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The Comparative Effects of Hot Yoga and Thermoneutral Yoga on Flexibility, Heart Rate, Sweat Rate, and Mood

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The Comparative Effects of Hot Yoga and Thermoneutral Yoga on Flexibility, Heart Rate, Sweat Rate, and Mood

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by

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Abstract

Yoga is an ancient Indian philosophy, described as a therapeutic intervention and health maintenance practice that unites the mind and body to aid healing through the combination of physical postures, breathing techniques, and meditation. There is ample research regarding yoga practiced in an environment that is thermoneutral, or in an environment that does not alter the metabolic heat production or evaporative heat loss of people. However, minimal research exists on the increasingly popular form of yoga known as hot yoga, or yoga practiced in an environment that is often humidified and 95° F or warmer. This exploratory study compared the physiological and mood effects deriving from a single bout of hot yoga and a single bout of thermoneutral yoga in 15 female, experienced yoga practitioners. Data collected pre-to post-hot yoga and pre-to-post-thermoneutral yoga included flexibility of the lower back, trunk, and hamstrings, heart rate, sweat rate, and mood. All variables increased following both yoga classes, however flexibility was 10% greater following the thermoneutral yoga class. Sweat rate and heart rate were significantly greater, sweat rate by 52% and heart rate by 11%, during the hot yoga class than the thermoneutral yoga class. Mood was similar between the two forms of yoga. Physical exhaustion was increased by 31% following the hot yoga class and decreased by 16% following the thermoneutral yoga class. These results have implications to provide health professionals, yoga teachers, and yoga practitioners with further knowledge on which form of yoga yields greater health benefits.

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Introduction

Practiced for nearly 3000 years and deriving from ancient Indian philosophy, yoga is described as a therapeutic intervention and health maintenance practice that unites the mind and body to aid healing (Iyengar, 1966; Javnbakht, Kenar, & Ghasemi, 2009). Most commonly incorporating physical postures, breathing techniques, and meditation, yoga has become a popular form of exercise and a means of promoting mental health in North America and Europe (Cramer, Krucoff, & Dobos, 2013). Nearly 16 million Americans practiced some form of yoga in 2008 (Quilty, Saper, Goldstein, & Khalsa, 2014). Furthermore, while yoga is becoming ever more popular as a form of exercise it is also becoming a recognized form of medical therapy. The National Center for Health Statistics conducted a National Health Interview Survey reporting that U.S. adults spent $4.1 billion in 2007 on mind-body classes (Quilty et al., 2013). Cramer et al. (2013) found that approximately 14 million Americans, 6.1 % of the population, reported that yoga was recommended to them by a physician and that roughly 30 million people worldwide are regularly practicing yoga for health reasons.

There are multiple types of yoga practices. Hatha yoga is the most commonly practiced form of yoga and is normally performed in a thermoneutral environment. Hatha yoga incorporates the traditional model that includes physical postures, breathing techniques, and meditation. The practice of hatha yoga, both in the long term and in short bouts, has been reported to yield numerous physical and mental benefits (Bhata, Kumar, Kumar, Pandey, & Kochupllai, 2003; Bryan, Raju, Terrance, & Zipp, 2013; Kochupillai et al., 2005; Martin, Prichard, Hutchinson, & Wilson, 2013; Satin, Linden, & Millman, 2013; Sharma et al., 2003; Kumar et al., 2013; Tran, Holly, Lashbrook, & Amsterdam, 2001; Streeter et al., 2010).

While research has found ample benefits of practicing thermoneutral hatha yoga, very little research has been conducted on the benefits and variances of hot yoga. Hot yoga is a trending and emerging form of yoga that is practiced in a heated, to 95 ℉ or warmer, and sometimes humidified room. Hot yoga studios are becoming prominent, and often make marketing claims that yoga practiced in the heat generates greater benefits than yoga practiced in a thermoneutral environment. Benefits commonly believed, or marketed, as deriving more from hot yoga than thermoneutral yoga include greater flexibility, greater cardiovascular benefits, and increased ability to release toxins (Bikram Yoga, 2014). Support for these allegations remains unknown, as there is an absence of empirically observed research.

Purpose of the Study

There is ample research regarding practicing thermoneutral hatha yoga, yet there is very little research that currently exists on hot hatha yoga. To my knowledge there is no scientific research conducted on the variances between the two forms of yoga. Therefore it is the purpose of this study to compare the physiological and mood differences produced from practicing a single bout of both thermoneutral and hot yoga.

Hypotheses

H_1: Yogis will have significantly higher average heart rate and sweat rate during the hot yoga class than the thermoneutral yoga class.

H_2: Yogis will have greater flexibility following the hot yoga class than the thermoneutral yoga class.

H_3: Yogis will have significantly better mood state following the thermoneutral yoga class than the hot yoga class.

Operational Definitions

Thermoneutral – the range of ambient temperatures without regulatory changes in metabolic heat production or evaporative heat loss. Thermoneutral zone varies individually, for the purpose of this study thermoneutral environment will be 70° - 72°F.

Hatha yoga – a yoga system of physical exercises and breath control.

Hot yoga – hatha yoga practiced in an environment ≥ 95 °F.

Yogis – experienced yoga practitioners who completed 20, or more, one-hour yoga sessions.

Mood state – scales on mood from the scientifically-validated Exercise-Induced Feeling Inventory (EIFI).

Assumptions

Assumptions for this study include the honesty of participants answering truthfully as being an experienced yogi. It is assumed that the participation in all of the testing will be unbiased and each participant will do their best in the flexibility and mood assessments following both the thermoneutral and hot yoga classes.

Limitations

Limitations for this study included the validity and reliability of participants self-reporting honestly as being an experienced yogi. The mood test was a limitation because of the varying moods participants may have during test days, as well as honestly self-reporting their mood states. The heart rate monitors were also a limitation due to the fact that the dynamic movement of the yoga class led to missing heart rate data. Another limitation was the thermoregulation capability of the yoga studio to exactly 70°-72°F and 95°F.

Delimitations

Delimitations of this study included that the study only comprised of participants from the Fayetteville, Arkansas area. Another delimitation was the short duration of the study and assessing physiological and mood changes following single bouts of each yoga intervention. Modulating factors like energy expenditure, heat production, skin blood flow, clothing, age, and body composition are delimitations as they can influence the thermoneutral zone. In addition, menstrual cycle was a delimitation as it can influence mood. This study only included physically healthy female participants as indicated by a consent form, PAR-Q and You physical activity readiness questionnaire, and health history questionnaire prior to the yoga intervention (ACSM, 2014).

Review of Literature

From the multiple types of yoga practices, hatha yoga remains the most prevalently researched. Tran et al. (2001) found increases in handgrip strength, muscular endurance, flexibility, and maximal oxygen uptake in healthy adults after an 8-week yoga intervention. Increases in cognitive function, mental performance, exercise adherence, and mindful-eating behaviors have also been correlated to hatha yoga (Bryan et al., 2013; Martin, et al., 2013). In addition, hatha yoga has been shown to elicit reductions in anxiety, depression, stress, sleep disturbance, and mood disturbance. A 12-week hatha yoga intervention was associated with greater improvements in mood due to the increases in γ-Aminobutyric acid (GABA)-ergic activity (Streeter et al., 2010). GABA is an acid in the body that when reduced is associated with mood and anxiety disorders. Also, due to its gentle approach, hatha yoga is a promising form of exercise for individuals who are unable to engage in high-impact, strenuous activities (Satin et al., 2013). People suffering from injury, cancer, or any other debilitating conditions are able to engage in yoga because of the wide range of postures encompassing various ranges of motion and wide variety of intensities. Recently, yoga has been investigated as a possible adjunct therapy for cancer patients and survivors due to the fact that it is a low risk activity, requires little to no equipment, and has been shown to present numerous physical and psychological benefits (Littman, Bertman, & Cebellos, 2012). Yoga techniques have been found to increase natural killer cells (Kochupillai et al., 2005), lower blood lactate levels, boost antioxidant defense mechanisms (Sharma et al., 2003), induce relaxation, lower anxiety (Kumar et al., 2013), enhance beta, or high frequency, waves on electrocardiograms suggesting a significant

implication of relaxed alertness (Bhata et al., 2003), and also increase the ability to alter gene expression by up-regulation of anti-apoptotic genes and pro-survival genes (Sharma et al., 2008).

Research surrounding the benefits of hot yoga is limited, but growing. In a study that examined the before and after effects of an eight-week Bikram yoga intervention, or hot yoga intervention, yoga subjects exhibited similar benefits compared to those found deriving from thermoenutral yoga. Bikram yoga participants showed increases in deadlift strength, lower back and hamstring flexibility, and decreased body fat (Tracey & Hart, 2013). While currently the research regarding the benefits of hot yoga is insufficient, it is well known that exercising in the heat has physiological costs. For example, impaired working efficiency and fatigue are consequences of prolonged exercise in heat stress. The cause of impairment is due to cerebral changes, like reduced neural drive and cerebral blood flow (Radakovic et al., 2007). Acclimation to heat also impacts a person's ability to perform certain tasks during and after heat strain. According to Armstrong and Maresh (1991), acclimatization to heat requires gradually increasing the duration and intensity of exercise during an initial 10–14 days of heat exposure, while maximal acclimatization can take up to 12 weeks. In a study that tested the effects of heat acclimation on cognitive performance in soldiers during exertional heat stress, mild deficits in attention were shown by a fall in the percentage of correct cognitive responses, as well as a delay in movement responses (Radakovic et al., 2007). The same study found that unacclimatized soldiers experienced weakness, fatigue, and physical pain during the heat testing and urged to terminate the test, whereas acclimatized soldiers did not approach the same levels of discomfort and therefore could withstand the heat testing (Radakovic et al., 2007). Acclimation to heat prior to participating in a hot yoga class is particularly important for the health and safety of

practitioners. The question then remains unanswered as to which form of yoga, hot or thermoneutral, reaps greater benefits for health, flexibility, and fitness, and also how they differ. Hagins, Moore, and Rundle (2007) examined whether hatha yoga in a thermoneutral environment satisfies the recommendations for intensity of physical activity to improve and maintain health and cardiovascular fitness. They observed maximal oxygen uptake, heart rate, metabolic equivalents, and energy expenditure in 20 yoga practitioners during a beginner-level hatha yoga class. It was found that the metabolic costs of an hour-long session of hatha yoga averaged as equivalent to walking on a treadmill at 1.98 mph which is roughly 2.0 METS. This does not meet the American College of Sports Medicine (ACSM) recommended level of physical activity, walking at least 3.0 to 4.5 mph for 30 to 60 minutes, for improving or maintaining health and cardiovascular fitness (ACSM, 2014). However, Pate and Buono (2014) found that a standardized Bikram yoga class had an average intensity of 2.73 METS with certain postures equivalent to moderate intensity of 3.0-<6 METS (Pate & Buono, 2014). This meets requirements for exercise of light-to-moderate intensity and could be used for weight management or weight loss if practiced regularly. While hot yoga is generally known to have a class structure that is more intense, other studies examining cardiovascular benefits during thermoneutral hatha yoga have found that it too can meet the physical activity requirements for improving or maintaining health. In a study that measured cardiorespiratory and metabolic responses in experienced yoga practitioners during a 30-minute thermoneutral yoga class, participants averaged 80 % of their age-predicted maximal heart rate during the yoga class, which is enough to maintain or improve cardiorespiratory fitness, as well as promote weight management (Mody, 2010). Thus, increased experience in the yoga practice, class structure, and

the choice of poses taught are how a yoga instructor can make a class intense and cardiovascular based, or modified for a less intense, stretching approach. While there is ample research regarding practicing thermoneutral hatha yoga, there is very little research that currently exists on hot hatha yoga. To my knowledge there is no scientific research conducted on the variances between the two forms of yoga. Therefore it is the purpose of this study to compare the physiological and mood differences produced from practicing a single bout of both thermoneutral and hot yoga.

Methodology

Research Design

This study used a quasi-experimental approach and repeated measures design to compare heart rate, sweat rate, flexibility, and mood state between a single bout of hot yoga and a single bout of thermoneutral yoga.

Subjects

Participants included 15 experienced yogis from the Fayetteville, Arkansas area. Participants were selected using convenience sampling. The participants were all experienced female yogis with an average age range 24.5 years old, as this is the primary demographic of yoga practitioners in the United States (Quilty et al., 2013). Average height of the participants was 156.46 cm and average weight was 63.01 kg. To be included in this study each participant was female, an experienced yogi, and physically healthy, as determined by the health history questionnaire and PAR-Q and You physical activity readiness questionnaire. Each participant was also unacclimatized to the heat, meaning they were not habitual hot yoga practitioners. To be included in this study, participants did not practice hot yoga more than three times a week for a total of eight weeks, and did not participate in any hot yoga classes within 10 days of the trial (Armstrong & Maresh, 1991; Tracey & Hart, 2013). The researcher obtained appropriate human subjects approval from the University of Arkansas Institutional Review Board (IRB) prior to the study. Written consent was obtained from each participant prior to her participation in the study.

Measures

Demographic. Participants completed a questionnaire regarding age and yogi status (i.e. experienced or non-experienced, hot or thermoneautral). The primary investigator took baseline weight to the nearest 0.1kg and height to the nearest 0.1cm for each participant.

Heart Rate. Each participant's heart rate was measured during both the thermoneutral and hot yoga interventions using the Timex Ironman Run Trainer 2.0 watch and the ANT+™ heart rate sensors. Heart rate was recorded in beats per minute and in intervals of five minutes during the entire hour of both yoga classes. Heart rate records were uploaded and stored in a private folder on the principal researchers computer using the Training Peak online application.

Sweat Rate. Sweat rate was attained by analyzing body mass change as a percent reduction in body weight, as described by an equation (equation 1) by the guidelines provided by the American College of Sports Medicine (ACSM, 2014).

[(Pre-ex body mass - Post-ex body mass) + fluid consumed during ex]/ ex duration

(1)

Nude weight was taken pre-to post-yoga class for both the thermoneutral and hot yoga classes. Hydration was measured using the urine specific gravity test and Master-SUR/NM Manual Refractometer as a way to insure the each participant was properly hydrated before they were allowed to participate in the study.

Flexibility. Flexibility of the hamstrings and lower back was measured at baseline using the sit-and-reach test as used by James and Goodman (2013). The sit-and-reach test followed the procedures from the ACSM (2014) guidelines. Instruments used for this test required a

flexometer and data recording forms. Subjects removed their shoes and sat on the floor, legs together and extended out straight. The subject's feet were firmly pressed against the flexometer box and knees remained straight. The subject extended their arms out in front of them, one hand placed directly on top of the other with the middle fingers lined up. The subject began to lean forward, reaching their hands over the box to slide the flexometer gauge as far as they could. The subject held their maximal distance for a minimum of two seconds. The test was repeated three times and the highest score recorded. For best results, the participant exhaled and dropped their head between their arms when reaching forward (Pescatello, Arena, Riebe, & Thompson, 2014). The sit-and-reach test is easy to administer, time and cost efficient, and does not require a laboratory setting for implementation. The sit-and-reach test is one of the oldest field tests for predicting flexibility and has been found to have acceptable test-retest reliability and moderate validity (Ayala, Baranda, Croix, & Santonja, 2012). The reliability of the sit-and-reach test ranges from .70 to .98, while the validity of the sit-and-reach test varies (Beam & Adams, 2014). For example, validity of the sit-and-reach test is more valid in terms of hamstring flexibility than lower back flexibility (Beam & Adams, 2014). The validity of the sit-and-reach test ranges from .39 to .58 in terms of hamstring criterion, where as the validity ranges from .15 to .42 for lower back flexibility criterion (Beam & Adams, 2014).

Mood State. Mood state was measured with a reliable and valid psychologic scale selected to monitor the effects of the yoga interventions on mood. Mood was assessed with the Exercise-Induced Feeling Inventory (EIFI), which has four subscales: Positive Engagement, Revitalization, Tranquility, and Physical Exhaustion that encompass a total of 12 questions (Gauvin & Rejeski, 1993). Mood state was measured using the EIFI questionnaire at baseline

and pre and post both yoga interventions. EIFI is easy to administer, time and cost efficient, and does not require a laboratory setting for implementation to evaluate mood. In addition to the EIFI survey, perception of workload was measured at the end of each yoga intervention using the Borg Rating of Perceived Exertion Scale (R.P.E.) and the NASA Task Loading index (ACSM, 2014; Hart & Staveland, 1988).

Procedures

Consent was obtained from each participant during a brief familiarization meeting that also included each participant completing a health history questionnaire and the PAR-Q and You physical activity readiness questionnaire (ACSM, 2014). Prior to baseline testing, participants completed a written demographic form including age, height, weight, and yogi status. Baseline testing of flexibility was assessed using the sit-and-reach test. Mood state was assessed using the EIFI questionnaire. Heart rate was measured using the Timex Ironman Run Trainer 2.0 watch and the ANT+™ heart rate sensors. The principal researcher assigned each participant to both a 60-minute hot yoga class and a 60-minute thermoneutral yoga class. A randomized testing order was applied to decide which yoga class, thermoneutral or hot, each participant would take first. To control for residual effects, there was a seven-day rest period in between testing days and participants were asked to refrain from taking part in or practicing yoga 48 hours prior to testing.

Assessment and intervention took place at Trailside Yoga Studio and Beyond located in Fayetteville, Arkansas that had the capability to heat to 95 °F or warmer, and also remain thermoneutral at 70-72 °F. Studio temperatures were set prior to each yoga intervention and measured using a handheld Wet Bulb Globe Temperature (WBGT). To confirm that participants were well hydrated, they were asked to drink one liter of water two hours prior to the study, 16-

20 ounces of water one hour prior to each yoga intervention, and 8-12 ounces of water 15 minutes prior to the interventions (Simpson & Howard, 2011). Urine samples were collected and tested using the urine specific gravity test and a manual refractometer to ensure each participant was hydrated. Yoga participants arrived to the studio prior to the yoga intervention to take baseline measures of the EIFI questionnaire, weight, and flexibility. The researcher provided an EIFI survey and pen for each participant to take the mood state test, a standardized and calibrated scale to measure weight, and a sit-and-reach box to measure flexibility. The data was recorded using data recording forms. Each participant was given 16 ounces of water to drink during the class. Water consumption was measured and recorded at the end of class as part of the sweat rate equation. The Timex Ironman Run Trainer 2.0 watch and ANT+™ heart rate sensors were placed on the participant prior to the beginning of each yoga class. Heart rate was monitored and recorded in five-minute intervals in beats per minute for the entire hour of the yoga class. The principal researcher, a certified Yoga Alliance 200 hour yoga instructor, taught both the hot and thermoneutral yoga classes. Each yoga class consisted of a standardized class that consisted of the same poses that included 10 minutes of warm up poses, 30 minutes of power flow poses, 10 minutes for cool down poses, and 10 minutes for final relaxation. Power flow poses included many standing poses, as these poses evoke increases in cardiovascular response (Miles, Chou, Lin, Hunter, Dhindsa, Nualnim, & Tanaka, 2013). Immediately following both yoga sessions, each participant completed measurements for mood using EIFI, R.P.E., and NASA Task Loading Index, as well as flexibility, using the sit-and-reach test. Sweat rate was measured in an equation as a percent reduction in body mass. Heart rate records were uploaded in beats per minute using

the Training Peak online application. Participants returned no sooner than seven days for their next yoga trial and repeated the same measures and methodology again.

Data Analysis

The independent variables for this study included the hot yoga and thermoneutral yoga interventions. The dependent variables were the physiological and psychological responses that include sweat rate, heart rate, flexibility, and mood state. In order to assess the effects both yoga interventions have on sweat rate, heart rate, flexibility, and mood state, data were analyzed using the Statistical Package for the Social Sciences (SPSS) software. All data were reported anonymously or as group data with no specific identifying information. Demographic information was summarized using descriptive data. Hypotheses were tested using a dependent t-test and Repeated Measures of ANOVA comparing the baseline and post-yoga intervention scores. Statistical significance was be set at alpha = .05.

Results

Yoga participants were assigned to take both a hot and thermoeneutral yoga class. Each participant was randomly assigned to take either the hot yoga class or the thermoneutral yoga class first. Each yoga class, both the hot and thermoneutral classes, consisted of a standardized 60-minute yoga class that comprised of the same poses held approximately for the same amount of time. Studio temperatures were set prior to the beginning of each yoga class and checked at both the beginning and end of class. Studio temperatures varied by two degrees or less between trials (70.68 ± 2.00 for thermoneutral) (100.2 ± 0.76 for hot yoga). Mood, flexibility, and hydration were all measured prior to class beginning. All, but one, participants were well hydrated for their yoga trials (1.008 ± 0.01 for thermoneutral yoga) and (1.005 ± 0.005 for hot yoga). One participant was slightly dehydrated prior to her thermoneutral trial. In addition, heart rate monitors were placed on each participant prior to the start of class and were checked to make sure they were working properly. However, due to the dynamic movements of the yoga class, heart rates of many of the participants were not recorded for portions of the class. Thus heart rate at the five-minute mark, 60-minute mark, and average heart rate of the entire hour were reported from each yoga trial to compare results.

Flexibility. Figure one and two show lower back, trunk, and hamstring flexibility increased pre- to post-yoga for both the hot and thermoneutral yoga classes, however, there were no significant differences between the two classes. Flexibility deriving from the thermoneutral class did however, have an increase that was 10% greater than the hot yoga class (43.23 ± 4.77 vs. 43.10 ± 4.90). The average increase in flexibility pre- to post-thermoneutral yoga was 3.0 cm and 2.7 cm pre- to post-hot yoga.

Heart Rate. Average heart rate was significantly different between the hot yoga class and thermoneutral yoga class (p=0.002). Average heart rate was 11% higher in the hot yoga class when compared to participants' heart rate during the thermoneutral class (109.56 ± 4.037 vs. 98.94 ± 4.016).

Sweat Rate. Figure three shows sweat rate was significantly greater in the hot yoga class than in the thermoneutral yoga class (p=0.004). Sweat rate was 52% greater in the hot yoga class than in the thermoneutral yoga class (0.559 ± 0.143 L for hot yoga) (0.291 ± 0.249 L for thermoneutral yoga).

Mood. Mood was assessed pre- to post-hot yoga and pre-to post-themorneutral yoga on four subscales: positive engagement, revitalization, tranquility, and physical exhaustion. Positive engagement increased similarly, by an average of 17%, between the hot yoga class and thermoneutral yoga class (5.33 ± 2.024 and 6.33 ± 2.637 for hot yoga) (7.00 ± 2.420 and 8.53 ± 3.701 for thermoneutral yoga). Revitalization increased 49% following the hot yoga class and 42% following the thermoneutral yoga class (3.53 ± 2.900, 6.93 ± 3.081 for hot yoga) (4.53 ± 1.846, 7.80 ± 2.455 for thermoneutral yoga). Tranquility increased 39% following the hot yoga class and 51% following the thermoneutral yoga class (5.33 ± 2.160, 8.67 ± 3.169 for hot yoga) (4.80 ± 2.305, 9.80 ± 1.474 for thermoneutral yoga). Figure four shows physical exhaustion scores were different between hot yoga and thermoneutral yoga. Physical exhaustion scores decreased by 16% pre-to post-thermoneutral yoga and increased by 31% pre-to post-hot yoga (3.47 ± 2.924, 3.00 ± 1.604 for themoneutral yoga) (3.67 ± 2.968, 5.33 ± 2.968 for hot yoga). Rate of perceived exertion (R.P.E.) scores were significantly different in the hot yoga class when compared to the thermoneutral yoga class (p= 0.001). RPE was higher in the hot yoga class than

in the thermoneutral yoga class (15.27 ± 0.884 for hot yoga) and (13.07 ± 0.884 for thermoneutral yoga). NASA task loading scores were significantly different, (p=0.018), between hot yoga and themorneutral yoga (297.60 ± 55.458 for hot yoga) (231.47 ±55.986 for thermoneutral yoga).

Discussion

There is a considerable amount of research regarding the benefits and characteristics of thermoneutral yoga, however research is non-existent surrounding the benefits and variances of the increasingly popular hot yoga. Therefore, it was the purpose of this exploratory study to compare the effects of a single bout of hot yoga and a single bout of thermoneutral yoga on flexibility, heart rate, sweat rate, and mood in 15 experienced yoga practitioners. Flexibility, heart rate, sweat rate, and mood all increased pre- to post both the hot yoga and thermoneutral yoga classes, however the variables between the two forms of yoga were significantly different.

Flexibility scores of the trunk, lower back, and hamstrings, as measured by the sit-and-reach test, increased significantly in both the hot yoga class and thermoneutral yoga class. However, yoga participants' flexibility increased 10% more in the thermoneutral yoga class when compared to their scores deriving from the hot yoga class. This is contrary to the general belief, and a hypothesis of this study, that hot yoga yields greater flexibility than thermoneutral yoga (Bikram, 2014). While the poses during each yoga class in this study were standardized, timed, and monitored for length of hold, and yoga practitioners were encouraged to exert the same amount of effort in both the hot and thermoneutral yoga class, participants reported applying more effort in the hot yoga class when compared to the thermoneutral yoga class. While it is common for yoga instructors to encourage participants to abide by and attempt to perform the exact cues for each posture given in class, it is also customary to encourage participants to expend the amount of energy and effort in each pose that they can in that moment. Thus the amount effort put towards a posture and length of hold can vary from class to class, even if the classes are standardized to be the same. The participants' scores from the NASA

Task Loading Index indicate that perceived amount of effort was much greater in the hot yoga class than in the thermoneutral yoga class. Therefore, the slightly greater increase in flexibility following the thermoneutral yoga class may have been due to the fact the perceived amount of effort required to hold and relax in to the poses was lower when compared to the hot yoga class. Participants may have prolonged flexion and extension of the yoga poses, or were able to fully embody the yoga poses more successfully in the thermoeneutral yoga class because the effort required to complete the thermoeneutral yoga practice was lower. Rather, during the hot yoga class participants might have been more resistant, tense, and flowed rapidly in and out of the poses because perception of effort was greater.

Average heart rate was 11% greater in the hot yoga class than in the thermoneutral yoga class. This may have been a result of the hot yoga classes being significantly hotter, by an average of six degrees Fahrenheit, than the thermoneutral yoga classes. This is similar to previous findings that found physiological workload is greater when exercising under heat stress (Radakovic et al., 2007). Also, each yoga participant was unacclimatized to practicing yoga in the heat and therefore may have been an additional factor for a higher average heart rate during the hot yoga class.

Sweat rate increased in both the hot and thermoneutral yoga classes but was significantly greater, by 52%, during the hot yoga class. Average studio temperatures and humidity were significantly greater during the hot yoga classes than in the thermoneutral yoga classes, which is similar to previous findings that found exercise under heat stress and humidity leads to greater skin blood flow and sweat rate (Roberts & Wengner, 1979). The hot yoga class had an average

temperature of 100.2° F and 45.3%, humidity, while the thermoneutral yoga class had an average 71.2° F and 39.3% humidity.

Mood scores improved significantly following both the thermoneutral and hot yoga classes. This is consistent with other findings that find yoga practice enhances mood (Streeter et al., 2010). Positive engagement, revitalization, and tranquility were all increased following both forms of yoga, however, scores for physical exhaustion had varying outcomes. Interestingly, while physical exhaustion increased pre- to post-hot yoga, physical exhaustion scores decreased pre- to post-thermoneutral yoga. Yoga participants reported feeling more physically exhausted after practicing hot yoga, and less physically exhausted following the thermoneutral yoga class. Previous findings are similar in that prolonged exercise in the heat yields impaired working efficiency and fatigue (Radakovic et al., 2007). Physical exhaustion deriving from hot yoga could also be in part due to the fact that yoga participants' average rate of perceived exertion was 15% greater following the hot yoga class when compared to the thermoneutral yoga class.

There is a considerable amount of evidence that yoga has the efficacy to aid healing of the mind and body. Studies show yoga elicits increases in handgrip strength, muscular endurance, flexibility, maximal oxygen uptake, cognitive function, mental performance, exercise adherence, and mindful-eating behaviors (Bryan et al., 2013; Martin, et al., 2013; Tran et al., 2001). In addition, yoga has been shown to elicit reductions in anxiety, depression, stress, and mood disturbance (Kumar et al., 2013; Sharma et al., 2003; Streeter et al., 2013). While there is sufficient research regarding the benefits and characteristics of yoga practiced in a thermoneutral environment, there is minimal literature that exists on hot yoga, or yoga practiced in a heated environment.

Future research on the various types of yoga practiced is important to expand the knowledge of, and better define, which yoga practice yields greater health outcomes. Prospective research should further examine the physiological and mood responses deriving from hot yoga, in addition to examining the differences between hot yoga and thermoneutral yoga over a longer period of time. In addition, as acclimation to heat can alter a person's physical and mental responses to exercising under heat stress, future studies should include acclimatized hot yoga practitioners when examining the physiological and mood responses of yoga.

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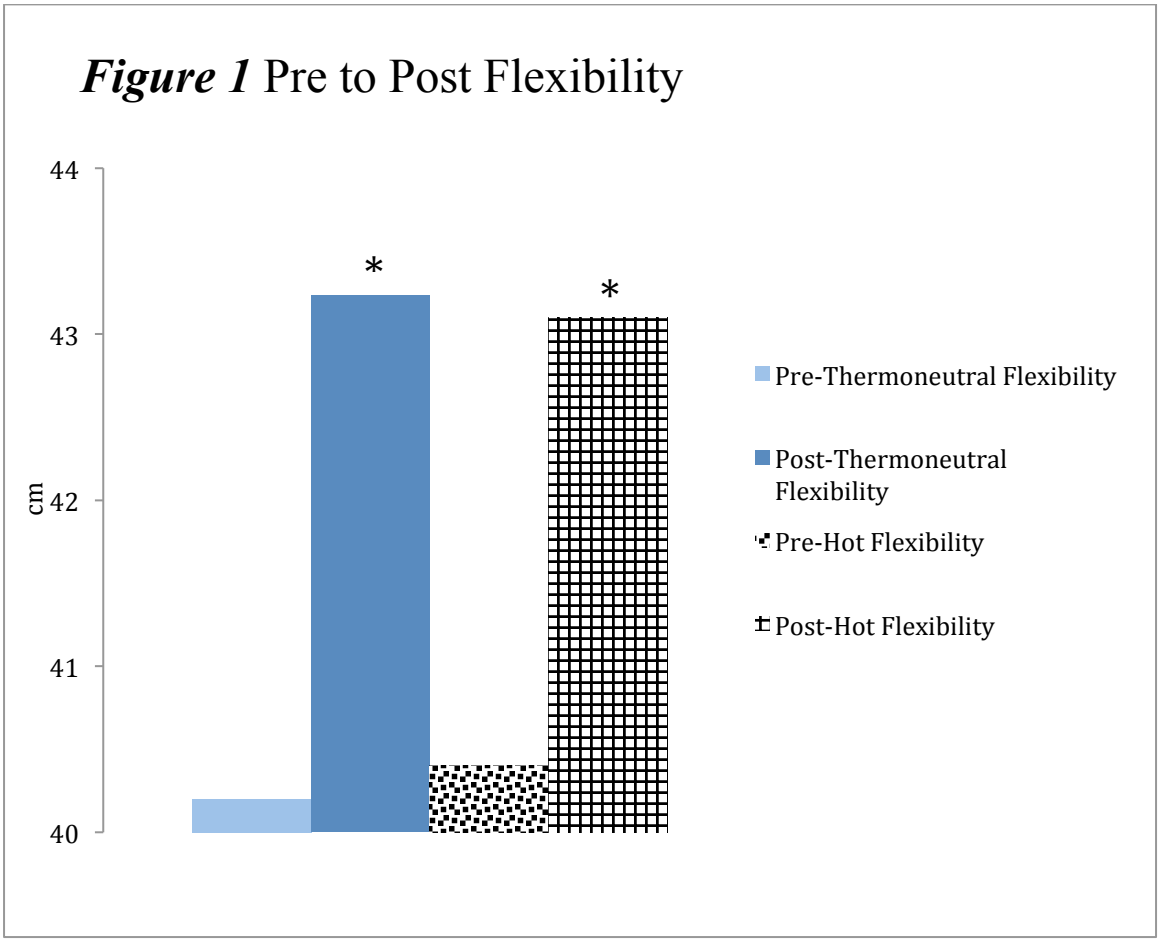
Figure 1 Pre to Post Flexibility



Firgure 2 Post Flexibility

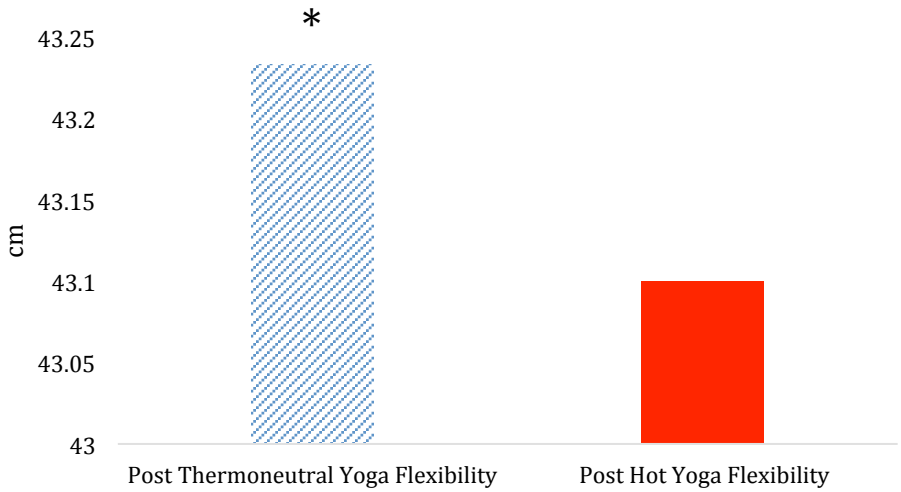


Figure 3 Sweat Rate

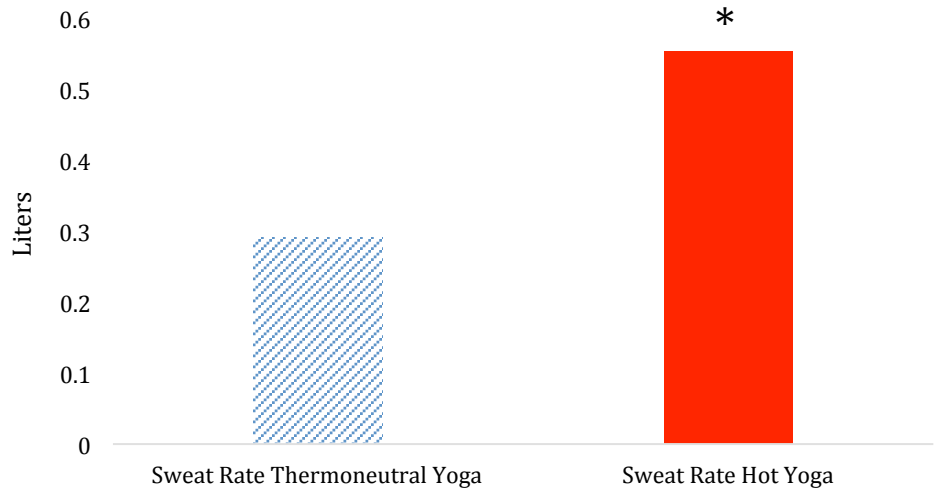


Figure 4 Physical Exhaustion

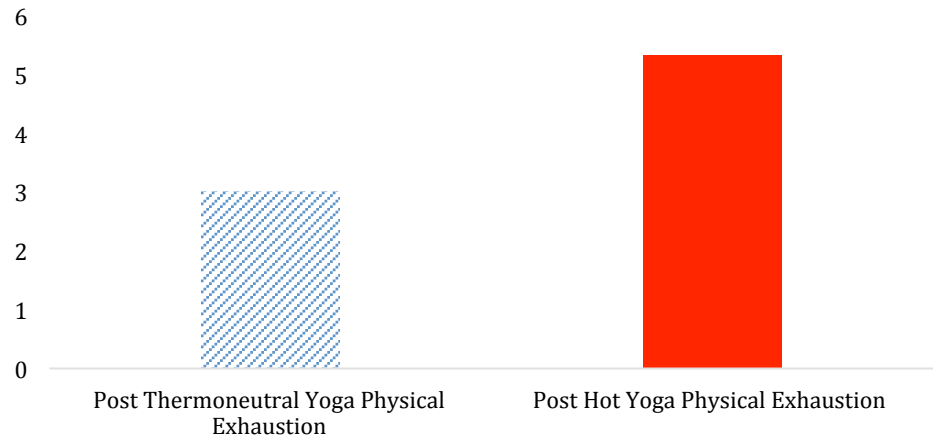


Figure 5 Heart Rate

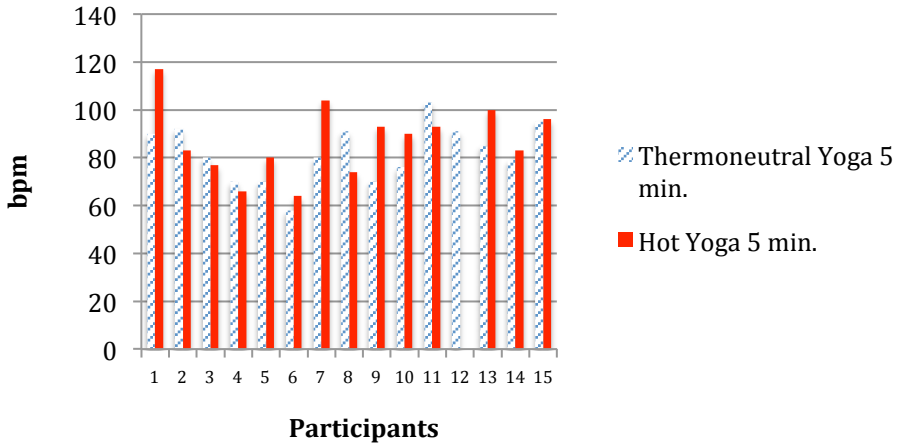


Figure 6 Heart Rate

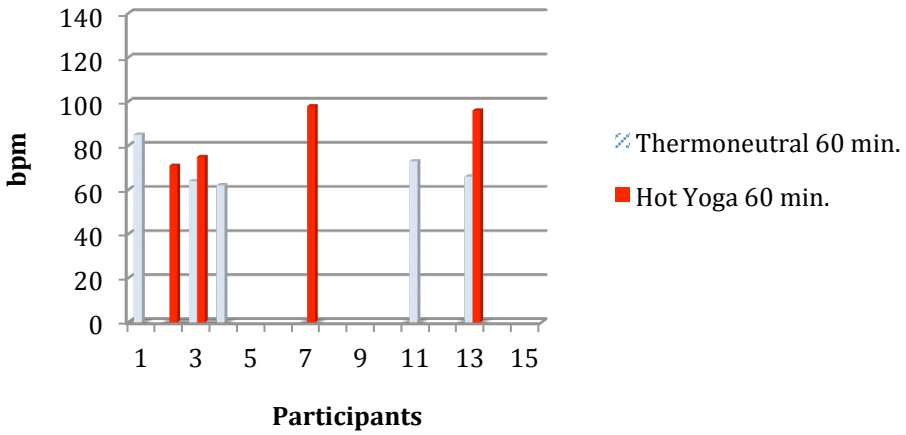
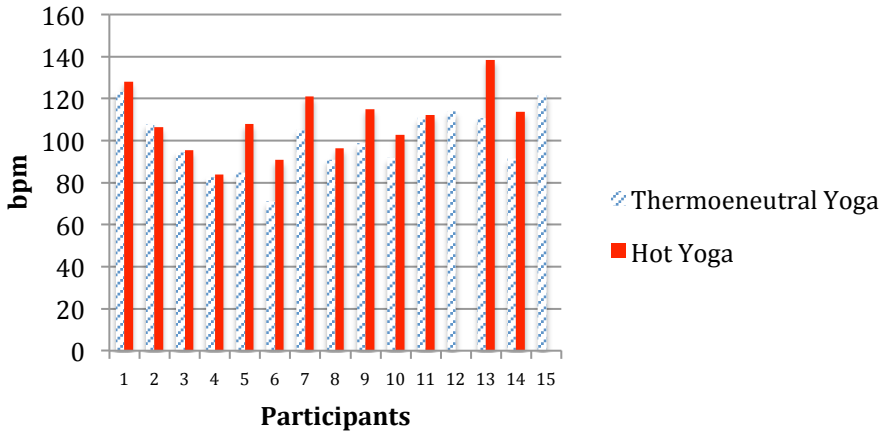


Figure 7 Average Heart Rate



UNIVERSITY OF ARKANSAS

Office of Research Compliance
Institutional Review Board

April 9, 2015

MEMORANDUM

TO:	Hannah Campbell Michelle Gray
FROM:	Ro Windwalker IRB Coordinator
RE:	New Protocol Approval
IRB Protocol #:	15-03-589
Protocol Title:	*The Comparative Effects of Hot Yoga and Thermoneutral Yoga on Flexibility, Heart Rate, Sweat Rate, and Mood*
Review Type:	☐ EXEMPT ☒ EXPEDITED ☐ FULL IRB
Approved Project Period:	Start Date: 04/09/2015 Expiration Date: 03/31/2016

Your protocol has been approved by the IRB. Protocols are approved for a maximum period of one year. If you wish to continue the project past the approved project period (see above), you must submit a request, using the form *Continuing Review for IRB Approved Projects*, prior to the expiration date. This form is available from the IRB Coordinator or on the Research Compliance website (https://vpred.uark.edu/units/rscp/index.php). As a courtesy, you will be sent a reminder two months in advance of that date. However, failure to receive a reminder does not negate your obligation to make the request in sufficient time for review and approval. Federal regulations prohibit retroactive approval of continuation. Failure to receive approval to continue the project prior to the expiration date will result in Termination of the protocol approval. The IRB Coordinator can give you guidance on submission times.

This protocol has been approved for 60 participants. If you wish to make *any* modifications in the approved protocol, including enrolling more than this number, you must seek approval *prior to* implementing those changes. All modifications should be requested in writing (email is acceptable) and must provide sufficient detail to assess the impact of the change.

If you have questions or need any assistance from the IRB, please contact me at 109 MLKG Building, 5-2208, or irb@uark.edu.