could be because the training was not long enough. Interestingly, Cohen et al (2011) studied the effects of Iyengar yoga on ambulatory blood pressure and did not find reductions in 24- hour ambulatory blood pressure at 6 weeks of training compared to baseline measures, but did find reductions after 12 weeks of training in prehypertensive and Stage 1 hypertensive individuals. Similar to other other yoga researchers, Cohen et al. (2011) did not report when, in relation to the last bout of yoga, post-testing ambulatory blood pressures were measured. It is unclear whether the changes in blood pressure were due to training or to the last acute bout of yoga. Perhaps reductions in blood pressure as a result of yoga training do not appear until 12 weeks. In the current study, subject inclusion criteria was a minimum of 3 months (12 weeks) current regular Bikram yoga practice, with the average participant having 30.8 months of experience. This, together with what can be garnered from Cohen et al. (2011) study, could imply that a minimum of 12 weeks of yoga training in necessary to elicit significant changes in ambulatory blood pressure. However, the differences between ambulatory blood pressure on NBY and BY days were unrelated to

the amount of previous Bikram yoga experience, which ranged from as little as 4 months to as much as 10.3 years. Individuals new to any practice of yoga may need time to become comfortable with the exercise and adapt. However, changes in ambulatory blood pressure as a result of an acute bout of yoga compared to a non-yoga day has previously been shown to be reduced as early as the first yoga session (Mulvey et al., 2011).

Mulvey et al. (2011) was the only research group to appear to have reported when, in relation to the last bout of yoga, the ambulatory blood pressures were taken. In this single-subject design study, an untrained prehypertensive male trained in Hatha yoga showed reductions in 24- hour ambulatory blood pressures immediately after a single bout of yoga. Ambulatory blood pressures after yoga were lower only during the asleep time period when compared to a non-yoga control day, which was possbily due to the fact the yoga sessions took place in the evening, rather than the morning. It was reported that the greatest decrease due to an acute bout of Hatha yoga was immediately after the first yoga session. No significant change in ambulatory blood pressure was found from pre- to post- training. However, over the 9-week training program, nighttime ambulatory blood pressure was consistently shown to be lower after an acute bout of yoga compared to the same time frame on a non-yoga control day. It may be that acute effects, rather than training effects, are what is mostly responsible for the decrease in blood pressure with yoga.

In the current study, Bikram yoga was shown to acutely reduce state anxiety which was similar to previous research in which an acute bout of yoga was shown to reduce state anxiety and stress (Smith et al., 2007; Wei et al., 2006; West et al., 2004). In

the current study, different from previous studies, measures of perceived stress were taken at the end of 24-hour ambulatory blood pressure monitoring for NBY and BY days in order to examine if there was a relationship between differences in perceived stress and differences in blood pressure between the days. There were no significant differences in perceived stress between NBY and BY days, and differences in perceived stress were not significantly related to differences in blood pressure for the corresponding NBY and BY days. Therefore, lower ambulatory blood pressures consequent to BY can not be attributed to changes in perceived stress.

The mechanisms by which physcial activity elicits a blood pressure lowering effect is controversial, because contradictory results have been found related to the type of exerice, duration of exercise, intensity of exercise, magnitude and duration of blood pressure reduction, as well as differences between populations (MacDonald, 2002). Potential mechanims include deacreased cardiac output, peripheral resistance, resting heart rate, and circulating catecholamines. These mechanisms may be affected by thermoregulation, blood volume, and autonomic nerve activity among other things. It could be that the cause is not controlled by a single factor, but rather a combination of these factors. Because Bikram yoga is practiced in a uniquely hot and humid studio environment, decreased blood pressure following Bikram yoga may be due to decreased vascular resistance (vasodilation). In the current study, the idea of decreased total peripheral resistance during BY days is further supported by findings of higher heart rates on the BY days (implying higher cardiac outputs). A better understanding of the mechanisms could lead to a better understanding of the prevention, treatment, and

management of hypertension through a non-pharmalogic intervention such as yoga.

There are some limitations to this study. Because blood pressure is influenced by physical activity level, posture, and diet, ambulatory blood pressure measures may have been affected by variations in these three variables. However, there were no apparent differences in subjects's log- reported activites, posture, and diet between the NBY and BY days. Data was collected on subjects in a cold climate, which may have affected measurements on blood pressure. Another limitation of this study was that potential mechanisms were not explored beyond the relationship between differences in perceived stress and differences in ambulatory blood pressure for NBY and BY days.

Since mechanisms contributing to the antihypertensive effects of exercise remain unclear, a recommendation for future study would be to examine the mechanisms contributing to the blood pressure lowering effects of Bikram yoga, which could differ depending on age, sex, and training status. It is also important to look at the effect of the unique room environment that is specific to Bikram yoga, and how the heat and humidity play a role on effecting blood pressure. Further research needs to be done to examine normotensive versus hypertensive and prehypertensive subjects, and untrained versus trained subjects.

In conclusion, a single 90-minute bout of Bikram yoga performed in the morning resulted in significantly lower 24-hour ambulatory SBP (- 10 mm Hg), DBP (- 6 mm Hg) and MAP (- 7 mm Hg) compared to a non-Bikram yoga day. With the exception of the Mulvey et al. (2011) study, previous researchers, who have used ambultory blood pressure as an outcome measure, were unclear about when measurements were taken in

relation to the last bout of yoga (Cohen et al., 2011; Montfrans et al. 1990). Based on results from the Mulvey et al. (2011) study and the current research, it may be that yoga must be practiced regularly in order to elicit a blood pressure lowering effect. Previous researchers on Bikram yoga have shown improvements across biomechanics, physiology, and psychology, in measures of balance, leg strength, leg muscle control, flexibility, body composition, mindfulness, and perceived stress as a result of Bikram yoga training. This research further supports the benefits of Bikram yoga for health and fitness. Given that physcial activity is an integral part of lifestyle modification, Bikram yoga may be a effective alternative to traditional exercise and may be of value when formulating exercise prescriptions for normotensive and prehypertenisve individuals. Based on the magnitude of lower ambulatory blood pressure from acute Bikram yoga practice, Bikram yoga should be recommended for reduction of ambulatory blood pressure in normotensive and prehypertensive individuals.

Appendix A

Volunteers Needed

Graduate Research Project:
Acute Effects of Bikram Yoga on Ambulatory Blood Pressure

- You must:

Be 18 years of age or older

Be a non-smoker

Not be pregnant

Not be on blood pressure medications

Have been practicing Bikram yoga regularly for the past three months

Be available January 2-16, 2013

- Be able to:

Attend one morning Bikram yoga class

Wear a 24-hour ambulatory blood pressure monitor on two days

Refrain from exercise (including Bikram yoga) for three consecutive days

- Benefits:

Heart rate and 24-hour blood pressure information related to your yoga practice

Please contact me by December 15, 2012

Jozlyn Jareunpoon (xxx) xxx-xxx jaj132@humboldt.edu

Appendix B

ACUTE EFFECTS OF BIKRAM YOGA ON AMBULATORY BLOOD PRESSURE

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, include the risks and benefits of its associate, and want to participate.

Principal Investigator:

Jozlyn A. Jareunpoon, B.A.
Humboldt State University
(xxx) xxx-xxx
jaj132@humboldt.edu

Faculty Advisor:
Tina M. Manos, Ed. D.
Department of Kinesiology and Recreation Administration
1 Harpst Street
Humboldt State University
(707) 826-5962
tmm52@humboldt.edu

Project Description:

The purpose of this study will be to investigate the acute effects of Bikram yoga on 24-hour ambulatory blood pressure. This research may help to show the effects of Bikram yoga practice on blood pressures for the 24-hours immediately after a single session of Bikram yoga (acute effects) and after 48 hours of no Bikram yoga practice.

Consent:

1. You must be at least 18 years old to participate in this study.
2. Your participation in this study is voluntary.
3. You may choose not to participate at all, or you many 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:

1. Will sign an informed consent. (Approximate time: 10 min)
2. Will fill out a Participant Questionnaire, and Physical Activity Questionnaire at the beginning of the 2-week study. (Approximate time: 15 minutes)
3. Will have measures taken at either the Farmington Hills or Troy, MI Bikram yoga studio for resting heart rate, resting blood pressure, height, weight, waist and hip circumferences, and body composition by skinfold measurements at the beginning of the 2-week study. Circumferences will be measured at the narrowest part of the waist and widest part of the hips using a Gulick tape measure. Skinfold measurements require a caliper placed directly on the skin surface where a pinch is maintained for 1 to 2 seconds on three sites. (Approximate time: 30 minutes)
4. Will refrain from exercise including Bikram yoga classes while taking 24-hour ambulatory blood pressure measures on two days, and also two days prior to the non-Bikram yoga ambulatory blood pressure measurements.
5. Will have taken two 24-hour blood pressure measures from beginning to end of the 2-week study to include a 24-hour blood pressure measure immediately after a Bikram yoga session and 24-hour blood pressure measure 48-hours after a Bikram yoga session. All 24-hour blood pressure measures will be taken during your daily activities and while sleeping. (Approximate time: 2 days)
6. Will write down and record your activity immediately after each blood pressure reading (except when sleeping) during 24-hour blood pressure measures. (Approximate time: 1 hour total)
7. Will wear a heart rate monitor for a Bikram yoga class related to acute/non-Bikram yoga day testing. (Approximate time: 90 minutes)
8. Will fill out a questionnaire on anxiety before and after a Bikram yoga class related to acute testing. (Approximate time: 20 minutes)
9. Will fill out a questionnaire on perceived stress immediately after both 24-hour ambulatory blood pressure measures are complete. (Approximate time: 10 minutes)

Possible Risks and Discomforts:

This study requires using a 24-hour ambulatory blood pressure monitor, using a heart rate monitor, and participate in Bikram yoga classes.

1. _____ You may experience mild discomfort that is associated with the skin fold calipers in order to obtain a body composition measurement.

2. _____ There is a possibility of injuring yourself while performing any of these activities.

3. _____ You may experience some brief mild discomfort during the inflation of the cuff of the blood pressure monitor.

4. _____ You may experience bruising or skin irritation from wearing the blood pressure monitor.

5. _____ You may experience difficulty sleeping during the night while wearing the blood pressure monitor due to the periodic inflation sounds and the pressure applied to the arm by the device.

Benefits:
You will be receiving free body composition, personal heart rate information during Bikram yoga class, and ambulatory blood pressure information over the duration of the study.

Responsibilities You Have as a Participant in this Research:
Information you possess about your health status, and current or previous experiences may affect the value of the exercise you will do as part of this research study. You agree to report this information to the principle investigator. You also agree to inform the primary investigator of any changes in medical status or medication use.

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 the investigator will answer any questions you 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 the study described above.

(Print your full name here) _____

(Sign your full name here) _____

____/____/_____ (Date)

Appendix C

Participant Questionnaire

Name: _____ Date: _____

Phone: (_____) _____-_____ Email: _____

Emergency Contact:

Name: _____Phone: (_____) _____-_____

The following questions are designed to help describe the subject population in this study. Please take the time to answer these questions accurately.

Current Age: _____Date of Birth: _____Sex: _____

1. How long in total have you been practicing Bikram yoga?

   _____ years _____ months _____ weeks

3. Are you *currently* practicing Bikram yoga *regularly* (at least 3 times per week)?

   Circle one: YES NO

4. If yes, how long have you been practicing *regularly*?

   _____ years _____ months _____ weeks

5. If no, how long has it been since you practiced Bikram yoga *regularly*?

   _____ years _____ months _____ weeks _____never

6. How many **days** per week do you *currently* practice Bikram yoga?

   _____ days

7. How many Bikram yoga **classes** do you *currently* take per week?

   _____ classes

8. What time do you typically sleep (circle AM or PM)?

   _____ AM / PM to _____ AM / PM

9. 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

10. Are you pregnant ? ( ) Yes ( ) No

11. Are you a non-smoker? ( ) Yes ( ) No

12. Are you taking blood pressure lowering medication? ( ) Yes ( ) No

13. Have you ever had:

Yes	No	
( )	( )	11. Heart disease, heart attack, and/or heart surgery
( )	( )	12. Abnormal EKG or rhythm disturbance
( )	( )	13. Stroke
( )	( )	14. Uncontrolled 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 or implanted/external cardiac defibrillator?
( )	( )	22. Do you currently have an acute systemic infection, accompanied by a fever, body aches, or swollen lymph glands?
( )	( )	23. Do you have a chronic 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.

_____

_____

_____

_____

13. Please list the current medications that you take:

_____

_____

_____

_____

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

Date _____ Signature _____

Appendix D

INTERNATIONAL PHYSICAL ACTIVITY QUESTIONNAIRE

We are interested in finding out about the kinds of physical activities that people do as part of their everyday lives. The questions will ask you about the time you spent being physically active in the **last 7 days**. Please answer each question even if you do not consider yourself to be an active person. Please think about the activities you do at work, as part of your house and yard work, to get from place to place, and in your spare time for recreation, exercise or sport.

Think about all the **vigorous** activities that you did in the **last 7 days**. **Vigorous** physical activities refer to activities that take hard physical effort and make you breathe much harder than normal. Think *only* about those physical activities that you did for at least 10 minutes at a time.

1. During the **last 7 days**, on how many days did you do **vigorous** physical activities like heavy lifting, digging, aerobics, or fast bicycling?

   _____ **days per week**

   ☐ No vigorous physical activities → ***Skip to question 3***

2. How much time did you usually spend doing **vigorous** physical activities on one of those days?

   _____ **hours per day**

   _____ **minutes per day**

   ☐ Don't know/Not sure

Think about all the **moderate** activities that you did in the **last 7 days**. **Moderate** activities refer to activities that take moderate physical effort and make you breathe somewhat harder than normal. Think only about those physical activities that you did for at least 10 minutes at a time.

3. During the **last 7 days**, on how many days did you do **moderate** physical activities like carrying light loads, bicycling at a regular pace, or doubles tennis? Do not include walking.

   _____ **days per week**

   ☐ No moderate physical activities → ***Skip to question 5***

4. How much time did you usually spend doing **moderate** physical activities on one of those days?

_____ **hours per day**

_____ **minutes per day**

☐ Don't know/Not sure

Think about the time you spent **walking** in the **last 7 days**. This includes at work and at home, walking to travel from place to place, and any other walking that you have done solely for recreation, sport, exercise, or leisure.

5. During the **last 7 days**, on how many days did you **walk** for at least 10 minutes at a time?

_____ **days per week**

☐ No walking → ***Skip to question 7***

6. How much time did you usually spend **walking** on one of those days?

_____ **hours per day**

_____ **minutes per day**

☐ Don't know/Not sure

The last question is about the time you spent **sitting** on weekdays during the **last 7 days**. Include time spent at work, at home, while doing course work and during leisure time. This may include time spent sitting at a desk, visiting friends, reading, or sitting or lying down to watch television.

7. During the **last 7 days**, how much time did you spend **sitting** on a **week day**?

_____ **hours per day**

_____ **minutes per day**

☐ Don't know/Not sure

This is the end of the questionnaire, thank you for participating.

Appendix E

Checklist for Participants

Projected schedule of testing that will take place at Bikram yoga Detroit locations either in Farmington Hills, MI or Troy, MI

Day 1: Preliminary Meeting: Questionnaires, Resting Measures, Descriptive Tests

- Informed consent
- Questionnaires: Participant Questionnaire and Physical Activity Questionnaire
- Resting Hear Rate and Resting Blood Pressure measures
- Height and Mass
- Body Composition via circumferences and skin folds

Day 1 and 2:

- Acute or non-Bikram yoga control day ABP measures
- Questionnaires: Perceived Stress Scale and State Trait Anxiety Inventory (before and after Bikram yoga class)
- Bikram yoga class wearing a heart rate monitor
- One week take 24-hour ambulatory blood pressures immediately after class and the second week take 48-hours after class or vice versa *

*Participants will be randomized into either Schedule A or Schedule B to reduce sequencing effects. Participants on Schedule A take measures immediately following class first and participants on Schedule B take non-Bikram yoga control day measures first.

Appendix F

Participant Measurements

ID# _____ Date: _____ Time: _____

Arm Circumference: _____ cm

Cuff Size: _____

Resting HR: _____

Resting BP Day 1:

(1) _____ mm Hg

(2) _____ mm Hg

(3) _____ mm Hg

Resting BP Day 2:

(4) _____ mm Hg

(5) _____ mm Hg

(6) _____ mm Hg

Average Resting BP: _____

Height: _____cm

_____ feet _____ inches

Weight: _____ lbs

_____ kg

Waist Circumference: _____ inches

Appendix G

Suntech Oscar 2 User Instructions

Beginning the study:

1. To turn the monitor on, push the Start/Stop (☐/☐) button on the
   the screen.
2. With the monitor on, press the Start/Stop (☐/☐) button on the
   BP reading.
3. The clock icon should appear on the display indicating that the study is in progress.
4. During BP readings minimize movement and let the arm rest slightly away from the body so the monitor can take a successful reading.
5. If the reading is unsuccessful, the cuff may immediately re-inflate up to 4 times.
6. If a BP reading was not recorded successfully, the next BP reading will be taken 5 minutes after the unsuccessful BP reading.

Information for use:

1. The best reading is taken when the whole body is still. Let the cuffed arm hang loosely, slightly away from the body.
2. A measurement in progress can be stopped by pressing the Start/Stop (☐/☐) button.
3. Between BP readings the cuff should not be removed unless it may be wet or damaged.
4. Make sure the hose is not kinked when sleeping.
5. Keep the monitor dry and do not drop it.
6. Do not attempt to clean the unit with any detergents or cleaning agents.
7. Keep away from flammable anesthetics.
8. If the monitor or cuff causes extreme pain or pain not normally associated with blood pressure measurement, remove the cuff and turn off the monitor.

Finishing the study:

1. To finish the study, turn the monitor off by holding down the Start/Stop (☐/☐) button for 5
   seconds. The Oscar 2 will beep and the display will turn off.
2. Take the cuff, monitor and strap/belt off.

Reminders:

1. 24-hours Prior to ABP measures please refrain from:
   - alcohol
   - formal exercise

2. On days of ABP monitoring repeat same pattern of activity, diet, and sleep

3. While wearing the ambulatory blood pressure monitor please refrain from:
   - Exercise or vigorous physical activity
   - Showering/bathing
   - Naps/sleeping other than regular sleeping hours

Appendix H

Suntech Oscar 2
Participant Check Out Form

By checking out this equipment I am subject to the following conditions (please initial after you have read each statement):

1. _____ I will be responsible for the equipment while it is checked out to me.
2. _____ I will not expose the equipment to flammable anesthetics.
3. _____ I will keep the equipment dry and not drop it.
4. _____ I will not immerse the equipment in any fluid, place fluids on top, or attempt to clean the unit with any liquid detergents or cleaning agents.
5. _____I will remove the cuff and turn off the monitor if it may be wet or damaged (i.e. shower, exercise).
6. _____ I will remove the cuff if it fails to deflate within 3 minutes.
7. _____ I will remove the cuff if it causes extreme pain, pain not normally associated with blood pressure measurement, or any allergic reaction.
8. _____ I will store the equipment in a safe and secure place when it is not in use to prevent it from being lost or stolen.
9. _____ I agree to release the Humboldt State University, its employees, affiliates, agents, officers, directors, and research investigators from all liability for injury, death, property loss, and damage which results from the equipment user's participation in physical activity, or is in any way related to the use of this equipment, including all liability which results from the negligence of providers, or any other person or cause.

Monitor _____Cuff _____

I (print full name) _____ have read, understand, and agree to abide by all the conditions described on this form.

Signature _____ Date _____

Appendix I

Activity and Diet Log Instructions

Please write clearly.

Activity Log:

1. Immediately following each blood pressure reading, write down the **TIME** (Hour:Minute), your **POSITION** (standing, sitting, lying down), and the **ACTIVITY** you were doing just before the arm cuff began to inflate.

2. Write the time you go to **SLEEP** (Hour:Minute).

3. Write the time you **WAKE UP** (Hour:Minute).

4. If you remove the cuff for any reason, write down the **TIME** and **ACTIVITY** you were doing. Under **POSITION** please note that you removed the cuff.

Diet Log:

1. Record the **TIME** (Hour:Minute), **FOOD**, **BEVERAGE**, and the **AMOUNT** you consume throughout 24-hour ambulatory blood pressure monitoring.

Appendix J

Ambulatory Blood Pressure Activity Log

ID # _____ Date _____

Time (Hour:Min)	**Position** (Standing, Sitting, Lying Down)	**Activity**

Appendix K

Ambulatory Blood Pressure Diet Log

ID # _____ Date _____

Time (Hour:Min)	**Food or Beverage**	**Amount**

Appendix L

State-Trait Anxiety Inventory for Adults

Instrument (Adult Form) and Scoring Guide

Developed by Charles D. Spielberger
in collaboration with R.L. Gorsuch, R. Lushene, P.R. Vagg, and G.A. Jacobs

Published by Mind Garden, Inc.

info@mindgarden.com
www.mindgarden.com

SELF-EVALUATION QUESTIONNAIRE **STAI Form Y-1**

Please provide the following information:

Name_____Date_____S_____

Age_____ Gender (*Circle*) **M** **F** T_____

DIRECTIONS:

A number of statements which people have used to describe themselves are given below. Read each statement and then circle the appropriate number to the right of the statement to indicate how you feel *right* now, that is, *at this moment*. There are no right or wrong answers. Do not spend too much time on any one statement but give the answer which seems to describe your present feelings best.

	NOT AT ALL	SOMEWHAT	MODERATELY SO	VERY MUCH SO
1. I feel calm	1	2	3	4
2. I feel secure	1	2	3	4
3. I am tense	1	2	3	4
4. I feel strained	1	2	3	4
5. I feel at ease	1	2	3	4
6. I feel upset	1	2	3	4
7. I am presently worrying over possible misfortunes	1	2	3	4
8. I feel satisfied	1	2	3	4
9. I feel frightened	1	2	3	4
10. I feel comfortable	1	2	3	4
11. I feel self-confident	1	2	3	4
12. I feel nervous	1	2	3	4
13. I am jittery	1	2	3	4
14. I feel indecisive	1	2	3	4
15. I am relaxed	1	2	3	4
16. I feel content	1	2	3	4
17. I am worried	1	2	3	4
18. I feel confused	1	2	3	4
19. I feel steady	1	2	3	4
20. I feel pleasant	1	2	3	4

SELF-EVALUATION QUESTIONNAIRE

STAI Form Y-2

Name_____Date_____

DIRECTIONS

A number of statements which people have used to describe themselves are given below. Read each statement and then circle the appropriate number to the right of the statement to indicate how you *generally* feel.

	ALMOST NEVER	SOMETIMES	OFTEN	ALMOST ALWAYS
21. I feel pleasant	1	2	3	4
22. I feel nervous and restless	1	2	3	4
23. I feel satisfied with myself	1	2	3	4
24. I wish I could be as happy as others seem to be	1	2	3	4
25. I feel like a failure	1	2	3	4
26. I feel rested	1	2	3	4
27. I am "calm, cool, and collected"	1	2	3	4
28. I feel that difficulties are piling up so that I cannot overcome them	1	2	3	4
29. I worry too much over something that really doesn't matter	1	2	3	4
30. I am happy	1	2	3	4
31. I have disturbing thoughts	1	2	3	4
32. I lack self-confidence	1	2	3	4
33. I feel secure	1	2	3	4
34. I make decisions easily	1	2	3	4
35. I feel inadequate	1	2	3	4
36. I am content	1	2	3	4
37. Some unimportant thought runs through my mind and bothers me	1	2	3	4
38. I take disappointments so keenly that I can't put them out of my mind	1	2	3	4
39. I am a steady person	1	2	3	4
40. I get in a state of tension or turmoil as I think over my recent concerns and interests	1	2	3	4

State-Trait Anxiety Inventory for Adults Scoring Key (Form Y-1, Y-2)

Developed by Charles D. Spielberger in collaboration with R.L. Gorsuch, R. Lushene, P.R. Vagg, and G.A. Jacobs

To use this stencil, fold this sheet in half and line up with the appropriate test side, either Form Y-1 or Form Y-2. Simply total the scoring **weights** shown on the stencil for each response category. For example, for question # 1, if the respondent marked 3, then the **weight** would be **2**. Refer to the manual for appropriate normative data.

Form Y-1	NOT AT ALL	SOMEWHAT	MODERATELY SO	VERY MUCH SO
1.	4	3	2	1
2.	4	3	2	1
3.	1	2	3	4
4.	1	2	3	4
5.	4	3	2	1
6.	1	2	3	4
7.	1	2	3	4
8.	4	3	2	1
9.	1	2	3	4
10.	4	3	2	1
11.	4	3	2	1
12.	1	2	3	4
13.	1	2	3	4
14.	1	2	3	4
15.	4	3	2	1
16.	4	3	2	1
17.	1	2	3	4
18.	1	2	3	4
19.	4	3	2	1
20.	4	3	2	1

Form Y-2	ALMOST NEVER	SOMETIMES	OFTEN	ALMOST ALWAYS
21.	4	3	2	1
22.	1	2	3	4
23.	4	3	2	1
24.	1	2	3	4
25.	1	2	3	4
26.	4	3	2	1
27.	4	3	2	1
28.	1	2	3	4
29.	1	2	3	4
30.	4	3	2	1
31.	1	2	3	4
32.	1	2	3	4
33.	4	3	2	1
34.	4	3	2	1
35.	1	2	3	4
36.	4	3	2	1
37.	1	2	3	4
38.	1	2	3	4
39.	4	3	2	1
40.	1	2	3	4

Appendix M

Perceived Stress Scale

The questions in this scale ask you about your feelings and thoughts **in the last 24 hours**. In each case, you will be asked to indicate by circling *how often* you felt or thought a certain way.

ID # _____Date _____ Age _____ Gender (*Circle*): **M F**

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

1. In the last 24 hours, how often have you been upset because of something that happened unexpectedly? **0 1 2 3 4**
2. In the last 24 hours, 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 24 hours, how often have you felt nervous and "stressed"? **0 1 2 3 4**
4. In the last 24 hours, how often have you felt confident about your ability to handle your personal problems? **0 1 2 3 4**
5. In the last 24 hours, how often have you felt that things were going your way? **0 1 2 3 4**
6. In the last 24 hours, 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 24 hours, how often have you been able to control irritations in your life? **0 1 2 3 4**
8. In the last 24 hours, how often have you felt that you were on top of things? **0 1 2 3 4**
9. In the last 24 hours, how often have you been angered because of things that were outside of your control? **0 1 2 3 4**
10. In the last 24 hours, how often have you felt difficulties were piling up so high that you could not overcome them? **0 1 2 3 4**

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