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The effects of type of yoga training on physiological and psychological fitness in college aged men and women.

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By

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Abstract

Yoga has become a popular alternative to traditional exercise regimes and many therapies to enhance physical and psychological well-being. Many yoga studios and health clubs now offer hot yoga in addition to regular yoga where the room temperature is elevated before the yoga practice begins. There are many anecdotal benefits to practicing hot yoga but any physiological adaptations have yet to be documented in the scientific literature. Novice and beginner yoga practitioners, 10 males and 21 females, aged 19–33 years were randomized to either an 8 week trial of Hatha yoga performed under normal temperatures (n=15) or hot yoga (n=16). For the normal temperature yoga and hot yoga, 3 and 4 participants, respectively, were lost to drop out. All participants attended 80 minute yoga classes at a local studio 3 times per week and several physiological and psychological outcomes were evaluated at baseline, at 4 weeks, and at the end of trial, including: body mass index (BMI), body composition (BF%), systolic and diastolic blood pressure (SBP, DBP), flexibility, peak oxygen consumption, Beck Depression Inventory, and State Trait Anxiety Inventory. Participants' heart rates and temperatures were monitored during weekly yoga classes to assess cardiovascular intensity of yoga as exercise.

Hot yoga participants worked at a significantly higher cardiovascular intensity (61.0±2.0 versus 48.2±1.8 percent of their maximum recorded HR respectively, $p<0.05$). Further, participants in the hot yoga group spent more time at greater than 60%, 70% and 80% of their maximum heart rate throughout the exercise period ($p<0.05$). For all training groups, improvements were seen in body composition and flexibility, but there were no differences between groups. Further, mean SBP decreased by 5.8 ±12.5 mmHg after 4 weeks of yoga training and remained reduced at the end of 8 weeks ($p<0.05$). There was a significant improvement in trait anxiety levels and depression scores. These observations suggest that there are no additional psychological or physiological benefits gained by hot yoga training, but more importantly, there are several health benefits of engaging in regular yoga practice.

Dedication

I would like to dedicate this thesis document to my brother, Adrian, and parents, Kristin, Pat, Kelly, and Ted, who always follow their dreams and expect me to do the same. Thank you for all of your love.

To my second family, the Pastorius', my roommates Raeleen Hunter and Krista Seguin, and the HK Grad students. You fed, housed and clothed me over the past two years. Thank you for keeping me sane when the heat got too intense!

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Table of Contents

List of Tables

List of Figures

List of Appendices

Chapter 1

1.1 A brief history of yoga

Yoga is an ancient Indian practice that has been dated back to 2500 BCE. The first written records of the practice include Patanjali's *Yoga Sutras,* written in approximately 400 CE, describing the philosophy of yoga. Originally used to purify the mind and improve endurance of physical hardships to realize "Atman", or one's true self (108), the sutras say nothing of body twisting or stretching during meditation. A book entitled *Hatha Yoga Padipika*, written in 1400 CE by Svatmarama, describes fifteen postures and many techniques used currently in Western yoga practice (107). Thus, modern day yoga is seen as a discipline of both body and mind. Hatha yoga is the origin of most of the current styles practiced in North America (16). This type of yoga is less involved with the religious philosophy and is centred mostly on postures, breathing, and drills meant to strengthen the body and mind.

The early claims made of yoga practice range from the commonplace to the miraculous. In *Hatha Yoga Padipika* it is stated that practitioners of yoga can relieve constipation, neutralize poisons, destroy all diseases, obviate evil, and achieve immortality (107). While these assertions may sound extravagant, it is interesting to note that regular exercise training is associated with a reduced risk for most chronic diseases, including cardiovascular disease (CVD), metabolic syndrome and diabetes (67; 81), osteoperosis (115) and some cancers (2; 13). Further, regular exercise has been shown to reduce ratings of depression (7; 14) and more fit individuals have reduced risk of early mortality (31; 68). Similarly, regular yoga practice not only increases flexibility, muscular strength, and muscular endurance (57; 113), but can be used as a potential treatment for many disorders including, back pain (105), menopause (22; 94) schizophrenia (36), and type II diabetes (72). Moreover, used in place of traditional exercise rehabilitation, yoga confers similar improvements in cardiovascular and skeletal muscle functioning (37; 96).

The early claims that yoga creates a connection between body and mind are also reflected in modern-day science. Physical activity is associated with general improvements in mood and anxiety And increasing involvement in aerobic exercise or strength training reduces the risk of developing depression (39; 99) . In fact, a possible dose response relationship of exercise in the treatment of major depression exists. Dunn et al. (2005) showed that a dose of aerobic exercise consistent with public health recommendations was an effective treatment for mild to moderate depression and a lower dose was comparable to placebo with no differences between 3 and 5 weekly sessions (35). Although yoga does not meet the current guidelines for aerobic physical activity, its practice has been shown to improve mood and anxiety levels more than metabolically matched walking exercise in healthy women in their mid-twenties (110). This may be related to the spiritual philosophy of the practice, since a meta-analysis of mindfulness based therapy suggests that adding regular meditation to the treatment of major depression improves therapy outcomes (19). Further, Smith et al. (2011) found that yoga classes with integral ethical and spiritual components provided additional mental health benefits over yoga practiced only as an exercise regime (109).

1.2 Yoga in society today

The use of yoga as exercise has been and is growing in popularity in North America. In 2008, 15.8 million people practiced yoga in the US, spending almost 6 billion dollars on yoga classes, clothing, and equipment (48). It was forecast that expenditures will grow to 6.8 billion at the end of 2012 and be an estimated 8.6 billion by 2017 (104). Given that yoga is undoubtedly taking the place of other daily physical activities for many, it should be assessed to determine its health benefits in its varied forms. In two recent meta-analyses on aerobic exercise and cardiovascular (118) or metabolic (20) health improvement, the median length of typical exercise programs was noted as 12 weeks and a minimum of 8 weeks, respectively. Studies exploring the benefits of yoga with adults have used 6-24 week protocols (76), with classes ranging from 2-3 times weekly, duration 60-90 minute. Thus, yoga training regimens are typically consistent with aerobic type activity. Nonetheless, yoga is not typically classified as aerobic activity. Hagins *et al.* (2007) determined that the averaged metabolic costs across the entire Hatha yoga session represent low levels of physical activity, similar to walking on a treadmill at 3.2 kilometers per hour (kph)(47). This does not meet recommended levels of physical activity for improving or maintaining health or cardiovascular fitness as prescribed by either the Canadian Society of Exercise Physiologists (CSEP) or American College of Sports Medicine (ACSM). Further, much of the research involving yoga has focused on disease and illness recovery or relief (97). Despite the popular perception that yoga is exercise, the information from the published yoga research is not easily generalized to a healthy population.

1.3 Exercise intensity and health

Intensity appears to be very important when considering exercise for cardiovascular health. The higher the exercise intensity, the greater the benefits in all cases (30; 73; 88; 116). It is not surprising then that studies have found a significant inverse dose-response relationship between physical activity and all-cause mortality in men and women, such that the greater the intensity and duration of physical activity undertaken, the lower the rate of disease and mortality among participants (31; 119; 120). An intriguing dichotomy exists between low intensity calming exercise that can have dramatic effects on mood and health (i.e. yoga) and high intensity strenuous exercise that maximizes adaptations, but also risks adverse events. High intensity exercise can exacerbate underlying health issues that may have been previously undiagnosed, which in extreme cases, can lead to death (25). Less serious consequences of high intensity exercise such as musculoskeletal injury (e.g. strained muscle, stress fracture) or soft tissue injury (e.g. blisters) are prevalent and can be a deterrent for beginners who are interested in becoming more physically active (114). Yoga seems to draw novice and veteran exercisers alike, but unfortunately it has not been shown in the literature to provide cardiovascular improvements similar to higher intensity physical activity.

1.4 Introduction to hot yoga

A new branch of Hatha yoga was created in the 1970's (34) that involves similar poses, but is practiced at elevated room temperatures (typically up to 40^{o}C). Bikram Choudhury, a yogi to the Hollywood stars, claims to have introduced this more challenging yoga practice to North America and consequently it has been referred to as Bikram yoga. Other, less strict forms with less intense heat requirements are practiced in studios around North America commonly called Moksha yoga or simply hot yoga. Many yoga studios and health clubs offer hot yoga in addition to regular yoga where the room temperature is raised before the yoga practice begins and subsequently gets hotter as the practitioners body heat from the physical activity contributes to room temperature. However, several media outlets have labeled hot yoga as a more “dangerous” form of exercise, citing increased risks of injury, heart complications and disruption to the meditative practice of yoga as possible deterrents (10; 95). It is important to note that the adverse events purported to be associated with hot yoga are undocumented, and ACSM recommendations for exercise and heat are usually concerned with more intense exercise (see below).

1.5 Physiological responses to passive heating (acute responses)

Passive heating of the body stresses the cardiovascular system (CVS) differently than exercise. In an attempt to maintain an average temperature of approximately 37^{o}C wen an individual is exposed to passive heat, blood flow is redirected from central circulation to cutaneous circulation where heat can dissipate from the body core to the skin (29). This decreases central venous pressure, central blood volume and ultimately right-sided preload volume and right atrial pressure. Hence, there is competition between the need to maintain of blood pressure and the need to maintain adequate skin perfusion for heat exchange (27). Many studies have shown that orthostatic tolerance is greatly reduced when heat stress occurs (122; 123). As a consequence, cardiac output must increase to sustain sufficient whole body perfusion. This is accomplished by increased myocardial contractility in an effort to maintain stroke volume. Further, heart rate is increased by 40-90 beats per minute (bpm) with only 1^{o}C change in body temperature (28). As such, cardiac output can increase to upwards of 13 L/min (compared with rest at 5L/min) which, along with splanchnic and renal vasoconstriction, allows skin blood flow to reach levels as high as 8 L/min (100).

The cardiovascular stress of passive heating seems to mimic that of low intensity exercise. For example, during both exercise and external heat stress there is an increase in cardiac output (121). Although the challenge to maintain or elevate cardiac output occurs for additional reasons during exercise (i.e. muscle blood flow and thermoregulation) compared with heat stress (i.e. thermoregulation alone), there is still increased blood flow through large arteries (i.e. aorta, brachial and femoral arteries), which in turn increases shear stress in these vessels (64). Shear stress induces endothelial production and release of endogenous nitric oxide (NO) production and release in the endothelium (49; 111); a well-known contributor to healthy endothelial function and reduced blood pressure (58; 106). Moreover, passive heating with a resultant elevated core temperature decreases arterial stiffness (44). Consequently, physical activity and thermal therapy seem to affect similar pathways in improving at least one component of cardiovascular health.

1.6 Heat acclimation (chronic exposure to heat) and physiological adaptations

The body will adapt to regular heat stress just as it will adapt to accumulated bouts of physical activity. Passive heat acclimation induces a “training” effect including improvements in maximal oxygen consumption (a reliable measure of fitness) and exercise capacity/duration (11). Favourable adaptations occur in the heart such as lower resting HR (103), greater compliance (53) and increased stroke volume (103). Underlying these mechanical changes are the upregulation of genes associated with excitation–contraction coupling and calcium (Ca^{2+}) regulatory proteins leading to greater Ca^{2+} transients and increased contractile force (23; 84). Myocytes also develop a tolerance against ischemia. When reperfused after an insult, heat acclimated ventricular tissue has reduced signs of injury along with superior mechanical and metabolic performance compared with non-acclimated tissue (74; 75).

Other long-term changes associated with heat acclimation include increased plasma volume (86), enhanced endothelial (blood vessel) function (50), improved blood pressure (60), improved body composition (12), and increased insulin sensitivity (21; 45; 70). Because of these improvements, regular exposure to passive heat stress has been termed thermal therapy and is a novel homeopathic treatment used to treat patients with chronic heart failure (59) and individuals with diabetes (51). Similar to physical activity, thermal therapy is now being used to treat, rehabilitate, and improve the lives of patients. However, it should be noted that passive heating (e.g. Finnish sauna, hot baths, etc.) has been practiced recreationally for centuries to improve health (79).

1.7 The combination of heat and exercise

The combination of heat and vigorous exercise can have negative consequences and every year, heat exertion injuries and deaths are widely publicized. For example, during the 2007 Chicago marathon, 1 runner died and 49 others were hospitalized when the race occurred during an October heat wave (5). More recently, the 2012 Boston Marathon issued a heat advisory for their race because of unseasonably high temperatures (6). The race organizers even gave runners the unprecedented option of competing in the following year's event to avoid the potential adverse effects of exercise in the heat. Ambient temperature is often considered a limiting factor to maximal exertion (18) and is a significant risk factor for high intensity exercise (3) because of the added cardiovascular strain demanded to regulate body temperature. Not surprisingly, the ACSM position on exercise in the heat recommends that physical activity should be modified during higher environmental temperature by decreasing the duration and intensity of exercise and by removing clothing (3).

An immediate physiological response to physical activity includes increases in heart rate and contractility (117) and diversion of blood flow from the non-essential organs to the working muscle via vasoconstriction and vasodilation, respectively. In passive heating conditions, a similar increase in heart rate and redirection of blood flow occurs, but it is toward the skin. When combining external heat with exercise, increased demands are placed on the heart because both the skin and muscles compete for increased blood flow (43). Cardiovascular drift is the term used to describe the progressive increase in heart rate and decrease in stroke volume that begins after approximately ten minutes of moderate-intensity exercise, and is associated with decreased maximal oxygen uptake, particularly during heat stress (124). This increased heart rate reflects the increased relative cardiac and metabolic intensity during prolonged exercise in the heat (125).

Thus, it is likely that low intensity exercise performed in above room temperature conditions (e.g. in a warm room) would increase the cardiovascular demand of that exercise. Therefore, it is possible that the adaptations to the combined stresses would be comparable those observed under more intense exercise under normothermic conditions, and consequently, an individual would receive a greater health benefit for a lower intensity exercise. Although normal temperature Hatha yoga is not intense enough to be considered an aerobic activity, hot Hatha yoga may raise the cardiac intensity for the practitioner such that greater aerobic exercise benefits can be observed.

This is appealing for several reasons. High intensity exercise is often associated with increased forces on joints, greater muscle damage, and overall discomfort (38; 77). Eliminating the potential for these injuries, while maintaining a similar cardiovascular demand is a practical way of obtaining a higher dose of exercise without the usual drawbacks. Many North Americans struggle to meet the daily physical activity recommendations due to time constraints and lack of motivation and energy (26). Moreover, vigorous physical activity is associated with a lack of adherence to exercise prescription (93), likely because individuals find this type of exercise difficult or fatiguing. Combining passive heating and physical activity could provide extensive health benefits of a higher intensity exercise at a lower perceived intensity.

Secondly, while many of the physiological adaptations to heat stress are similar to those associated with exercise, they are not all the same. Consequently, benefits would be garnered from the adaptations of both exercise and heat. For example, one of the cardio-protective adaptations that occurs in the heart due to heat acclimation is the conversion of fast heavy chain myosin isoform (V1) to the slow heavy chain myosin isoform (V3) (55). This slow twitch fiber is said to be more metabolically efficient, producing less adenosine triphosphatase (ATPase), and delaying lactate production during ischemia (52). Therefore, in the event of a heart attack, the myocardium has an increased chance of recovery upon reperfusion. Conversely, there is a higher V1 myosin isoform concentration with increased myosin ATPase activity in adaptation to exercise (98; 102). Some studies have found that the V1 phenotype is associated with improved left ventricular dilation and function (1). These differences in exercise and passive heat adaptation suggest that each treatment could provide unique benefits and the interaction needs to be investigated further.

In rodents, Kodesh and Horowitz (2010) found that exercise training in combination with heat acclimation increased force generation in isolated skeletal muscles and contractile endurance (69). This adaptation was more than either of these stresses produced alone. They also noted many short and long term changes in gene expression important to immunity and protection, as well as metabolism and skeletal muscle composition, respectively. Horowitz and Kodesh (2010) concluded from their research that the combination of these two stressors did not simply induce an additive response, but instead created a dynamic scenario that requires further study (54).

Another positive physiological adaptation derived from both heat and exercise stress is the induction of heat shock proteins (HSPs). The highly studied Hsp70 (molecular weight is 70 kiloDaltons) is stress induced and otherwise not found in remarkable levels in unstressed cells, with few exceptions. The synthesis of Hsp70 is triggered by heat, elevated pH, cytokines, cell damage, adrenergic signaling, and oxidative stress; and therefore is synthesized under conditions of thermal and exercise stress (87). Intracellular Hsp70 is considered both anti-apoptotic and anti-oxidative (112). Thus, high levels of this protein induced by thermal therapy or moderate physical activity, can explain much of the cellular protection from other insults, such as environmental carcinogens (126) and myocardial infarction or ischemia-reperfusion injury (90). Moreover, the accumulation of Hsp70 in tissues has also been linked with improved insulin resistance (46).

A dose response in the synthesis of this protein is observed with increasing exercise intensity (82). A similar relationship exists with increasing passive heat stress (41). Recently, a study by Periard at al. (2012) suggested that the expression of Hsp70 during moderate and high intensity exercise in the heat may relate to the core temperature attained and rate of increase in core temperature during exercise (92).

This is consistent with recently published data from Milne et al. (2011) and suggests that one of the beneficial responses to exercise in the heat may be duration and intensity dependent (83). It is possible that the benefits provided by increased intracellular Hsp70 during higher intensity exercise may be mimicked by low intensity exercise at above average core temperatures. The possible benefits of low intensity exercise in the heat have not yet been examined; yoga provides a real-world venue to explore this interaction.

While much research has been conducted to examine the role of ambient temperature in heat exhaustion in humans (65; 66), the mechanisms underlying the physiological responses to combined exercise and heat acclimation have been derived primarily from animal experimentation. What can be gathered from the literature is that the interaction between these two stresses creates an unusual benefit in mammals and should be examined in humans. Research previously conducted in humans regarding the long-term "training" effects of exercising in the heat has been mostly concerned with elite athlete performance and enhancement (9; 33; 40). Although the purpose of this research was not to examine the consequences to general health, it is useful in showing that heat acclimation can occur in humans while exposed for brief (1 h) period to heat during exercise. Also, it is noted that additional physiological changes such as increases plasma volume occur when training in the heat (80), indicating that untrained participants may also receive additional benefits when exercising in hotter conditions.

1.8 Heat acclimation induction

As mentioned above, heat acclimation research has focused on athletes' responses to repeated heat stress. Protocols to induct heat acclimation often mimic training camp scenarios in which athletes are exposed to heat stress (approximately 40°C) during their workout for 6-14 days consecutively (42; 78; 85; 103). One study was designed to correspond to distance runners' tapering period in preparation for a 6 day, 243 km endurance race across the Sahara Desert (101). Although these protocols ensure heat acclimation induction, they are not practical or sustainable for those who are simply interested in using physical activity to improve their health. Armstrong et al. (2005) created a unique 7-8 week combined heat acclimation and physical training program for women to study the interaction of contraceptive use, heat stress and exercise training. College-age participants were heat acclimated by exercising 90 minutes a day, 3 days a week at an indoor temperature of 36-37°C (4).

1.9 Physiological changes due to exercise and heat: the effects of biological sex

In examining the combination of these two factors, it is interesting to note the sex differences in thermoregulation and exercise associated benefits. Because core temperature is modified by sex hormones, men and women may respond differently to this type of training. Women's core temperature fluctuates 0.5°C throughout the course of their menstrual cycle (62). This has been accredited to changing concentrations of progesterone, a sex hormone that is important to the luteal phase of the menstrual cycle but is also involved in thermoregulation (17). In fact, it appears that whereas estradiol will prevent increases in body temperature, progesterone will exacerbate them (71). There is also sexual dimorphism in physiological heat dissipation mechanisms. Men have a lower concentration of heat-activated sweat glands but produce more sweat than both pre- and post- menopausal women (8). On average, women also have a higher body surface area to body mass ratio, meaning a greater area for sweat evaporation (61).

Interestingly, some of the physiological adaptations seen with intense exercise also show a sexual dimorphism that may be a result of differences in thermoregulation. The induction of cardio-protective HSPs in the heart after exercise is much greater in male rats versus female rats exercised at the same absolute intensity (91). However, on average, female rodents do not reach the same temperature as male rats exercised at the same intensity (83). As a consequence, male rat hearts show improved cardiovascular recovery following ischemia-reperfusion injury, but female hearts do not (89).

Sex differences in thermoregulation indicate that sex should be included as a variable when examining exercise and heat stress in combination. This is particularly relevant to the study of yoga since 70 percent of the practitioners in North America are female (63). Canadian females typically exercise less frequently and at lower intensities than their male counterparts (24) and it therefore seems especially important to determine the exercise benefits of yoga and hot yoga among women.

1.10 Summary

Yoga classes are now available at the majority of fitness clubs in the United States and in a growing number of studios specific to yoga. There are videos available for home practice for all levels of experience. As yoga grows in popularity, the media coverage of its usefulness grows as well and, as noted above, much speculation has been made about the safety of yoga practice with and without the addition of increased environmental temperature. In fact, William Broad, a New York Times journalist who has been following yoga in North America for many years, wrote in February 2012 that:

> A number of factors have converged to heighten the risk of practicing yoga. The biggest is the demographic shift in those who study it. Indian practitioners of yoga

> typically squatted and sat cross-legged in daily life, and yoga poses, or asanas, were an outgrowth of these postures. Now urbanites who sit in chairs all day walk into a studio a couple of times a week and strain to twist themselves into ever-more-difficult postures despite their lack of flexibility and other physical problems (15).

These types of statements are good warnings to individuals who may unknowingly get themselves involved in a potentially dangerous practice, but they are also misleading given that very little data exist regarding the adverse or health effects of yoga practice alone or in the heat. Given that yoga is a growing industry, the need for scientific review of this ancient and now modern practice is required for both health and safety reasons. Further, by using yoga practice in combination with passive heating, participants may potentially experience greater cardiovascular stresses to adapt to, possibly combining the health benefits normally associated with regular physical activity and thermal therapy without some of the associated risks or barriers to exercise initiation. However, to date, the physiological and psychological health benefits of hot yoga are primarily anecdotal, but given the potential benefits noted above, the study of this growing area is warranted.

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Chapter 2

2.1 Introduction

Yoga has become a popular alternative to traditional exercise regimes and many therapies to enhance physical and psychological well-being. It is estimated that approximately 15 million North Americans practice yoga with the yoga industry being one of the fasted growing industries in North America (32,70). Hatha yoga is a style of yoga that is most commonly practiced in North America and that comprises physical postures, breath control, meditation, and spiritual components.

Practicing yoga regularly increases flexibility, muscular strength, and muscular endurance (39,81), and can also be used as a potential treatment for many disorders including depression (38), back pain (71), menopause (14,63), schizophrenia (19), and type II diabetes (50). Moreover, used in place of traditional exercise rehabilitation, yoga confers similar improvements in cardiovascular and skeletal muscle functioning (20,66). Despite these benefits, the intensity of yoga does not meet recommended levels of physical activity for improving or maintaining health or cardiovascular fitness as prescribed by either the Canadian Society of Exercise Physiologists (29) or the ACSM (34). Since yoga has become a popular leisure time physical activity for many, its varied forms should be assessed to determine its health benefits

A branch of Hatha yoga called hot yoga has spread rapidly through studios and gyms over the past few years. Hot yoga involves completing traditional poses in a heated room, sometimes reaching 40^{o}C. Exercising in the heat increases heart rate and heart contractility (83) beyond the levels that would occur at room temperature, as competition for blood supply is created between the working muscles and cutaneous tissue (26). Consequently, the added cardiovascular demand of hot yoga may provide practitioners with benefits normally seen from more vigorous activity. To our knowledge, there are no published data comparing hot yoga with normal yoga.

Heat therapy (e.g. Finnish sauna, hot baths, etc.) is a human practice to improve health that has been practiced for centuries (56), but has likely been performed since early in human evolution. Heat acclimation without exercise causes improvements in maximal oxygen consumption, lower resting heart rate (69), greater ventricular compliance (36), increased stroke volume (69), increased plasma volume (60), enhanced endothelial (blood vessel) function (33), improved blood pressure (41), improved body composition (6), and increased insulin sensitivity (13,28,49). Interestingly, these are similar to those conferred by traditional aerobic type training programs (2,12). Favorable adaptations resulting from the combination of heat acclimation and exercise have generally been documented in athletes, military personnel and animals. The results suggest that this combination may dynamically affect the body to create adaptations that differ than those seen after heat acclimation or exercise training alone (37). For this reason, the use of heat as an adjunct or supplement to physical activity training has been suggested (55).

Interestingly, sex differences exist in human thermoregulation as body temperature is modified by sex hormones, notably estrogen and progesterone (44). Men also have a lower concentration of heat-activated sweat glands but produce more sweat than both pre- and post- menopausal women (5). On average, women also have a higher body surface area to body mass ratio, resulting in a greater area for sweat evaporation and thus differences in heat dissipation (45). Given that females typically exercise less frequently and at lower intensities than their male counterparts (15) and make up approximately 70% of the yoga consumers in North America, it seems especially important to determine if sex differences exist in the benefits of yoga and hot yoga as exercise.

Given the above, it is surprising that the combination of a low intensity exercise, such as yoga, performed during elevated ambient temperatures has not been investigated even though this could offer increased cardiovascular benefits. Moreover, given the preponderance of female participation in yoga, this provides a unique setting to examine any differences in how males and females respond to exercise and the heat.

Consequently, the primary purpose of this study was to determine whether the physiological and psychological health benefits of yoga are increased when performed at elevated ambient temperatures.

As such, the following hypotheses were tested:

1) Regular yoga training would result in physiological and psychological fitness improvements at both 4 and 8 weeks and these changes would be greater in participants undergoing combined passive heating and yoga practice (i.e. hot yoga).

2) Men would exhibit greater physiological improvements to yoga training under normal conditions, but there would be no differences after yoga training in the heat.

2.2 Methods

2.2.1 Recruitment

Participants were recruited using posters around the University of Windsor (Windsor, Canada) campus and by word of mouth. Further, a University of Windsor Daily News article on this study was circulated to University students and staff and the Windsor news community in general. Study recruitment and training occurred in two sessions, one from June to August and the other from September to November 2011. All procedures were cleared by the University of Windsor Research Ethics Board prior to initiation (REB#10-241, Appendix A).

Participants were screened with the inclusion and exclusion criteria listed in Table 2.1.

Table 2.1. Inclusion and exclusion criteria for study participation.

Inclusion Criteria	Exclusion Criteria
• between the ages 18-35 years, • body mass index (BMI) of less than 30 kg/m^2 • must be sedentary or lightly active (<6 METs per day*) • physically able to complete exercise testing and the yoga sessions as outlined	• an answer of “yes” to any question on the Par-Q (Appendix B), • are currently dieting or intending to diet, • are pregnant or planning to become pregnant, • participate in moderate to intense physical activity on 2 or more days per week, • have participated in an instructor led yoga program for at least 1 month any time in the past.

* An average of <6 METs per day was calculated using the Godin scale. The metabolic equivalent (MET) is a commonly used unit of energy expenditure where 1 MET is defined as the minimum amount of energy (3.5mL O_2/kg/min) required to keep the body alive during no activity (7,8)

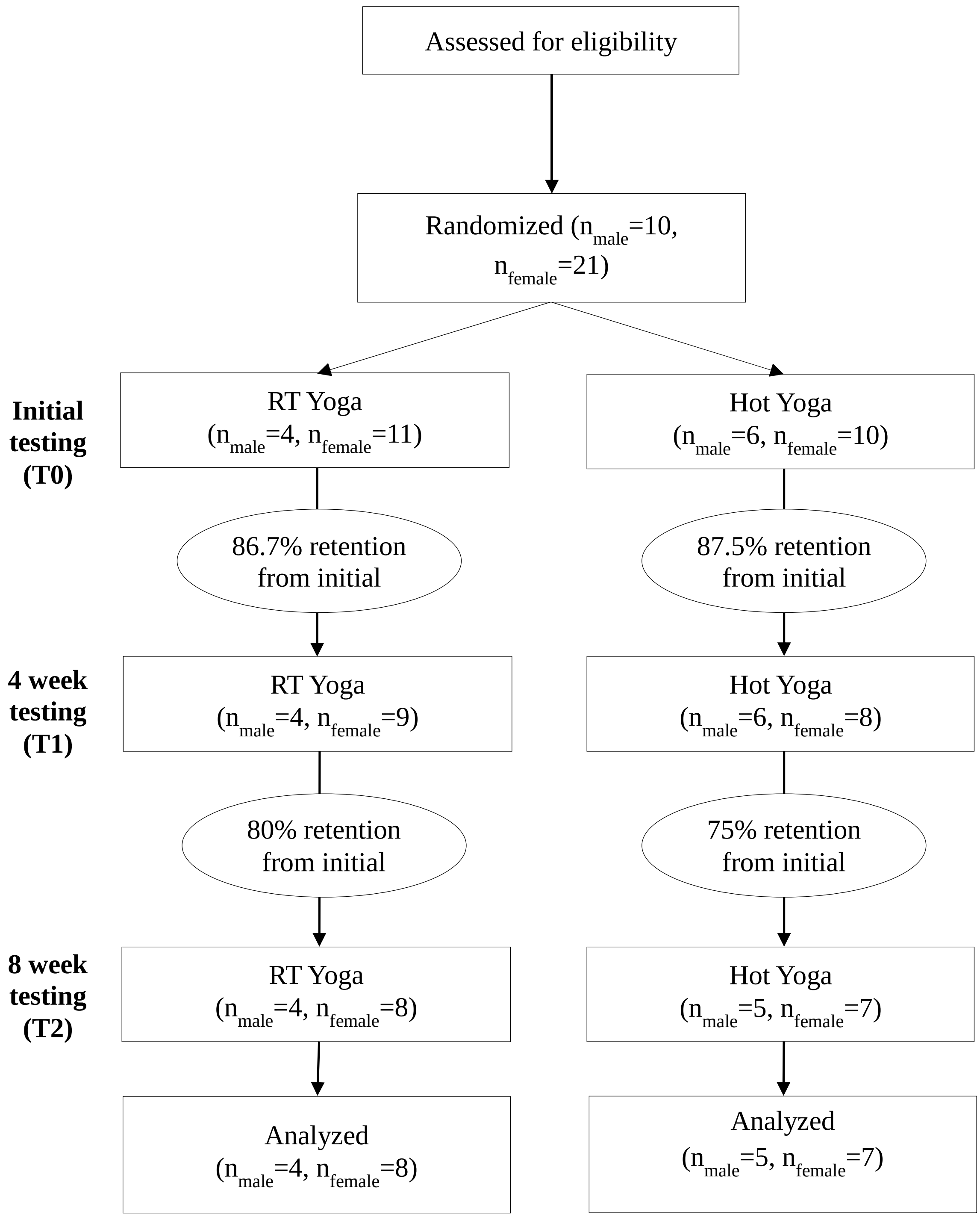
Each person who inquired about the study reported to the Physical Activity and Cardiovascular Research (PACR) lab for an initial visit that included a tour of the lab and familiarization of the testing procedures and instruments. If the volunteer met the study criteria, they were given the Letter of Information detailing the requirements of participation, the Consent Form, PAR-Q form (Appendix B), and Personal Information sheet (Appendix C). Once written informed consent was obtained, instructions on what to wear and how to prepare for the first testing session were given. Moreover, all questions regarding scheduling of yoga classes and study involvement were addressed at that time. Thirty-one people who responded to the recruitment advertisements met the study criteria and all those recruited were novice yoga participants. Of the 31 people who completed the initial testing, 27 completed 4 weeks of yoga training, and 24 completed the full 8 weeks. Participants were excluded from the study if they missed a week of classes (3 consecutive yoga training sessions) or failed to complete 75% of the training. Table 2.2 contains characteristics of the 27 participants who completed the first half of the training and testing and Figure 2.1 indicates a flow diagram of study procedures and participation.

Table 2.2. Participant characteristics of those completing at least 4 weeks of training.

Sex	n	Age (y)	Height (cm)	Weight (kg)	Weekly Activity (METS)
male	10	23.9 ± 3.56	177.6 ± 6.78*	81.91 ± 13.15*	3.36 ± 1.85*
female	17	22.59 ± 1.61	169.09 ± 5.37	67.17 ± 12.59	2.78 ± 1.51

* indicates a significant difference between males and females.

Figure 2.1


Assessed for eligibility
Randomized (n_{male}=10, n_{female}=21)
Initial testing (T0)
RT Yoga (n_{male}=4, n_{female}=11)
Hot Yoga (n_{male}=6, n_{female}=10)
86.7% retention from initial
87.5% retention from initial
4 week testing (T1)
RT Yoga (n_{male}=4, n_{female}=9)
Hot Yoga (n_{male}=6, n_{female}=8)
80% retention from initial
75% retention from initial
8 week testing (T2)
RT Yoga (n_{male}=4, n_{female}=8)
Hot Yoga (n_{male}=5, n_{female}=7)
Analyzed (n_{male}=4, n_{female}=8)
Analyzed (n_{male}=5, n_{female}=7)

2.2.2 Physical activity and psychological questionnaires

Participants returned within a week of the first meeting and familiarization for their individual testing. They were asked to have fasted for at least 2 hours prior to exercise testing according to Bod Pod protocol (BOD POD, Cosmed, USA). Upon arrival, participants were first asked to lie down and an investigator wrapped a standard adult blood pressure cuff around the bare left upper arm. They were left in a darkened room for 10 minutes of supine rest after which resting blood pressure and heart rate were recorded using an autonomic non-invasive device while they were in the supine position (Dinamap Procare 200/Carescape 200, GE Healthcare Canada, ON, Canada).

Subsequently, each participant was required to complete in the following order: the Godin Leisure Time Exercise Questionnaire (LTEQ, Appendix D), a modified Godin Intention to Exercise Questionnaire (ITEQ, Appendix E), Beck Depression Inventory (BDI, Appendix F), and State and Trait Anxiety Inventory (STAI, Appendix G). The participants were asked to answer each question truthfully and to their best ability prior to filling out the questionnaires in private. The LTEQ is a simple, self-explanatory questionnaire that estimates leisure time physical activity. It has been validated and proven reliable in a number of studies (25). The LTEQ requires that participants report on how many days in the previous 7 days they have engaged in strenuous physical activity (e.g. jogging, running, basketball), moderate physical activity (fast walking, baseball, volleyball) and mild exercise (e.g. yoga, golf, fishing) for more than 15 min of their free time. Weekly frequencies of strenuous, moderate, and light activities are multiplied by 9, 5, and 3 METs, respectively and total weekly leisure activity is calculated in arbitrary units by summing the products of the separate components. The BDI is designed to assess the intensity and depth of depression in individuals. It was originally intended for use with patients in a mental health setting, but is now commonly used in primary health care settings and clinical research (75,82). The BDI has been used since 1961 and its internal consistency and clinical relevance have had many years to be validated (4). The BDI consists of 21 questions and takes only 5 to 10 minutes to complete. Finally, the STAI is a measure of state and trait anxiety, indicating how anxious a participant is in the present situation (state anxiety) as well as his or her tendencies to perceive a given situation as stressful giving a more long-term measure of their anxiety levels (trait anxiety). The STAI has been used extensively in research and clinical practice (68) and has been proven a reliable and valid measure of anxiety (3). It consists of 40 questions that measure self-reported scales of feelings of apprehension, tension, nervousness, and worry. All participants were informed that the BDI and STAI dealt with topics that some people may find disturbing and consequently, the phone number for campus Psychological Services could be provided upon request.

2.2.3 Assessment of body composition

Following the completion of the surveys, height and weight were measured and body composition was analyzed using air displacement plethysmography (BOD POD, Cosmed, USA, Appendix H). For these measurements, participants wore the appropriate minimal attire (e.g. light shorts, bra top). Bod Pod measurements took approximately 5 min while body and thoracic gas volumes were analyzed.

2.2.4 Assessment of circulating health markers

Following body composition assessment, blood glucose, cholesterol, high-density lipoproteins and low-density lipoproteins were measured. The investigator wore latex gloves to clean each participant's finger with an alcohol swab. Blood was drawn using a commercially available lancet and needle (Accu-Chek) into two separate capillary tubes. The first tube contained an anticoagulant. The blood collected in the tube was immediately analyzed using a commercially available point of care blood chemistry analyser (Cholestech LDX®, Cholestech, USA). This test is highly comparable to The Centers for Disease Control and Prevention's Cholesterol Reference Method. The second tube was spun in a microhematocrit centrifuge (Statspin® Critspin, Iris Sample Processing, USA) to determine blood haematocrit percentage.

2.2.5 ***Assessment of flexibility***

A sit and reach test was administered using a standard metre rule and sit-and-reach box (SRBox). The sit-and-reach test is commonly used in health-related and physical-fitness tests to evaluate the hamstring and lower back flexibility (21,84). Participants sat on a mat in front of the SRBox on the floor without shoes and fully extended both legs so that the sole of the foot was flat against the end of the SRBox. They extended their arms forward, placing one hand on top of the other, palms facing downward. Participants were asked to reach forward and slide their hands slowly along the measuring scale as far as possible without bending the knees. Limb lengths were not expected to change over the course of 8 weeks therefore only raw scores were recorded and used for statistical analysis. This was repeated 3 times and the farthest measurement of the trials was recorded for analysis.

2.2.6 Assessment of VO_{2peak}

The final test during the initial assessment was a maximal oxygen consumption ramp cycling test to exhaustion. A graphical representation of the test is outlined in Figure 2.2. Participants were fitted with a telemetric heart rate monitor (Polar RS400, Canada) and the head strap used to secure a mouthpiece for gas (expired oxygen and carbon dioxide) analysis was fitted over their heads prior to mounting an electronically braked standard cycle ergometer (Ergoselect 200, Ergoline, Germany). Seat height and handle bar distance was adjusted for comfort and proper positioning of the participant. Before initiating testing, participants were informed of their right to terminate the test at any time. They were also encouraged to alert the test administrator to any discomforts or ill feelings they experienced during the testing session. The participants were asked to remain seated on the cycle ergometer without any exercise for a period of 2 minutes while resting physiological data could be recorded [i.e. volume of oxygen consumed (VO_2), volume of carbon dioxide produced (VCO_2), the respiratory exchange ratio (RER) and heart rate (HR)] using an Ergocard® metabolic cart (Medisoft, Belgium). Participants were then asked to start pedalling at a speed of 80 rotations per minute against no resistance and to try to maintain this pace throughout the entire test. Physiological data was continuously recorded until the end of the testing procedure. After this 2 minute warm up period, the resistance on the cycle was increased in an incremental fashion (25W/min) until volitional exhaustion (typically <15min total time). Throughout the test, verbal encouragement was given in an attempt to help the participant achieve maximal effort. Maximal effort was determined if 2 of the following 4 criteria were met: a heart rate within 10 beats of age predicted maximum; inability to maintain 60 rpm on the cycle ergometer; a plateau in VO_2 even though resistance had been increased; a respiratory exchange ratio greater than or equal to 1.1. Moreover, the test was stopped if the participant exhibited any physical signs of distress (such as pale skin, confusion, a reduction in heart rate with an increase in intensity, pains in the chest) that would have been indicative of an ability to meet the demands of exercise. After the test had been completed, the participant was required to remain on the cycle, pedalling against a self-selected resistance and pace until heart rate returned to within 10 beats of the initial stage (typically within 5 min). Subsequently, the mouthpiece was removed, the participant was free to stop pedalling and dismount the cycle. Peak VO_2 (VO_{2peak}) was determined using Expair® software (Medisoft, Belgium) that came with the metabolic cart. A bottle of water or a juice box was offered to the participant once all testing was completed.

Once the individual testing was completed, participants were randomly assigned to either a hot or normal temperature yoga group. Each participant was provided with a hard copy of the Downtown Yoga schedule with the classes they could attend highlighted along with the website where the schedule could also be viewed.

Figure 2.2

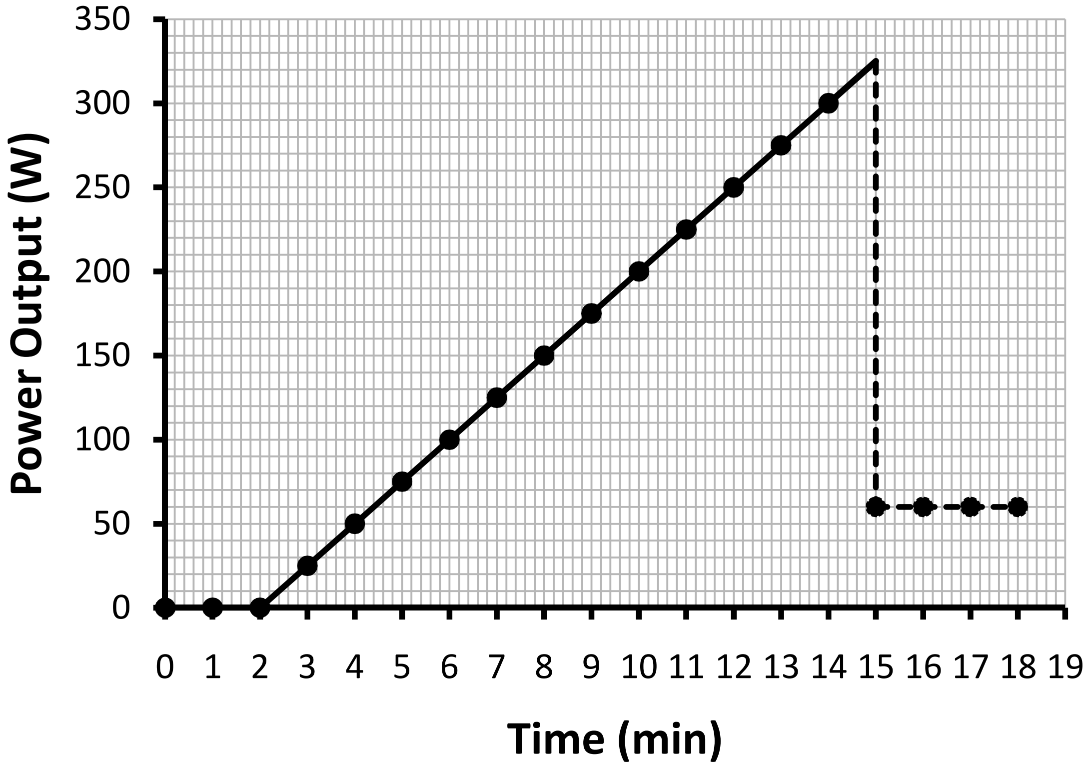


Figure 2.2. Graphical representation of cycling ramp test to exhaustion. The test consisted of a 2 min warm up at no resistance followed by an electronically regulated increase in work rate by 25 W/min. Testing was complete when participants could no longer continue and consequently, test duration and maximal work rate varied with each participant. Following exhaustion, participants were required to remain on the cycle ergometer at a self-selected work rate (dotted line) until heart rate returned to within 10 beats of the start of exercise (typically 2-5 min).

2.2.7 Yoga Training

Following the initial assessment, participants began the 8 weeks of yoga training following a similar training frequency and duration as outlined by Tran et al. (2001) (81). These authors utilized an 8 week Hatha yoga training schedule and observed improvements in health-related physical fitness variables including increased maximal oxygen consumption (81). Each participant was required to attend 3 yoga sessions on 3 separate days in any 1 week at a local Yoga studio under the direction of a trained Yoga instructor (Downtown Yoga Studio, Windsor, ON, Canada). Participants communicated verbally or via email weekly with the investigator as to which 3 classes they would be attending. A certified yoga instructor led all classes. This was important to the safety of novice participants given recent concern for the proper demonstration of poses and techniques. Costs of the Yoga sessions were paid by the researcher and since the classes were open to the general public as a regularly scheduled part of the Downtown Yoga studio's offerings, participants performed their sessions among non-participants.

Each participant was met by a researcher before their first class to introduce them to the studio, instructor and policies. Participants were informed by the researcher and yoga instructor that they should only perform exercises that they felt comfortable with. Moreover, they were taught restful poses to take if the class became too challenging. Participants were also advised to bring and/or utilize available water to maintain hydrated during each session. Hydration is an confounding variable to examine when considering heats stress as it influences an individual's response to heat. Hypohydration increases heat storage by reduced sweating rate (evaporative heat loss) and reduced skin blood flow (dry heat loss) for a given core temperature (67), thus reducing one's ability to tolerate heat strain. An individual's hydration status will therefore affect his or her core temperature fluctuations at any given room temperature.

Subsequently, participants were suited with a heart rate monitor and corresponding watch receiver (Polar RS400, Polar, Canada), and sensory armband (worn over the upper arm) to record skin temperature and estimate caloric expenditure (BodyMedia SenseWear System) immediately before beginning the class. The BodyMedia arm bands also act as a pedometer, and accelerometer. It has been used in previous studies to estimate caloric expenditure and intensity of exercise in METs. Although this is the first time the device has been used to measure intensity of yoga, studies have shown that the band reliably reports changes in intensity and caloric expenditure within an exercise activity (42,48).

A researcher recorded tympanic temperature using a portable tympanic thermometer (Genius 2 Tympanic Thermometer, Coviden, USA) prior to the start of yoga and then again at 3 times during the yoga session (i.e. the midpoint and end prior to relaxation in savasana). Core temperature is estimated by this device (note: this non-invasive device is commonly used in hospital triage centers), but tympanic temperature represents a close approximation of the blood passing near the hypothalamus, the primary regulator of temperature in the body. Room temperature was also recorded at the same intervals using a commercially available environmental thermometer.   Temperature measurements during the yoga session were completed in less than 20 seconds utilizing the tympanic thermometer and were taken at the beginning, approximate mid-point and at the 70 min mark of the yoga session prior to cool down.

Each class was approximately 80 min in duration, consisting of approximately 20 minutes of warm-up exercises, 50 minutes of asanas (yoga postures), and 10 minutes of relaxation in savasana (the corpse pose). The yoga postures varied from day to day at the discretion of the instructor, but all postures were taken from standard Hatha yoga practice.

The variables described above (i.e. heart rate, tympanic temperature, relative activity and skin temperature) were monitored on only one of the three weekly sessions. This was done to minimize disturbance to the classes, but served as a good indicator of the physiological responses to the yoga sessions across the weeks.

2.2.8 Midpoint Testing

At the end of the initial 4 weeks, participants underwent the same testing procedures (i.e. blood pressure, surveys, body composition, stretching, blood glucose, VO_{2max}) as described above. Midpoint testing was performed at least 2 days after the final yoga session of the 4 week period. Also at this point, participants were verbally asked if diet, activity level, or medication had changed in the past 4 weeks. If they reported changes, they were not to be considered for analysis but would be allowed to continue training. After the midpoint testing session, participants resumed yoga practice for the final 4 weeks in the same yoga type in which they were originally grouped.

2.2.9 Final Testing

At the conclusion of the final 4 weeks of yoga (i.e. after 8 total weeks of training), participants were required to return to the PACR lab to complete a third round of testing procedures. In addition to the previous measures, they were given an Exit Survey

(Appendix I) to measure their feelings about and intentions to perform, yoga after their participation in the study came to an end. Participants were free to continue the Yoga sessions at the Downtown Yoga Studio or any other studio they so wished after the final assessment.

2.2.10 Data Analysis and Statistics

Data analysis was conducted with IBM (PASW) SPSS Statistics 18 (SPSS Inc., Chicago, IL, USA). Statistical significance was set at $p<0.05$. An independent samples t-test was conducted to compare sex or training group (normal temperature and hot yoga) baseline characteristics to determine if any differences existed between groups before the classes began. A 3-way repeated-measures ANOVA was then conducted to determine if differences occurred mid- and post-training within and between groups. Independent variables included the between group variables of sex (male versus female) and yoga type (room temperature versus hot) and the within group variable of training time (pre, mid and post yoga training). Data from 27 subjects were used to analyze baseline to 4 weeks, and data from 24 subjects for 4weeks to 8weeks. Upon finding significant main effects, a Tukey's post hoc test ($p<0.05$) was performed to determine significant differences for the variable of time.

Additionally, a repeated measures ANOVA was used to analyze the heart rate, tympanic temperatures and skin conductance data collected in assessment of cardiovascular demand and conditions of the yoga training. This analysis consisted of the between group variables of sex and yoga type and within group variable of time (pre, mid and at the end of each yoga session). Any significant main effects for time were subsequently analyzed using a Tukey's post hoc test at $p<0.05$.

For all measures, correlations were performed between variables at each time point. Significant correlations were determined at $p<0.05$. Pearson r-values are reported along with p-values in the text.

2.3 Results

2.3.1 Participant retention

Of the 31 people who began the study, 27 completed at least 4 weeks and 24 completed the entire training protocol. Of the individuals who did not complete the full study, 3 were from the normal temperature yoga group and 4 were from the hot yoga group suggesting that there was not a preferential drop out of either yoga type. Reasons for dropping out were listed as time constrains and change in schedules. One subject was excluded from the study because they left for a week-long vacation. No drop outs were reported due to yoga difficulty or injury. Moreover, there was a significant increase in participants' intention to include yoga as part of their leisure time physical activity at least 1, 3 and 5 days per week at both 4 weeks and 8 weeks of yoga training ($p<0.05$).

2.3.2 Feelings about exercise and yoga participation

There was a significant main effect for time in the participants' knowledge about yoga, including a significant change in the belief that yoga is demanding exercise. These changes occurred at the 4 week point and were increased at the end of 8 weeks. Further, participants indicated a significant increase in their belief that they could perform at least 30 min of yoga at each time point ($p<0.05$). There were no significant differences in other physical activity participation in the other measures of feelings.

2.3.3 Yoga class environment

There was a significant difference between normal and hot yoga room temperatures (24.8 ±0.36 °C versus 29.8 ±0.36 °C, $p<0.05$), and in both situations, room temperature was significantly elevated during the yoga sessions ($p<0.05$, Figure 2.3).

Mean heart rate responses to hot yoga training were significantly higher than in the normal yoga classes (61.0±2.0 versus 48.2±1.8 percent of their maximum recorded HR respectively, $p<0.05$). Further, participants in the hot yoga group spent more time at greater than 60%, 70% and 80% of their maximum heart rate ($p<0.05$, Figure 2.4). However, no significant differences existed between groups in steps taken or average METs expended, energy expenditure, or steps taken during the training session ($p>0.05$, Table 2.31).

Tympanic temperatures differed between groups ($p<0.05$). Hot yoga participants reached an average of 37.9±0.19 °C, while the normal yoga participants averaged 36.9±0.19 °C (Figure 2.5).

Men showed significantly higher mean energy expenditure during yoga class with 1069.45±112.2 joules, than females at 867.0 ±96.5 joules ($p<0.05$). No differences were seen between sexes in regards to training heart rate, steps taken during yoga class, METs or temperature (Table 2.31).

2.3.4 Psychological Measures

There was a significant improvement in STAI scores regarding trait anxiety after 4 of training ($p<0.05$), but not state anxiety. Lowered in trait anxiety scores were maintained after 8 weeks of yoga. Depression ratings as indicated by the BDI were in the healthy range and were significantly reduced at 4 weeks and maintained at 8 weeks of yoga training ($p<0.05$). There was no difference in psychological improvements between sexes or yoga types (Table 2.32).

Figure 2.3

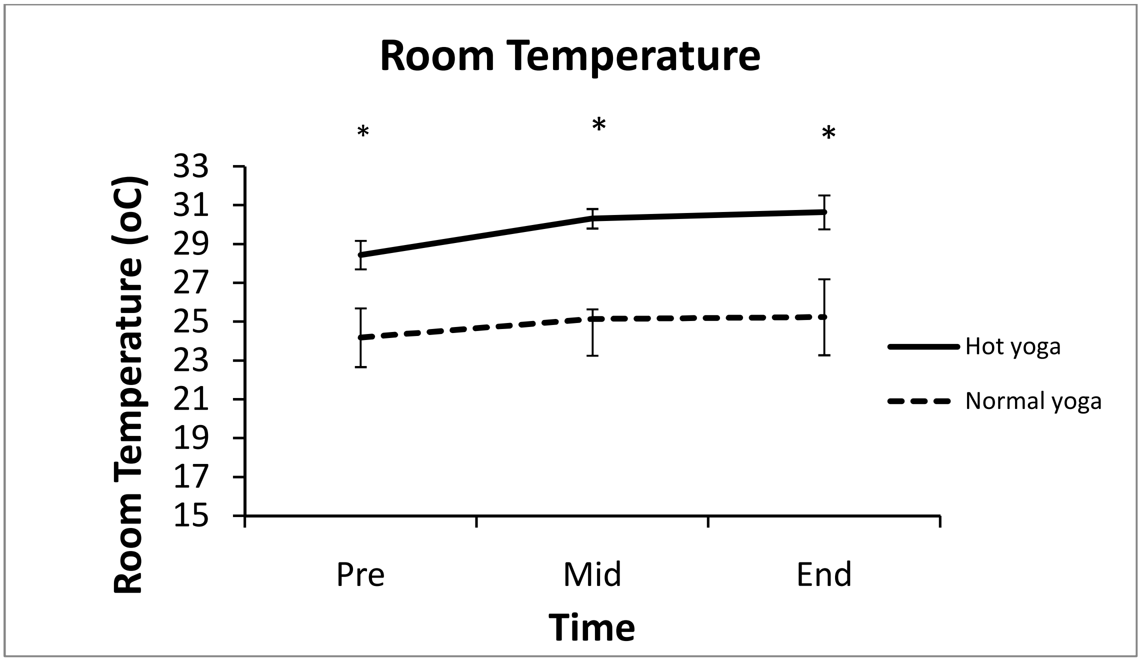


Figure 2.3. Average room temperature during yoga training at 3 intervals of the 80 minute class. Room temperature was significantly higher in the hot yoga classes throughout the session ($p<0.05$). Temperature was increased in both classes at the mid and end point measurements.

Figure 2.4

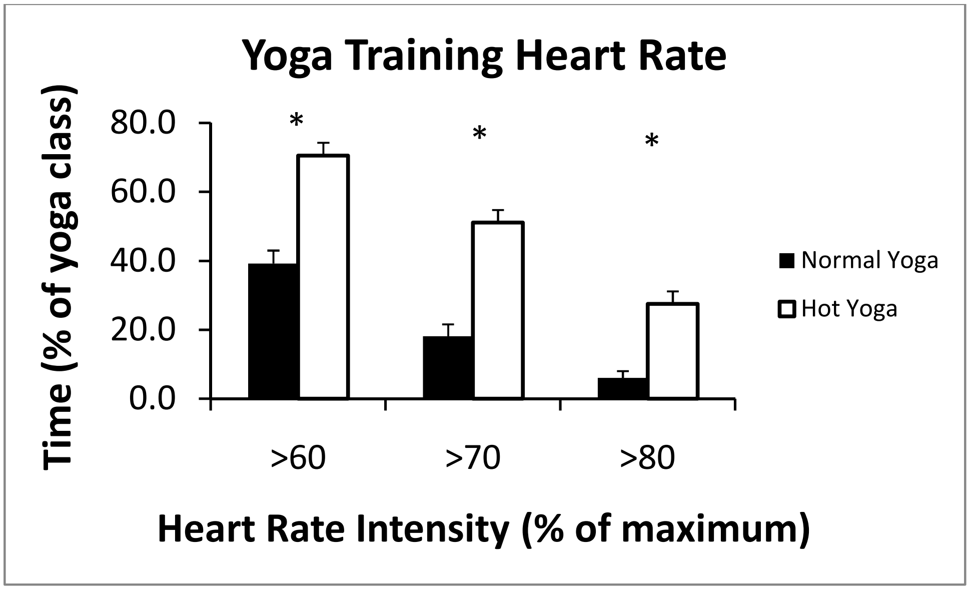


Figure 2.4. Percent of time participants spent at relative heart rate intensities during yoga training. This was calculated by using individual recorded heart rate maximums. Hot yoga participants spent significantly more time at elevated heart rates in each category ($p<0.05$).

Figure 2.5

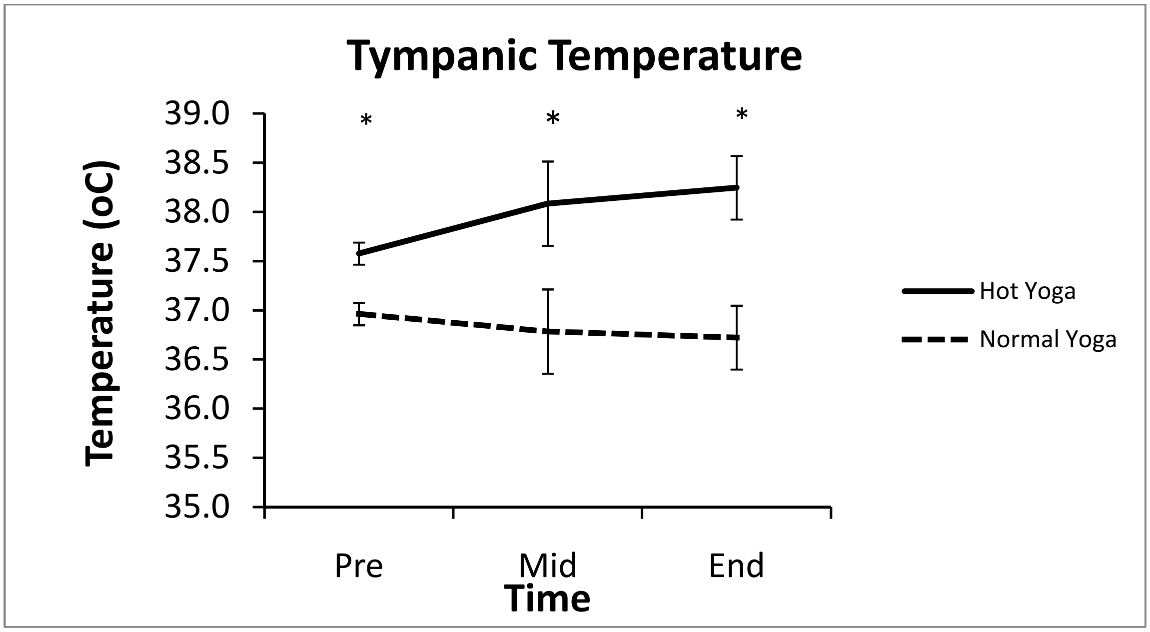


Figure 2.5. Average tympanic temperatures during yoga training taken at 3 intervals over the 80 minute class. Tympanic temperature was significantly greater in the hot yoga participants at all points ($p<0.05$).

Table 2.31

Parameter	Group		Mean		SD
Estimated Energy Expenditure (joules)	Normal	female	815.0	±	133.1
		male	1150.6	±	123.2
		Total	918.3	±	203.9
	Hot	female	867.0	±	96.5
		male	1069.5	±	112.2
		Total	960.4	±	144.7
	Total	female	837.8	±	117.8
		male	1101.9^{β}	±	117.5
		Total	939.4	±	174.6
METs	Normal	female	2.3	±	0.4
		male	2.9	±	0.7
		Total	2.5	±	0.6
	Hot	female	2.7	±	0.4
		male	2.6	±	0.3
		Total	2.6	±	0.4
	Total	female	2.5	±	0.4
		male	2.7	±	0.5
		Total	2.6	±	0.5
Steps Taken	Normal	female	94.1	±	55.4
		male	144.4	±	87.1
		Total	109.5	±	67.3
	Hot	female	143.8	±	40.8
		male	144.8	±	50.8
		Total	144.3	±	43.7
	Total	female	115.8	±	54.3
		male	144.6	±	62.9
		Total	126.9	±	58.3

Table 2.31 Average estimated activity level during a yoga session. SenseWear arm band data from weekly yoga classes showed the energy expenditure, METs as a measure of exercise intensity, and steps taken during both hot and norma-thermal yoga classes averaged across 8 weeks of training. Data collection from 27 participants used. Men yoga participants recorded higher energy expenditure than their female counterparts in each category ($^{\beta}$,$p<0.05$).

Table: 2.32

Parameters	YOGA	SEX	Baseline Mean		SD	4 Weeks Mean		SD	8 Weeks Mean		SD
Beck's Depression Inventory	Normal TEMP	Female	5.8	±	3.9	5.7	±	4.1	1.9	±	1.5
		Male	3.5	±	4.7	1.8	±	1.5	4.5	±	3.9
		Total	5.1	±	4.1	4.5	±	3.9	2.8	±	2.7
	Hot	Female	3.5	±	4.8	0.8	±	0.9	2.0	±	2.8
		Male	5.0	±	5.2	3.0	±	4.4	2.6	±	5.3
		Total	4.1	±	4.8	1.7	±	3.0	2.3	±	3.8
	Total	Female	4.7	±	4.4	3.4	±	3.9	1.9	±	2.1
		Male	4.4	±	4.8	2.5	±	3.4	3.4	±	4.5
		Total	4.6	±	4.4	3.0*	±	3.7	2.5*	±	3.2
STAI State Anxiety	Normal TEMP	Female	33.3	±	8.9	32.4	±	7.1	31.4	±	6.1
		Male	36.8	±	13.4	31.3	±	4.6	29.0	±	9.2
		Total	34.4	±	10.0	32.1	±	6.2	30.6	±	7.0
	Hot	Female	25.4	±	7.3	24.9	±	7.3	27.1	±	9.8
		Male	33.8	±	12.7	31.0	±	7.9	30.4	±	13.0
		Total	29.0	±	10.5	27.5	±	7.9	28.5	±	10.8
	Total	Female	29.6	±	8.9	28.9	±	8.0	29.4	±	8.1
		Male	35.0	±	12.3	31.1	±	6.5	29.8	±	10.8
		Total	31.6	±	10.4	29.7	±	7.4	29.5	±	8.9
STAI Trait Anxiety	Normal TEMP	Female	34.1	±	6.4	32.0	±	6.3	28.4	±	6.2
		Male	45.3	±	14.8	34.3	±	6.7	31.0	±	9.9
		Total	37.5	±	10.5	32.7	±	6.2	29.3	±	7.3
	Hot	Female	30.5	±	14.6	27.0	±	8.6	26.0	±	7.0
		Male	38.8	±	11.2	35.0	±	10.9	31.4	±	12.5
		Total	34.1	±	13.4	30.4	±	10.1	28.3	±	9.6
	Total	Female	32.4	±	10.8	29.6	±	7.7	27.3	±	6.5
		Male	41.4	±	12.4	34.7	±	9.0	31.2	±	10.7
		Total	35.7	±	12.0	31.5*	±	8.4	28.8*$^{\alpha}$	±	8.3

Table 2.32: Analysis of depression and anxiety scales with yoga training.

Depression ratings improved at 4 and 8 weeks compared to baseline ($p<0.05$). No change was seen in state anxiety. Trait anxiety improved at 4 weeks from baseline and further improved at 8 weeks ($p<0.05$).

*Significantly different from baseline ($p<0.05$)

$^{\alpha}$ Significantly different from 4 weeks ($p<0.05$)

2.3.5 Physiological Measures

2.3.6 Body Weight

Body weight did not change significantly for any of the training groups after 4 or 8 weeks of training. At baseline, males and females had significantly different body weights at baseline, 81.9 ± 13.9 kg versus 67.2 ± 13.0 kg, respectively, but no changes in body weight were seen for either sex after training.

2.3.7 Body Mass Index (BMI)

The average baseline BMI was in the normal range at 24.4 ± 4.5kg/m^2. No significant changes were seen in BMI after 4 and 8 weeks of training for either training group. No differences existed between male and female participants.

2.3.8 Body Composition

Body fat percentage improved significantly over time (Figure 2.6). No effects were seen regarding training group or sex. Mean body fat lowered from 30.4 ± 9.3% at baseline to 28.7 ± 9.0% after 4 weeks of training ($p<0.05$). At 8 weeks, body fat remained significantly lowered from baseline, but there was no change from midpoint testing at 29.3 ±9.0% ($p<0.05$).

Figure 2.6

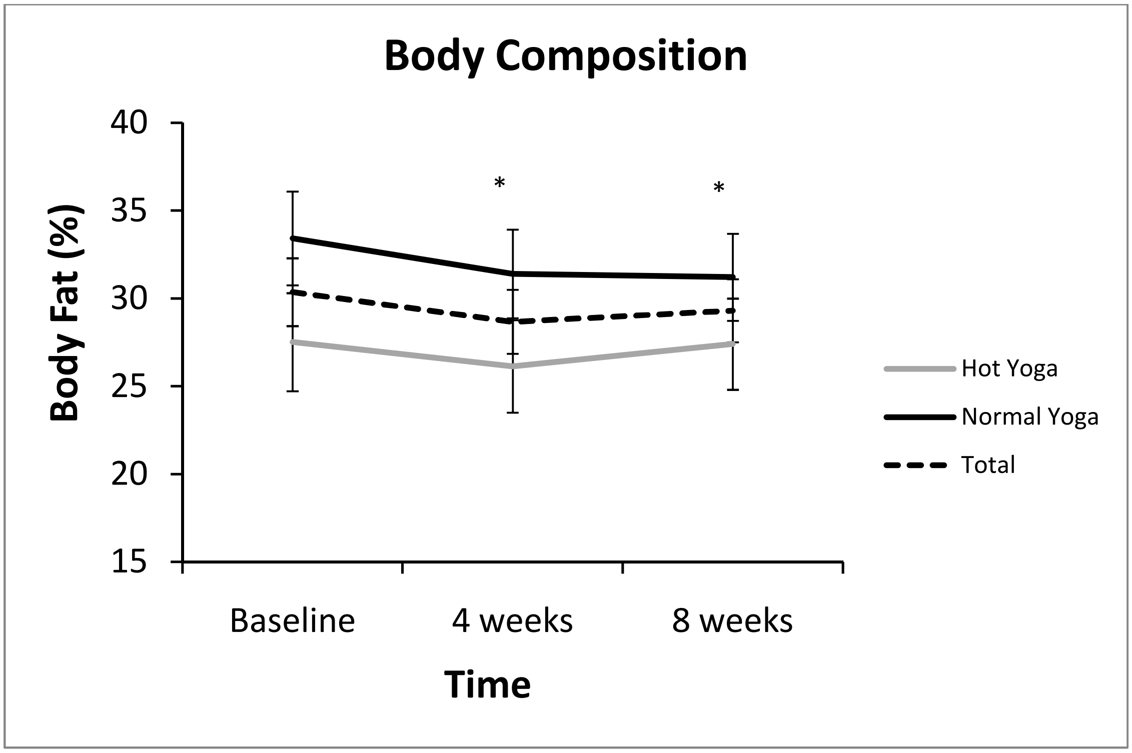


Figure 2.6: Body composition changed at 4 and 8 weeks of yoga training.

Body composition, as determined by body fat percentage, significantly lowered for all participants with yoga training. No differences existed between hot or normal yoga groups (*,p<0.05).

2.3.9 Blood Pressure

Systolic blood pressure (SBP) significantly decreased after 4 weeks regardless of training group (Figure 2.7). At baseline, participant mean SBP was 107 ±12.5 mmHg and decreased after 4 weeks to 101 ±8.7 mmHg ($p<0.05$). It remained significantly lowered after 8 weeks of training 99 ±21.6 mmHg, but was not different from 4 weeks ($p<0.05$). At baseline mean SBP was significantly lower in females at 101 ±10.0 mmHg compared to men at 116 ±10.7 mmHg ($p<0.05$), but there was no effect of training on these differences.

Significant changes in diastolic blood pressure (DBP) were not seen at 4 weeks but were recorded after 8 weeks ($p<0.05$) for all training groups. Baseline, midpoint, and final DBP means were 63 ±7.3 mmHg, 60 ±8.7 mmHg, and 60 ±7.0 mmHg respectively. DBP did not differ by sex.

2.3.10 Resting Heart Rate

There were no significant resting heart rate changes over the course of 4 or 8 weeks of yoga training between or within groups.

Figure 2.7

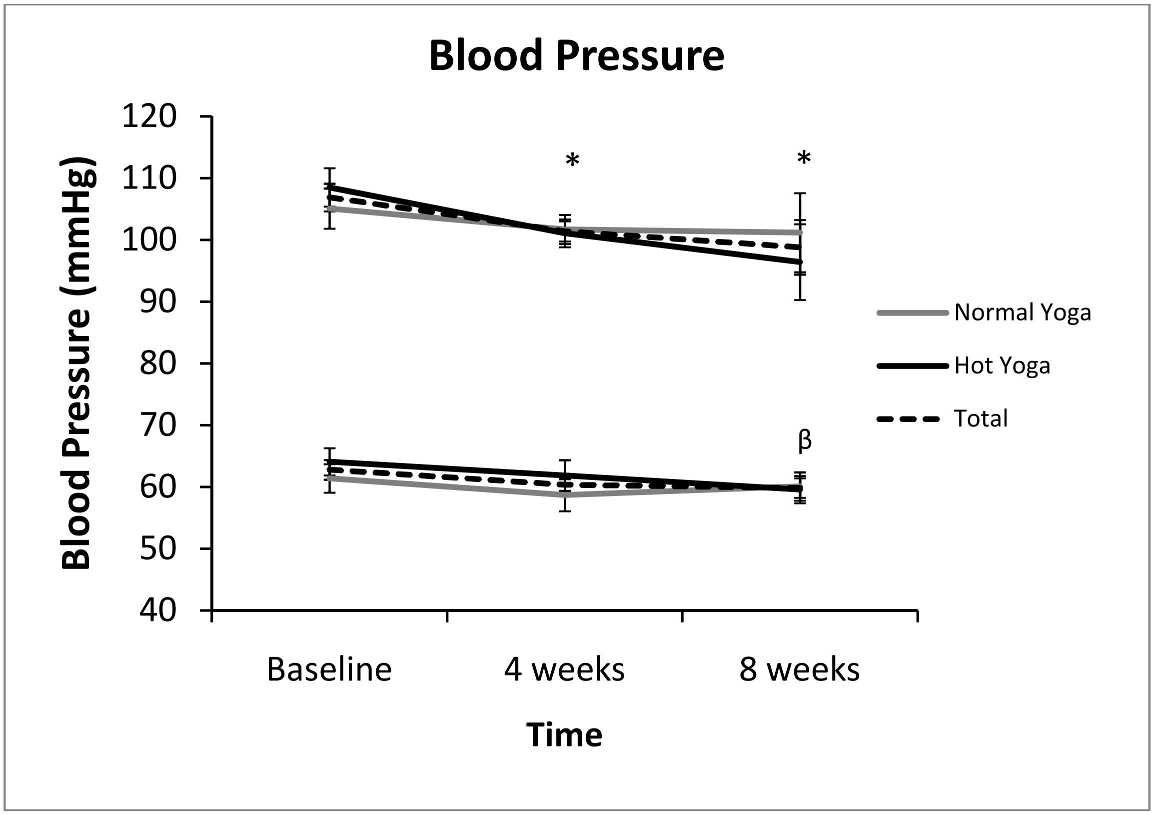


Figure 2.7. Systolic and diastolic blood pressure changes over 8 weeks of yoga training. There was a significant reduction in SBP at 4 and 8 weeks (*, $p<0.05$). DBP was not reduced at 4 weeks, but was significantly lower than baseline at 8 weeks (β, $p<0.05$)

2.3.11 Hematocrit

Hematocrit levels significantly differed at baseline for males (45.3 ± 4.5) and females (40.1 ± 2.4; $p<0.05$), but no changes occurred in hematocrit levels after training for either group. There was no interaction between sex and yoga training type on hematocrit levels.

2.3.12 Flexibility

Hamstring flexibility was significantly increased after 4 and 8 weeks of training ($p<0.05$, Figure 2.8), irrespective of sex or type of yoga training. Average participant flexibility improved from 26.4 ±10.4 cm at baseline to 41.4 ±4.4 cm after 4 weeks of yoga training (n=27; $p<0.05$). After 8 weeks, flexibility was still improved from baseline, but had significantly lowered from midpoint testing to 35.9 ±6.9 cm (n=24; $p<0.05$).

2.3.13 VO2peak

Males averaged an absolute oxygen consumption of 2.4±0.8 L/min, significantly higher than females, who averaged of 1.5 ± 0.3 L/min ($p<0.05$). Although no differences were seen over time between hot and normal training groups, a significant improvement was seen in VO_{2peak} for all yoga participants. The midpoint oxygen consumption mean of 2.05 ± 0.72 L/min significantly differed from a baseline value of 1.87 ± 0.68 L/min ($p<0.05$). VO_{2peak} did not remain elevated at 8 weeks with a mean of 1.91 ± 0.63 L/min (Figure 2.9). A significant interaction was seen between yoga training type and sex with regards to maximum oxygen consumption ($p<0.05$). The interaction revealed that normal yoga males and females did not see the same increases in VO_2 as hot yoga males at the 4 week testing point. Similarly, normal yoga females had lower VO_2 measures compared to both hot yoga females and hot yoga males.

Figure 2.8

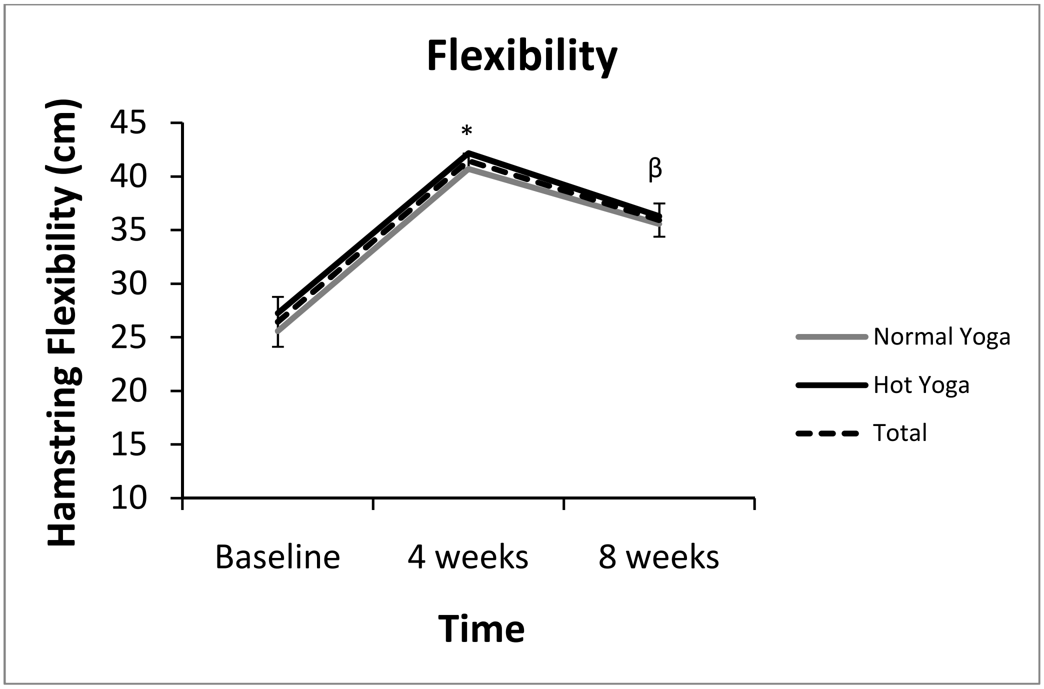


Figure 2.8. Flexibility changes at 4 and 8 weeks of yoga training. Participants in both training groups were significantly more flexible than baseline at 4 and 8 weeks of training (*, p<0.05), however, after 8 weeks of training, flexibility decreased (β, p<0.05) in comparison to weeks.

Figure 2.9

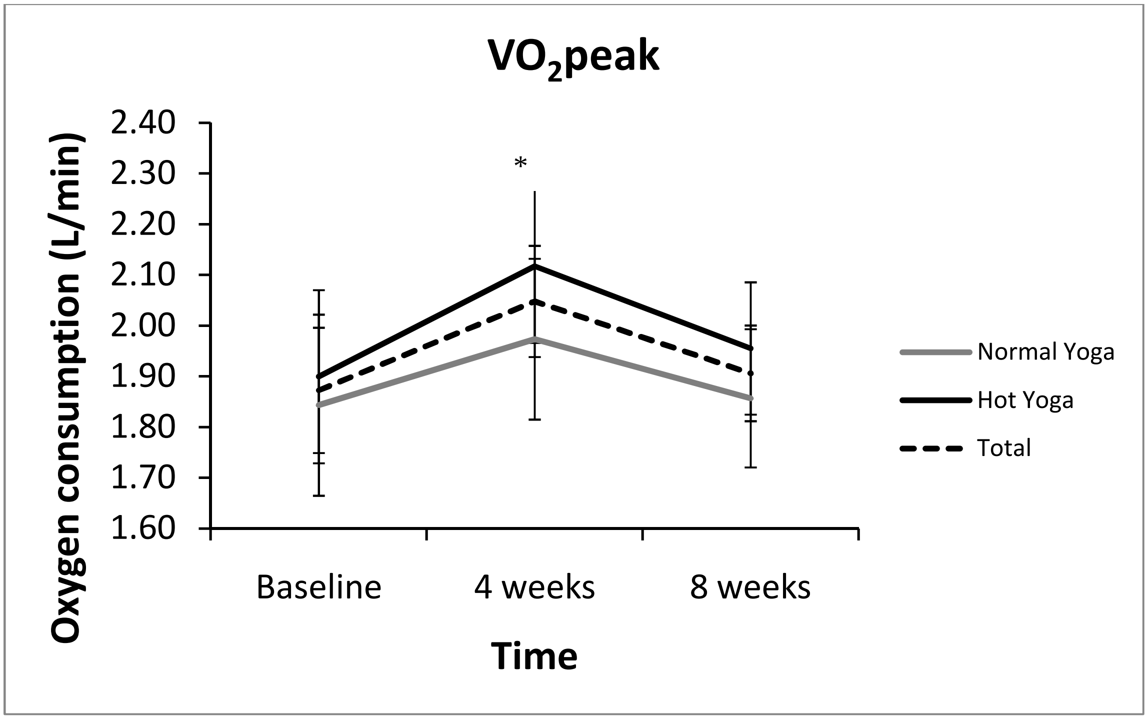


Figure 2.9: VO_{2peak} changed at 4 weeks of yoga training. Participants in both training groups had significantly higher aerobic capacity at 4 weeks than at baseline (*, $p<0.05$), but returned to baseline levels after 8 weeks.

2.3.14 Time to Exhaustion

Time to exhaustion during the VO_{2peak} test differed between the men and women at initial testing, with females and males averaging 399.8 ±58.8 seconds and 569.8 ± 120.0 seconds, respectively, but sex did not have a significant effect on time to exhaustion after training. Time to exhaustion changed significantly for all yoga participants at 8 weeks ($p<0.05$, Figure 2.10). Baseline, midpoint and final testing means were 462.8 ± 118.8, 469.2 ± 108.7, and 498.8 ± 133.2 seconds, respectively. Hot yoga had a positive significant effect on time to exhaustion with the hot yoga training group improving more than their normal temperature counterparts ($p<0.05$).

2.3.15 Correlations

A significant correlation was observed between trait anxiety and SBP at baseline ($r=0.431$, $p=0.018$) and at 4 weeks ($r=0.372$, $p=0.037$) but not at 8 weeks.

Figure 2.10

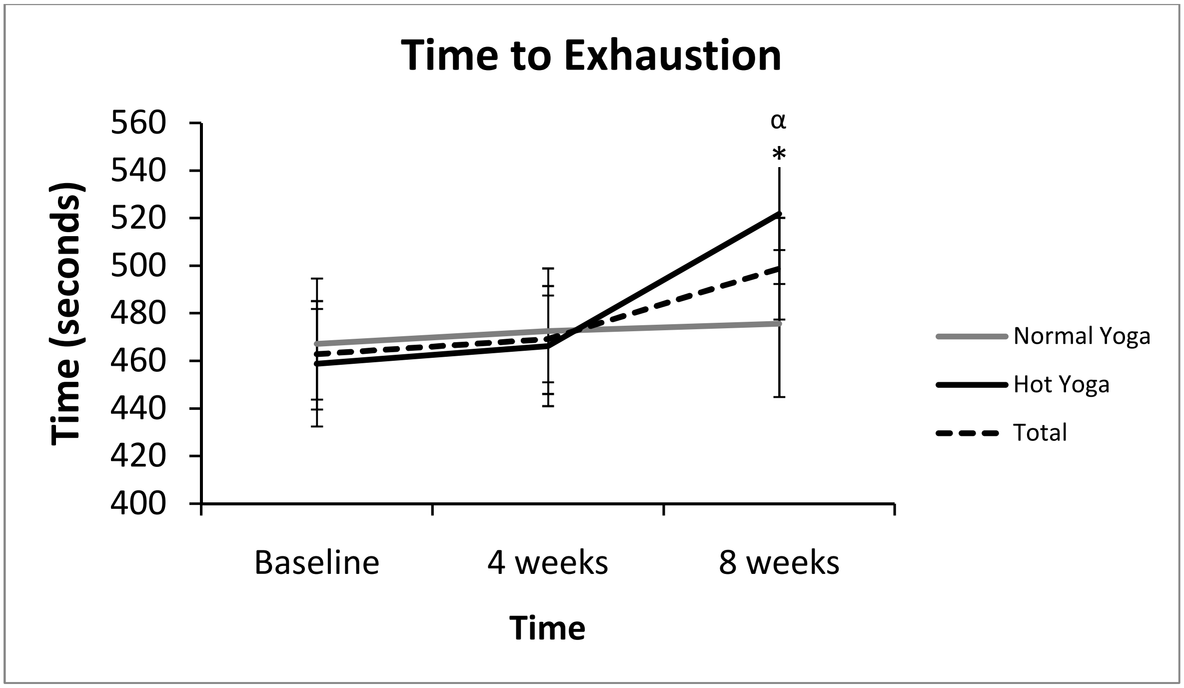


Figure 2.10: Time to exhaustion changes during a maximal aerobic test over the course of 8 week training program. A significant interaction was seen as time to exhaustion was greater at 8 weeks in the hot yoga training group compared to normal yoga group (* different from 4 weeks, $p<0.05$; α time-yoga type interaction, $p<0.05$).

2.4 Discussion

Yoga has become a popular mode of exercise training for many individuals. To meet the growing demand for a variety by participants, yoga studios offer a wide variety of yoga types for their members. Some examples of both the traditional and new forms include Hatha yoga, Vinyasa yoga, Ashtanga (Power yoga), Kundalini Yoga, Iyengar Yoga, Anusara Yoga, Restorative Yoga, ISHTA yoga (combing many styles), Naked yoga and Bikram (hot) yoga. While there is much anecdotal evidence of the health benefits of yoga practice, there is little data comparing the various forms. The present study examined the physiological and psychological health benefits of traditional room temperature Hatha yoga versus the more intense hot yoga in college aged adults. We first hypothesized that hot yoga participants would experience greater improvements than the norma-thermal yoga participants. Although this hypothesis was disproven, at both 4 and 8 weeks of regular yoga training, several variables were significantly altered, regardless of training group. These include reduced trait anxiety and reduced depression scores, a reduction in both systolic and diastolic blood pressure, increased flexibility, reduced body fat percent, and improved maximal oxygen consumption. It is important to note that these improvements were observed in a relatively healthy group of adults which is indicative of the power of this type of exercise training. Nonetheless, despite significant differences in room temperature, tympanic temperature, and intensity of exercise as measured by HR between room temperature yoga and hot yoga, the improvements in fitness measures indicated above were not different. This observation is intriguing given the increased cardiac strain on the hot yoga participants, but suggests that the physiological and psychological improvements were independent of the temperature of room.

High blood pressure or hypertension, characterized as systolic blood pressure >140 Hg and/or diastolic blood pressure >90Hg (61), is responsible for 13% of deaths globally and is the leading global risk for mortality in the world (57). Previous data regarding the ability of yoga training to reduce blood pressure is equivocal. Some researchers such as Smith et al. (2011), who used a similar college-age population in yoga training, found no change in blood pressure (75), while the present study contributes to the growing body of literature showing that yoga does reduce blood pressure (17,31,52). Moreover, the intensity of the cardiovascular stress of the two different practices of yoga seems to have no effect on blood pressure reduction. This supports the current theory that exercise training reduces systolic and diastolic blood pressure, irrespective of intensity and frequency (30,86).

Aerobic exercise has been the most widely studied and reported type of training to show clinically significant reductions in blood pressure and hypertension. The American College of Sports Medicine (ACSM) recommends an exercise regime of at least 30 minutes a day of moderate intensity aerobic exercise to those concerned with hypertension (62), which is consistent with the most recent recommendations for exercise participation for adults aged 18-64 years by the Canadian Society of Exercise Physiology (CSEP) which suggested 150 minutes of moderate to vigorous aerobic type activity each week (1). Yoga, however, is not considered an aerobic activity (29). In the present study, both normal temperature and hot yoga sessions were completed with estimated average MET readings of less than 3 METs per session, 2.5 and 2.6 METS for normal temperature and hot yoga, respectively. While it is important to note that the BodyMedia sensor device estimates METs based on step counting through an accelerometer, the galvanic skin response, which measure skin conductance, and skin temperature, heart rate and oxygen consumption are not included in the calculation of exercise work rate. For this reason, there is likely to be some error in the calculation of work in a type of exercise where static poses require prolonged muscular contractions and corresponding increases in energy expenditure. In argument against yoga not being an aerobic activity (29), yoga training in either environment improved cardiorespiratory fitness as measured by peak oxygen consumption (VO_{2peak}) at 4 weeks in a lowly active population. It is also interesting that blood pressure was reduced in healthy participants. As such, the findings of this study suggest that the current position stands on exercise and cardiovascular health should be reexamined since it appears that light exercise (yoga) is able to significantly reduce blood pressure and improve oxygen consumption.

In addition to aerobic type exercise, other modes of exercise have been assessed as treatment and prevention for hypertension, such as resistance training (16) and isometric contraction training (47,78). Although not usually described as an isometric contraction activity, holding yoga poses inherently involves sustained muscular contractions. It is possible that the resulting reduction in blood pressure after yoga training occurs because of the same mechanisms observed with isometric hand grip training and isometric leg presses. For example, isometric hand grip training programs with similar training schedules of 3 times per week for 8 weeks involving normotensive men and women can reduce systolic blood pressure (58). However, the exact mechanisms by which isometric contraction training modifies blood pressure remain unclear, but cannot be discounted as potentially contributing to the blood pressure lowering effects of yoga.

Further, it has been suggested that it is not the exercise component of yoga practice that is necessary for the reductions in blood pressure (9,64). Slow rhythmic breathing is an integral part of yoga practice and has been studied separately from their inclusion in yoga poses. By voluntarily controlling breathing patterns, autonomic nervous system functions, including heart rate variability and cardiac vagal tone can be influenced without physical exercise (22,53,77). Neuroendocrine function is also affected by yogic breathing, including decreased release of cortisol (23) and prolactin (43). Elevated cortisol is a major risk factor for cardiovascular disease including elevated blood pressure (87). Consequently, reductions in daily cortisol could manifest reduced resting blood pressure in the absence of cardiorespiratory changes. Prolactin levels can also be elevated with psychological stress and if chronic, can have serious effects on metabolic and reproductive health in men and women. It has been suggested that anxiety, depression and poor coping mechanisms can be linked to variable prolactin secretion (81). While not measured in the present study, these neural and neuroendocrine changes could have influenced blood pressure changes without significantly altering cardiorespiratory fitness.

Yoga, with its altered breathing, spiritual and ethical practices, has also been linked with decreased ratings of anxiety and depression (64). Smith et al. (2007) found that practicing yoga once a week is effective in reducing anxiety, stress and increasing mood ratings (74). In mild to moderately depressed college-aged adults, the non-exercise related components appear to be a necessity in the psychological mood altering effects of yoga (73). In the present study, trait anxiety, defined as the "relatively stable individual differences in anxiety proneness [referring] to a general tendency to respond with anxiety to perceived threats in the environment" (3) and depression scores (BDI), were significantly reduced after both 4 and 8 weeks of yoga training in both groups while state anxiety, a measure of current anxiety levels, was not. Again, the power of this type of activity is noted in the fact that the participants of the present study fit within the normal ranges of STAI and BDI scores prior to inclusion in the study and yet their scores were reduced even further (Table 2.3). Both the normal temperature and hot yoga sessions of the present study would be considered traditional integrated yoga in that breathing and spiritual components were included. Given that this was a field study in which members of the general public performed the yoga sessions alongside study participants, it would have been difficult to control for the amount of "spiritual" guidance given by the yoga instructors. Nonetheless, it is important to note that both the normal and hot yoga sessions were taught by the same instructors. These psychological changes appear to be clinically significant as well given that there was a strong correlation between trait anxiety measures and systolic blood pressure (r=0.431, p=0.018) prior to yoga training and at the 4 week mid-training test (r=0.372, p=0.037, Appendix K). In support of these findings, it has been shown that individuals with high scores on the STAI had significantly higher average systolic and diastolic blood pressure readings than individuals with low scores (65). Psychological stress has long been associated with cardiovascular disease (18,54). Participation in yoga seems to reduce this stress (10,73), whether through physical activity, social interaction, or exposure to psycho-spiritual philosophy. Since a significant correlation between blood pressure and trait anxiety was not observed at the third testing session, it is likely that with longer exercise training, it is the combination of reduced anxiety and physiological adaptations that may contribute to improved cardiovascular health.

The hypothesis that hot yoga, and the consequent increased cardiovascular strain during this type of activity, would induce significantly greater changes in all of the physiological health measures than normal temperature yoga was not supported. After 8 weeks of training, no significant differences were observed in any measures of health between normal and hot yoga. Although the studio temperature was hot enough to elicit a greater heart rate response, this did not correspond with any difference in cardiovascular or other physiological change. The average final temperature of the classroom during hot yoga was $30.6 \pm 0.24\,^{o}C$ (Figure 2.3). This is in contrast to the $40^{o}C$ room temperature at which traditional Bikram yoga classes are traditionally instructed to be performed at. This represents a limitation in using a field study to study these 2 yoga practices. Nonetheless, the results exemplify the elevated temperatures that the general public would experience if choosing to participate in hot yoga at this particular studio. It is not unreasonable to theorize that on average, the room did not get hot enough to elicit the same results as have been described by Bikram yoga enthusiasts. Nonetheless, it is a fair assumption that this field study will have relevance to practitioners across North America who do not have access to sufficiently environmentally controlled studios that could meet these guidelines. The range of temperatures experienced in real world hot yoga practice is likely both below and above the temperatures observed in the present study. However, it is important to reiterate that the hot yoga room temperatures did elicit both increased tympanic temperatures and HR responses during yoga as was hypothesized.

Two of the cardiovascular adaptations to heat acclimation are a reduced resting HR and increased plasma volume (59). While there was a trend for reduced hematocrit (indicative of increased plasma volume) in the hot yoga group, significant changes in these variables were not observed in the present study, suggesting that heat acclimation did not occur. Given that many studies regarding athletic performance and physiological adaptation to training in the heat have acclimated athletes on a daily basis (55), it is possible that the 3 weekly training sessions were not frequent enough to induce full acclimation. For example, previous research examining low-intensity exercise (cycling) in the heat in which a similar amount of exercise time to the yoga classes in the present study (90 versus 80 minutes, respectively) was used, had to expose participants to 35^{o}C heat daily to get full acclimation (24). However, a study conducted by Armstrong et al. (2005) used a similar protocol (i.e. circuit training females for 90 minutes 3 times weekly for 8 weeks in climatically controlled conditions of 36.0–37.0°C) and despite only heat induction 3 times weekly, observed heat acclimation in those participants (2). It is possible that higher temperature and longer duration of yoga training would have resulted in greater physiological adaptations associated with heat acclimation.

Participants in this study exhibited reductions in body fat percentage with yoga training (Figure 2.6). Improvements in body composition have wide reaching health benefits. Overweight and obesity are important public health problems in Canada, and accounted for approximately 57,000 deaths between the years 1985 and 2000 (27). Being overweight or obese is associated with metabolic syndrome, an increasingly prevalent disease and precursor to cardiovascular disease (40). Further, research has shown that the relative risk of hypertension, high cholesterol, and diabetes associated with a given BMI is higher at younger ages (11). Earlier adult weight gain appears to confer a greater risk for major ischemic heart disease and all-cause mortality than weight gain in later life (88). Yoga practice has been associated with attenuated weight gain in healthy, middle-aged men and women (51). Our findings that yoga can improve body composition in young adults who already fit within normal ranges suggests that this exercise modality could be a valuable tool in combatting obesity. This has even more generalizability given that the male (n=9) and female (n=15) participants had significantly different heights, body weights, body fat percentages, and aerobic capacities, the responses to both normal and hot yoga training were similar between sexes.

Greater flexibility is a well-documented result of yoga training (17,82). The increased range of motion can most likely be attributed to the static stretching nature of the yoga postures (82). It becomes increasingly more important with age to maintain flexibility as it is a health related component of physical fitness that relates to the range of motion available at joints (35).

It was also hypothesized that males would exhibit greater physiological improvements over females under normal conditions. This hypothesis was also disproven as there was no significant interaction for sex in any measures. Male and female participants were not matched for weekly leisure energy expenditure or fitness level. Because male participants were significantly more active and fit at baseline (Table 2.2), yoga may have provided a greater relative stress to adapt to for females. The difference between sexes at baseline may have contributed to the false hypothesis.

This was the first study to compare the health benefits of hot yoga with normal yoga. The results of this investigation indicate that 8 weeks of hatha yoga practice can improve multiple health-related parameters. Specifically, yoga training can reduce body fat percentage, blood pressure, ratings of depression and anxiety and improve flexibility and maximal oxygen consumption in a healthy population. However, in the present study, hot yoga did not have an independent significant effect on any measures of health. Whether it was performed in a heated room or not, yoga was able to confer significant health benefits to a young population. Yoga has long been heralded as a spiritual practice that connects the body and mind. The findings from this study join a growing body of literature suggesting that both physiological and psychological components of health can be improved with yoga practice. Further, psychological and physiological components of health correlate together. The yoga mind-body connection is a reminder that there needs to be a comprehensive approach to health.

2.5 Limitations

Training and data collection occurred in two different phases, June-August (summer) and September –November (fall). It is possible that the Windsor summer temperature may have influenced the cardiovascular responses to training in both groups more so than the fall time temperatures. For example, of the 62 days in July and August, the documented temperatures for 42 of those days was above 30^{o}C (Appendix L). This contrasts with the fall period of training in which none of the days were above 30^{o}C. Although participants' reported activity levels did not significantly change over the course of their training, they were not asked to report how frequently they were outdoors or if their places of residence had air conditioning. These environmental heat changes may have influenced the magnitude of physiological adaptations due to the yoga training. In fact, seasonal differences have been shown previously to affect heat acclimation factors. The core inter-threshold zone (CIZ), defined as the range between core temperature at the onset of shivering and that at the onset of sweating. Results from Kakitsuba et al (2011) suggest that greater exposure to light in the summer months can lead to a greater CIZ, possibly making those who participated in summer training less likely to sweat at the same core temperature than they would in the fall. While it cannot completely be eliminated as a possible confounding variable, the inclusion of time of year as an independent variable did not change the study outcomes between the 10 participants who completed the full training protocol in the summer compared with the 14 participants who completed the full study in the fall (46).

Blood pressure measurements could also have been skewed by the Dinamap measuring technique. Some research suggests that the cuff can give highly variable readings and that multiple readings are needed to get a more accurate blood pressure output (67). Although this protocol was not used, blood pressure measurements were all within the healthy range and remained highly correlated through the measurements at baseline, 4 weeks and 8 weeks.

Individual previous heat acclimation may also be a confounding variable. A study conducted by Tetievsky et al. (2008) showed that long term heat acclimation activated gene transcription factors of Hsp70 genes, and antiapoptotic genes which stay elevated even after a month of deacclimation (80). Further, they found that the re-induction of heat acclimation after its loss occurs markedly faster than that during the first time an individual is heat acclimated (78). This information would be difficult to ascertain therefore was not collected on participants of the present study. Nonetheless, it is possible that this may have washed out the magnitude of differences seen in this study. As noted, hydration status of participants could have also been a confounding variable in the rate of heat acclimation (68) and future studies should consider monitoring hydration status and fluid intake during yoga training.

2.6 Future Directions

Despite the relatively low aerobic intensity of yoga practice, it has implications on cardiovascular health for both men and women. For sedentary individuals especially, improvements in flexibility, anxiety, blood pressure, and body composition have long reaching effects on quality of life and mortality. Given the results of yoga practice in young healthy participants, benefits of yoga in older or diseased individuals could be great. Also, the results of this study were specific to young beginner practitioners at one Hatha yoga studio; further studies could examine a wider range of experienced practitioners at studios specific to Bikram or Maksha yoga, where room temperatures are much higher. Also, many positive adaptations of heat acclimation are only observed intracellularly. It would be interesting in the future to examine if gene expression changes are occurring providing cardio-protective benefits beyond the most commonly measured.

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Appendices

Appendix A: REB Approval

Office of the Research Ethics Board

University of Windsor
thinking forward

Today's Date: May 12, 2011
Principal Investigator: Ms. Kalin Gawinski/Ms. Michelle Dotzert/Dr. Kevin Milne
REB Number: 28877
Research Project Title: REB# 10-241: The effects of Bikram Yoga training on physiological fitness in college aged men and women.
Clearance Date: May 12, 2011
Project End Date: June 30, 2011
Milestones:
Renewal Due-2011/06/30(Pending)

This is to inform you that the University of Windsor Research Ethics Board (REB), which is organized and operated according to the Tri-Council Policy Statement and the University of Windsor Guidelines for Research Involving Human Subjects, has granted approval to your research project on the date noted above. This approval is valid only until the Project End Date.

A Progress Report or Final Report is due by the date noted above. The REB may ask for monitoring information at some time during the project's approval period.

During the course of the research, no deviations from, or changes to, the protocol or consent form may be initiated without prior written approval from the REB. Minor change(s) in ongoing studies will be considered when submitted on the Request to Revise form.

Investigators must also report promptly to the REB:
a) changes increasing the risk to the participant(s) and/or affecting significantly the conduct of the study;
b) all adverse and unexpected experiences or events that are both serious and unexpected;
c) new information that may adversely affect the safety of the subjects or the conduct of the study.

Forms for submissions, notifications, or changes are available on the REB website: www.uwindsor.ca/reb. If your data is going to be used for another project, it is necessary to submit another application to the REB. We wish you every success in your research.

[redacted]

Pierre Boulos, Ph.D.
Chair, Research Ethics Board

This is an official document. Please retain the original in your files.

401 Sunset Avenue, Windsor, Ontario, Canada N9B 3P4 . tel: 519.253.3000 ext. 3948 . web: www.uwindsor.ca/reb

Appendix B: Par-Q

Physical Activity Readiness Questionnaire - PAR-Q (revised 2002)

PAR-Q & YOU

(A Questionnaire for People Aged 15 to 69)

Regular physical activity is fun and healthy, and increasingly more people are starting to become more active every day. Being more active is very safe for most people. However, some people should check with their doctor before they start becoming much more physically active.

If you are planning to become much more physically active than you are now, start by answering the seven questions in the box below. If you are between the ages of 15 and 69, the PAR-Q will tell you if you should check with your doctor before you start. If you are over 69 years of age, and you are not used to being very active, check with your doctor.

Common sense is your best guide when you answer these questions. Please read the questions carefully and answer each one honestly: check YES or NO.

YES	NO		
☐	☐	1.	**Has your doctor ever said that you have a heart condition and that you should only do physical activity recommended by a doctor?**
☐	☐	2.	**Do you feel pain in your chest when you do physical activity?**
☐	☐	3.	**In the past month, have you had chest pain when you were not doing physical activity?**
☐	☐	4.	**Do you lose your balance because of dizziness or do you ever lose consciousness?**
☐	☐	5.	**Do you have a bone or joint problem (for example, back, knee or hip) that could be made worse by a change in your physical activity?**
☐	☐	6.	**Is your doctor currently prescribing drugs (for example, water pills) for your blood pressure or heart condition?**
☐	☐	7.	**Do you know of any other reason why you should not do physical activity?**

If you answered

YES to one or more questions

Talk with your doctor by phone or in person BEFORE you start becoming much more physically active or BEFORE you have a fitness appraisal. Tell your doctor about the PAR-Q and which questions you answered YES.

- You may be able to do any activity you want — as long as you start slowly and build up gradually. Or, you may need to restrict your activities to those which are safe for you. Talk with your doctor about the kinds of activities you wish to participate in and follow his/her advice.
- Find out which community programs are safe and helpful for you.

NO to all questions

If you answered NO honestly to all PAR-Q questions, you can be reasonably sure that you can:

- start becoming much more physically active – begin slowly and build up gradually. This is the safest and easiest way to go.
- take part in a fitness appraisal – this is an excellent way to determine your basic fitness so that you can plan the best way for you to live actively. It is also highly recommended that you have your blood pressure evaluated. If your reading is over 144/94, talk with your doctor before you start becoming much more physically active.

DELAY BECOMING MUCH MORE ACTIVE:

- if you are not feeling well because of a temporary illness such as a cold or a fever – wait until you feel better; or
- if you are or may be pregnant – talk to your doctor before you start becoming more active.

PLEASE NOTE: If your health changes so that you then answer YES to any of the above questions, tell your fitness or health professional. Ask whether you should change your physical activity plan.

Informed Use of the PAR-Q: The Canadian Society for Exercise Physiology, Health Canada, and their agents assume no liability for persons who undertake physical activity, and if in doubt after completing this questionnaire, consult your doctor prior to physical activity.

No changes permitted. You are encouraged to photocopy the PAR-Q but only if you use the entire form.

NOTE: If the PAR-Q is being given to a person before he or she participates in a physical activity program or a fitness appraisal, this section may be used for legal or administrative purposes.

"I have read, understood and completed this questionnaire. Any questions I had were answered to my full satisfaction."

NAME ____

SIGNATURE ____ DATE ____________________

SIGNATURE OF PARENT ____ WITNESS ____________________
or GUARDIAN (for participants under the age of majority)

Note: This physical activity clearance is valid for a maximum of 12 months from the date it is completed and becomes invalid if your condition changes so that you would answer YES to any of the seven questions.

Supported by: Health Canada Santé Canada

continued on other side...

Appendix C: Personal Information Form

University of Windsor

Personal Information

Name:___________________________________
Date:_____________________________

DOB: __ __ /__ __ /_________
D D M M Year

Sex: Male Female Prefer not to disclose

Contact Information: ____
(phone # and/or email address)

Are you currently **pregnant** or planning to become pregnant in the next 2 months: Yes No

Are you currently **dieting** or planning to diet in the next 2 months: Yes No

Have you recently had any changes made to your medication? Yes No

FEMALES ONLY Last start date of menstrual cycle: ______________________

Appendix D: Leisure-Time Exercise Questionnaire

Godin Leisure-Time Exercise Questionnaire

1. During a typical 7-Day period (a week), how many times on the average do you do the following kinds of exercise for more than 15 minutes during your free time (write on each line the appropriate number).

Times Per Week

a) STRENUOUS EXERCISE
(HEART BEATS RAPIDLY) ____________

(e.g., running, jogging, hockey, football, soccer, squash, basketball, cross country skiing, judo, roller skating, vigorous swimming, vigorous long distance bicycling)

b) MODERATE EXERCISE ____________
(NOT EXHAUSTING)

(e.g., fast walking, baseball, tennis, easy bicycling, volleyball, badminton, easy swimming, alpine skiing, popular and folk dancing)

c) MILD EXERCISE ____________
(MINIMAL EFFORT)

(e.g., yoga, archery, fishing from river bank, bowling, horseshoes, golf, snow-mobiling, easy walking

2. During a typical 7-Day period (a week), in your leisure time, how often do you engage in any regular activity long enough to work up a sweat (heart beats rapidly)?

1. Often _______ 2. Sometimes _______ 3. Rarely/Never _______

Appendix E: Intention to Exercise Questionnaire

Initial Survey

Please complete the following with regard to your current feelings about exercise. Circle the answer that BEST represents your feelings.

1. How knowledgeable are you about the practise of Yoga and Yoga exercises?

1	2	3	4	5	6	7
No knowledge at all						Very knowledgeable

2. How enjoyable is it for you to complete exercise or physical activities long enough to get sweaty 3-days/week?

1	2	3	4	5	6	7
Not enjoyable at all			Moderately enjoyable			Extremely enjoyable

3. How confident are you that you could complete exercise or physical activities long enough to get sweaty 3-days/week?

1	2	3	4	5	6	7	8	9	10
Not at all confident			Moderately confident				Completely confident		

4. How confident are you that you could physically complete a Yoga session of at least 30 minutes 3 days/week?

1	2	3	4	5	6	7	8	9	10
Not at all confident			Moderately confident				Completely confident		

5. I believe that Yoga exercises are physically demanding.

1	2	3	4	5	6	7
Strongly disagree						Strongly agree

6. At the conclusion of this study, I intend to add an instructor-led Yoga session of at least 30 minutes to my leisure time physical activity ...

    a. ...at least once per week

1	2	3	4	5	6	7
Strongly disagree						Strongly agree

    b. ...at least three times per week

1	2	3	4	5	6	7
Strongly disagree						Strongly agree

    c. ...at least five times per week

1	2	3	4	5	6	7
Strongly disagree						Strongly agree

7. Have you participated in an instructor-led Yoga session at least twice a week during your leisure time within the past 2 months?

YES / NO

b) If NO, how often did you participate in an instructor-led Yoga session during your leisure time within the past 2 months?

1	2	3	4
Not at all	About once a month	About two to three times a month	About once a week

8. Have you participated in a self-led Yoga session at least twice a week during your leisure time within the past 2 months?

YES / NO

b) If NO, how often did you participate in an self-led Yoga session during your leisure time within the past 2 months?

1	2	3	4
Not at all	About once a month	About two to three times a month	About once a week

9. The best thing about instructor-led Yoga sessions is ...

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10. The worst thing about instructor-led Yoga sessions is ...

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Appendix F: Beck's Depression Inventory (BDI)

Instructions: This questionnaire consists of 21 groups of statements. Please read each group of statements carefully, and then pick out the **one statement** in each group that best describes the way you have been feeling during the **past two weeks, including today.** Circle the number beside the statement you have picked. If several statements in the group seem to apply equally well, circle the highest number for that group. Be sure that you do no choose more than one statement for any group, including Item 16 (Changes in Sleeping Pattern) or Item 18 (Changes in Appetite).

1. 0 I do not feel sad.
   1 I feel sad.
   2 I am sad all the time and I can't snap out of it.
   3 I am so sad and unhappy that I can't stand it.

2. 0 I am not particularly discouraged about the future.
   1 I feel discouraged about the future.
   2 I feel I have nothing to look forward to.
   3 I feel the future is hopeless and that things cannot improve.

3. 0 I do not feel like a failure.
   1 I feel I have failed more than the average person.
   2 As I look back on my life, all I can see is a lot of failures.
   3 I feel I am a complete failure as a person.

4. 0 I get as much satisfaction out of things as I used to.
   1 I don't enjoy things the way I used to.
   2 I don't get real satisfaction out of anything anymore.
   3 I am dissatisfied or bored with everything.

5. 0 I don't feel particularly guilty.
   1 I feel guilty a good part of the time.
   2 I feel quite guilty most of the time.
   3 I feel guilty all of the time.

6. 0 I don't feel I am being punished.
   1 I feel I may be punished.
   2 I expect to be punished.
   3 I feel I am being punished.

7. 0 I don't feel disappointed in myself.
   1 I am disappointed in myself.
   2 I am disgusted with myself.
   3 I hate myself.

8. 0 I don't feel I am any worse than anybody else.
   1 I am critical of myself for my weaknesses or mistakes.
   2 I blame myself all the time for my faults.
   3 I blame myself for everything bad that happens.

9. 0 I don’t have any thoughts of killing myself.
1 I have thoughts of killing myself, but I would not carry them out.
2 I would like to kill myself.
3 I would kill myself if I had the chance.

10. 0 I don't cry any more than usual.
1 I cry more now than I used to.
2 I cry all the time now.
3 I used to be able to cry, but now I can't cry even though I want to.

11. 0 I am no more irritated by things than I ever was.
1 I am slightly more irritated now than usual.
2 I am quite annoyed or irritated a good deal of the time.
3 I feel irritated all the time.

12. 0 I have not lost interest in other people.
1 I am less interested in other people than I used to be.
2 I have lost most of my interest in other people.
3 I have lost all of my interest in other people.

13. 0 I make decisions about as well as I ever could.
1 I put off making decisions more than I used to.
2 I have greater difficulty in making decisions more than I used to.
3 I can't make decisions at all anymore.

14. 0 I don't feel that I look any worse than I used to.
1 I am worried that I am looking old or unattractive.
2 I feel there are permanent changes in my appearance that make me unattractive.
3 I believe that I look ugly.

15. 0 I can work about as well as before.
1 It takes an extra effort to get started at doing something.
2 I have to push myself very hard to do anything.
3 I can't do any work at all.

16. 0 I can sleep as well as usual.
1 I don't sleep as well as I used to.
2 I wake up 1-2 hours earlier than usual and find it hard to get back to sleep.
3 I wake up several hours earlier than I used to and cannot get back to sleep.

17. 0 I don't get more tired than usual.
1 I get tired more easily than I used to.
2 I get tired from doing almost anything.
3 I am too tired to do anything.

18. 0 My appetite is no worse than usual.
    1 My appetite is not as good as it used to be.
    2 My appetite is much worse now.
    3 I have no appetite at all anymore.

19. 0 I haven't lost much weight, if any, lately.
    1 I have lost more than five pounds.
    2 I have lost more than ten pounds.
    3 I have lost more than fifteen pounds.

20. 0 I am no more worried about my health than usual.
    1 I am worried about problems like aches, pains, upset stomach, or constipation.
    2 I am very worried about physical problems and it's hard to think of much else.
    3 I am so worried about my physical problems that I cannot think of anything else.

21. 0 I have not noticed any recent change in my interest in sex.
    1 I am less interested in sex than I used to be.
    2 I have almost no interest in sex.
    3 I have lost interest in sex completely.

Appendix G: State and Trait Anxiety Inventory (STAI) Questionnaire

Due to the terms of use of the STAI (see next page), a sample of only 5 questions may be used in this document.

Sample Items

I feel calm...1 2 3 4

I am tense..1 2 3 4

I feel self confident...1 2 3 4

I feel nervous...1 2 3 4

I am relaxed...1 2 3 4 mind garden

www.mindgarden.com

To whom it may concern,

This letter is to grant permission for the above named person to use the following copyright material;

Instrument: ***State-Trait Anxiety Inventory for Adults***

Authors: ***Charles D. Spielberger, in collaboration with R.L. Gorsuch, G.A. Jacobs, R. Lushene, and P.R. Vagg***

Copyright: ***1968, 1977 by Charles D. Spielberger***

for his/her thesis research.

Five sample items from this instrument may be reproduced for inclusion in a proposal, thesis, or dissertation.

The entire instrument may not be included or reproduced at any time in any other published material.

Sincerely,

[redacted]

Robert Most
Mind Garden, Inc.
www.mindgarden.com

Appendix H: Image of Bod Pod for Air Displacement Plythysmography

Appendix I: Exit Survey

Exit Survey

Please complete the following with regard to your current feelings about Yoga and exercise. Circle the answer that BEST represents your feelings.

11. How knowledgeable are you about the practise of Yoga and Yoga exercises?

1	2	3	4	5	6	7
No knowledge at all						Very knowledgeable

12. How enjoyable is it for you to complete exercise or physical activities long enough to get sweaty 3-days/week?

1	2	3	4	5	6	7
Not enjoyable at all			Moderately enjoyable			Extremely enjoyable

13. How confident are you that you could complete exercise or physical activities long enough to get sweaty 3-days/week?

1	2	3	4	5	6	7	8	9	10
Not at all confident			Moderately confident				Completely confident		

14. How confident are you that you could physically complete a Yoga session of at least 30 minutes 3 days/week?

1	2	3	4	5	6	7	8	9	10
Not at all confident			Moderately confident				Completely confident		

15. I believe that Yoga exercises are physically demanding.

1	2	3	4	5	6	7
Strongly disagree						Strongly agree

16. At the conclusion of this study, I intend to add an instructor-led Yoga session of at least 30 minutes to my leisure time physical activity ...

d. ...at least once per week

1	2	3	4	5	6	7
Strongly disagree						Strongly agree

e. ...at least three times per week

1	2	3	4	5	6	7
Strongly disagree						Strongly agree

f. ...at least five times per week

1	2	3	4	5	6	7
Strongly disagree						Strongly agree

17. Have you participated in a self-led Yoga session at least twice a week during your leisure time within the past 2 months?

YES / NO

b) If NO, how often did you participate in any self-led Yoga session during your leisure time within the past 2 months?

1	2	3	4
Not at all	About once a month	About two to three times a month	About once a week

18. The best thing about instructor-led Yoga sessions is ...

____

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19. The worst thing about instructor-led Yoga sessions is ...

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20. When scheduling Yoga sessions into my leisure time physical activity, I would prefer to include...

1	2	3	4
Hot Yoga	Regular Yoga	A mixture of Hot and Regular Yoga	No Yoga sessions

Appendix J: Table of physiological changes

			Baseline			4 Weeks			8 Weeks		
Parameters	**YOGA**	**SEX**	Mean		SD	Mean		SD	Mean		SD
Weight (kg)	Normal TEMP	Female	72.0	±	13.0	72.0	±	13.6	71.1	±	14.6
		Male	81.7	±	20.3	81.4	±	20.9	81.0	±	20.5
		Total	75.0	±	15.4	74.9	±	15.9	74.4	±	16.5
	Hot	Female	61.7	±	11.3	63.1	±	11.0	65.2	±	9.9
		Male	82.0	±	9.9	80.9	±	8.8	79.8	±	9.5
		Total	70.4	±	14.7	70.7	±	13.3	71.3	±	12.0
	Total	Female	67.2 □	±	13.0	67.8	±	12.9	68.3	±	12.5
		Male	81.9	±	13.9	81.1	±	13.8	80.3	±	14.3
		Total	72.6	±	14.9	72.7	±	14.5	72.8	±	14.2
BMI (kg/m2)	Normal TEMP	Female	24.7	±	5.4	24.7	±	5.6	24.4	±	5.9
		Male	26.0	±	4.1	25.9	±	4.4	25.8	±	4.2
		Total	25.1	±	4.9	25.1	±	5.1	24.8	±	5.2
	Hot	Female	22.2	±	4.4	22.8	±	4.6	23.5	±	4.4
		Male	25.7	±	3.3	25.4	±	3.0	25.0	±	3.2
		Total	23.7	±	4.2	23.9	±	4.1	24.1	±	3.9
	Total	Female	23.6	±	5.0	23.8	±	5.1	23.9	±	5.1
		Male	25.9	±	3.4	25.6	±	3.4	25.3	±	3.5
		Total	24.4	±	4.5	24.5	±	4.5	24.5	±	4.5
Body Fat (%)	Normal TEMP	Female	36.3	±	7.6	34.5	±	8.2	34.8	±	7.8
		Male	27.0	±	12.7	24.5	±	12.4	24.1	±	12.1
		Total	33.4	±	9.9	31.4	±	10.3	31.2	±	10.3
	Hot	Female	28.7	±	8.6	27.1	±	6.5	28.6	±	5.5
		Male	26.0	±	7.5	24.9	±	8.3	25.7	±	9.9
		Total	27.5	±	8.0	26.1	±	7.1	27.4	±	7.4
	Total	Female	32.7	±	8.8	31.0	±	8.1	31.9	±	7.3
		Male	26.4	±	9.2	24.7	±	9.5	25.0	±	10.2
		Total	30.4	±	9.3	28.7*	±	9.0	29.3*	±	9.0
SBP (mmHg)	Normal TEMP	Female	100.4	±	7.2	98.6	±	5.7	98.0	±	10.4
		Male	115.5	±	13.3	108.8	±	12.4	107.5	±	10.4
		Total	105.1	±	11.4	101.7	±	9.2	101.2	±	10.9
	Hot	Female	102.1	±	12.9	96.9	±	8.2	86.9	±	35.6
		Male	117.0	±	9.9	106.7	±	5.8	109.8	±	5.1
		Total	108.5	±	13.6	101.1	±	8.6	96.4	±	29.0
	Total	Female	101.2 □	±	10.0	97.8	±	6.8	92.8	±	25.1
		Male	116.4	±	10.7	107.5	±	8.4	108.8	±	7.4
		Total	106.9	±	12.5	101.4*	±	8.7	98.8*	±	21.6
DBP (mmHg)	Normal TEMP	Female	61.3	±	8.5	57.9	±	8.2	59.8	±	7.4
		Male	61.5	±	7.9	60.5	±	13.8	60.8	±	9.2
		Total	61.4	±	8.0	58.7	±	9.7	60.1	±	7.6
	Hot	Female	63.1	±	7.4	61.6	±	5.9	58.9	±	7.1
		Male	65.3	±	5.9	62.2	±	10.2	60.6	±	6.7
		Total	64.1	±	6.6	61.9	±	7.6	59.6	±	6.7
	Total	Female	62.2	±	7.8	59.6	±	7.2	59.3	±	7.0

		Male	63.8	±	6.6	61.5	±	11.0	60.7	±	7.3
		Total	62.8	±	7.3	60.3	±	8.7	59.8*	±	7.0
Resting Heart Rate (bpm)	Normal TEMP	Female	63.2	±	11.6	66.6	±	7.9	63.6	±	9.4
		Male	65.3	±	13.8	70.5	±	12.7	71.5	±	15.5
		Total	63.8	±	11.8	67.8	±	9.2	66.3	±	11.7
	Hot	Female	71.9	±	12.4	68.0	±	16.1	67.7	±	9.0
		Male	67.5	±	9.1	69.8	±	12.4	63.2	±	12.7
		Total	70.0	±	11.0	68.8	±	14.2	65.8	±	10.4
	Total	Female	67.3	±	12.4	67.2	±	12.1	65.5	±	9.1
		Male	66.6	±	10.5	70.1	±	11.8	66.9	±	13.8
		Total	67.0	±	11.6	68.3	±	11.8	66.0	±	10.8
Hematocrit (%)	Normal TEMP	Female	39.3	±	2.7	38.7	±	3.6	39.3	±	1.9
		Male	46.0	±	4.3	45.3	±	2.5	47.0	±	1.4
		Total	41.4	±	4.5	40.7	±	4.5	41.8	±	4.2
	Hot	Female	40.9	±	1.7	40.1	±	3.3	39.1	±	2.5
		Male	44.8	±	4.9	44.8	±	4.2	43.4	±	3.6
		Total	42.6	±	3.9	42.2	±	4.3	40.9	±	3.6
	Total	Female	40.1 □	±	2.4	39.4	±	3.4	39.2	±	2.1
		Male	45.3	±	4.5	45.0	±	3.5	45.0	±	3.3
		Total	42.0	±	4.1	41.4	±	4.4	41.4*	±	3.8
Flexibility (cm)	Normal TEMP	Female	25.1	±	10.3	38.7	±	3.6	34.9	±	6.3
		Male	26.8	±	9.8	45.3	±	2.5	37.0	±	6.9
		Total	25.6	±	9.8	40.7	±	4.5	35.6	±	6.3
	Hot	Female	27.8	±	13.7	40.1	±	3.3	36.0	±	9.1
		Male	26.6	±	8.5	44.8	±	4.2	36.7	±	5.8
		Total	27.3	±	11.4	42.2	±	4.3	36.3	±	7.6
	Total	Female	26.3	±	11.7	39.4	±	3.4	35.4	±	7.5
		Male	26.7	±	8.5	45.0	±	3.5	36.8	±	5.9
		Total	26.4	±	10.4	41.4*	±	4.4	35.9* $^{\alpha}$	±	6.9
VO_{2peak} (mL/kg/min)	Normal TEMP	Female	23.0	±	7.0	24.5	±	6.2	21.5	±	3.9
		Male	30.0	±	8.8	33.2	±	7.7	33.5	±	9.0
		Total	25.3	±	8.0	27.4	±	7.7	25.5	±	8.1
	Hot	Female	22.7	±	3.9	25.0	±	4.7	24.8	±	3.8
		Male	31.5	±	13.1	36.2	±	11.3	30.2	±	9.0
		Total	26.4	±	9.5	29.7	±	9.6	27.1	±	6.7
	Total	Female	22.9 □	±	5.5	24.7	±	5.4	23.0	±	4.1
		Male	30.8	±	10.8	34.9	±	9.4	31.7	±	8.6
		Total	25.9	±	8.6	28.5*	±	8.6	26.3	±	7.3
Time to Exhaustion (seconds)	Normal TEMP	Female	407.0	±	65.5	419.8	±	65.6	417.8	±	67.7
		Male	602.3	±	59.9	591.0	±	60.1	591.5	±	58.4
		Total	467.1	±	112.0	472.5	±	102.7	475.7	±	105.7
	Hot	Female	391.8	±	53.3	404.9	±	49.5	440.3	±	95.1
		Male	548.2	±	149.5	548.0	±	136.6	636.0	±	163.3
		Total	458.8	±	128.8	466.2	±	117.9	521.8$^{\beta}$	±	157.4
	Total	Female	399.8□	±	58.8	412.8	±	57.3	428.3	±	79.4
		Male	569.8	±	120.0	565.2	±	109.8	616.2	±	123.1
		Total	462.8	±	118.8	469.2	±	108.7	498.8*	±	133.2

There were 27 participants were analyzed at baseline and 4 weeks. Only 24 participants were used in the 8 week analysis due to drop out.

*Significantly different from baseline ($p<0.05$)

$^{\alpha}$ Significantly different from 4 weeks ($p<0.05$)

$^{\beta}$ Significantly different from normal temperature yoga training ($p<0.05$)

□ Significantly different from males ($p<0.05$)

Appendix K: F-values for Repeated Measures ANOVA

Source	Measure	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Time	Weight	0.92	2	0.46	0.14	0.87	0.01
	BMI	0.11	2	0.05	0.12	0.89	0.01
	BF	39.80	2	19.90	4.24	0.02	0.18
	HRrest	37.47	2	18.74	0.44	0.65	0.02
	SBP	449.46	2	224.73	7.20	0.00	0.27
	DBP	178.16	2	89.08	4.56	0.02	0.19
	HEM	4.93	2	2.47	0.62	0.55	0.03
	Flex	2916.71	2	1458.36	40.29	0.00	0.67
	VO2	0.63	2	0.31	5.61	0.01	0.22
	Time_exhaust	21654.36	2	10827.18	7.72	0.00	0.28
	BDI	43.97	2	21.98	2.59	0.09	0.11
	STAI_S	108.53	2	54.27	1.58	0.22	0.07
	STAI_T	751.04	2	375.52	17.52	0.00	0.47
Time * YOGA	Weight	2.36	2	1.18	0.37	0.70	0.02
	BMI	0.42	2	0.21	0.47	0.63	0.02
	BF	6.82	2	3.41	0.73	0.49	0.04
	HRrest	160.72	2	80.36	1.89	0.16	0.09
	SBP	33.22	2	16.61	0.53	0.59	0.03
	DBP	35.01	2	17.51	0.90	0.42	0.04
	HEM	6.57	2	3.28	0.82	0.45	0.04
	Flex	1.82	2	0.91	0.03	0.98	0.00
	VO2	0.04	2	0.02	0.37	0.70	0.02
	Time_exhaust	21117.63	2	10558.81	7.53	0.00	0.27
	BDI	5.86	2	2.93	0.34	0.71	0.02
	STAI_S	32.99	2	16.50	0.48	0.62	0.02
	STAI_T	39.44	2	19.72	0.92	0.41	0.04
Time * Sex	Weigh	9.74	2	4.87	1.51	0.23	0.07
	BMI	1.17	2	0.59	1.31	0.28	0.06
	BF	0.16	2	0.08	0.02	0.98	0.00
	HRrest	83.63	2	41.82	0.99	0.38	0.05
	SBP	47.99	2	23.99	0.77	0.47	0.04
	DBP	15.30	2	7.65	0.39	0.68	0.02
	HEM	6.99	2	3.50	0.88	0.43	0.04
	Flex	43.25	2	21.62	0.60	0.56	0.03
	VO2	0.09	2	0.05	0.84	0.44	0.04
	Time_exhaust	2327.03	2	1163.52	0.83	0.44	0.04
	BDI	21.45	2	10.72	1.26	0.29	0.06
	STAI_S	91.86	2	45.93	1.34	0.27	0.06
	STAI_T	88.19	2	44.10	2.06	0.14	0.09
Time * YOGA * Sex	Weight	7.26	2	3.63	1.13	0.33	0.05
	BMI	0.91	2	0.46	1.02	0.37	0.05
	BF	1.95	2	0.98	0.21	0.81	0.01
	HRrest	16.29	2	8.15	0.19	0.83	0.01
	SBP	19.57	2	9.78	0.31	0.73	0.02

	DBP	46.32	2	23.16	1.18	0.32	0.06
	HEM	0.33	2	0.17	0.04	0.96	0.00
	Flex	4.87	2	2.43	0.07	0.94	0.00
	VO2	0.46	2	0.23	4.08	0.02	0.17
	Time_exhaust	3045.38	2	1522.69	1.09	0.35	0.05
	BDI	38.26	2	19.13	2.25	0.12	0.10
	STAI_S	6.29	2	3.14	0.09	0.91	0.01
	STAI_T	60.85	2	30.42	1.42	0.25	0.07

Results from 3-way repeated measures ANOVA (n=24).

Appendix L: Correlation between trait anxiety and systolic blood pressure

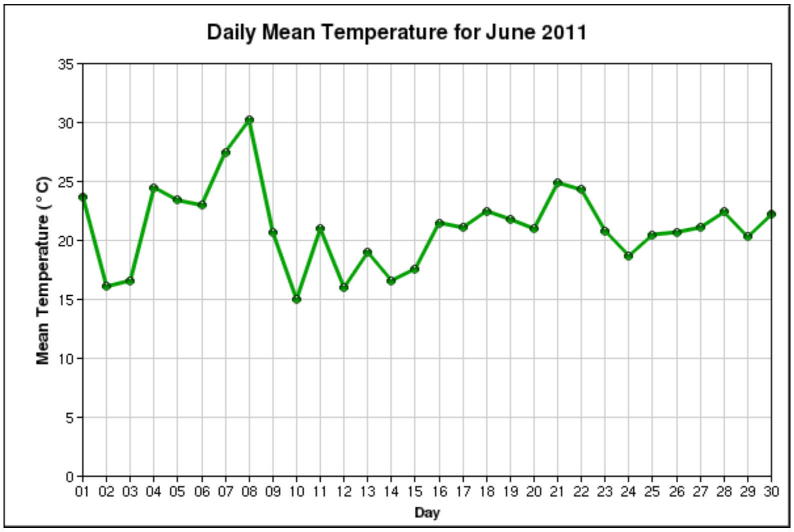
Correlations		SBP at baseline	SBP at 4 weeks	SBP at 8 weeks	Trait Anxiety at Baseline	Trait Anxiety at 4 Weeks	Trait Anxiety at 8 Weeks
SBP at baseline	Pearson Correlation	1	.717**	.620**	.431*	.323	.168
	Sig. (1-tailed)		.000	.001	.018	.062	.216
SBP at 4 weeks	Pearson Correlation	.717**	1	.673**	.430*	.372*	.408*
	Sig. (1-tailed)	.000		.000	.018	.037	.024
SBP at 8 weeks	Pearson Correlation	.620**	.673**	1	.223	.327	.166
	Sig. (1-tailed)	.001	.000		.147	.059	.219
Trait Anxiety at Baseline	Pearson Correlation	.431*	.430*	.223	1	.878**	.767**
	Sig. (1-tailed)	.018	.018	.147		.000	.000
Trait Anxiety at 4 Weeks	Pearson Correlation	.323	.372*	.327	.878**	1	.828**
	Sig. (1-tailed)	.062	.037	.059	.000		.000
Trait Anxiety at 8 Weeks	Pearson Correlation	.168	.408*	.166	.767**	.828**	1
	Sig. (1-tailed)	.216	.024	.219	.000	.000	

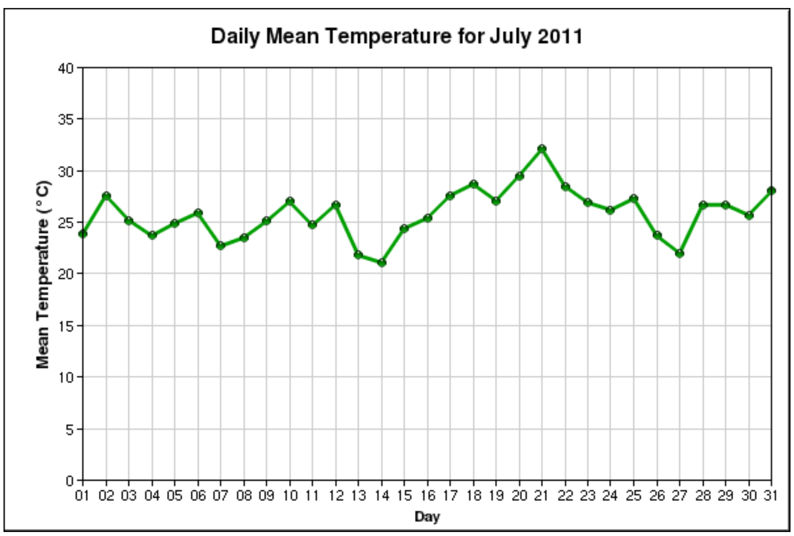
**. Correlation is significant at the 0.01 level (1-tailed).

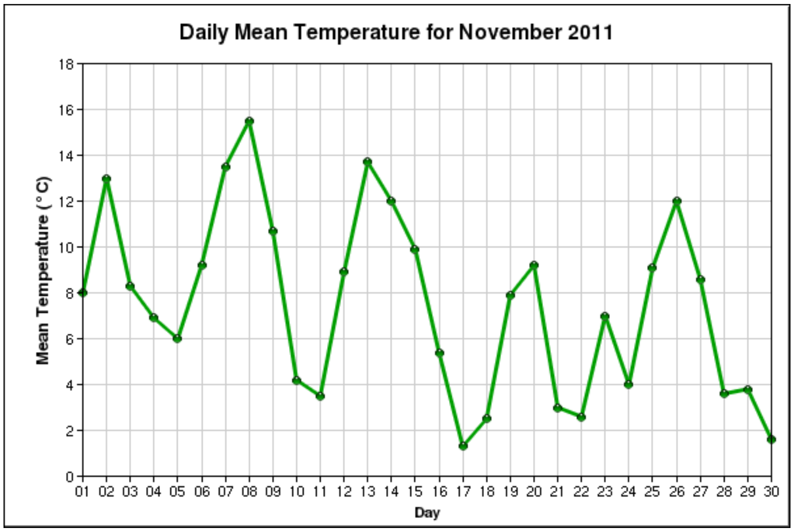
*. Correlation is significant at the 0.05 level (1-tailed).

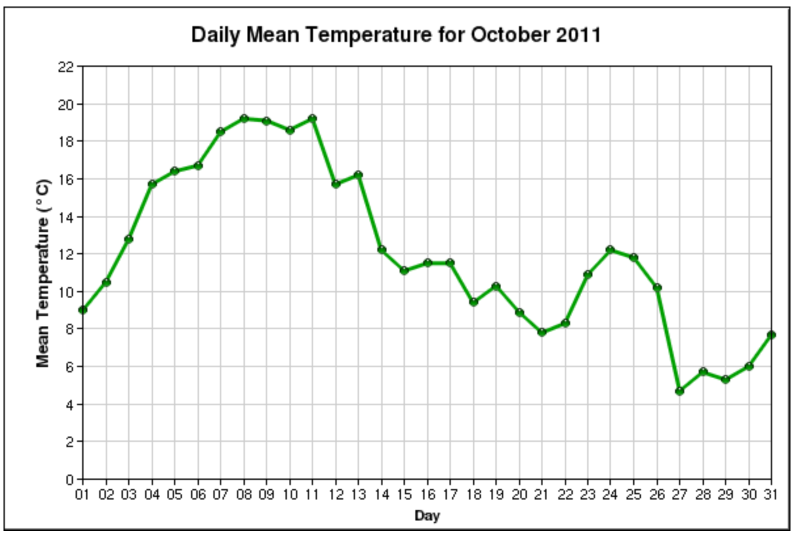
Appendix M: Windsor Climate Data 2011

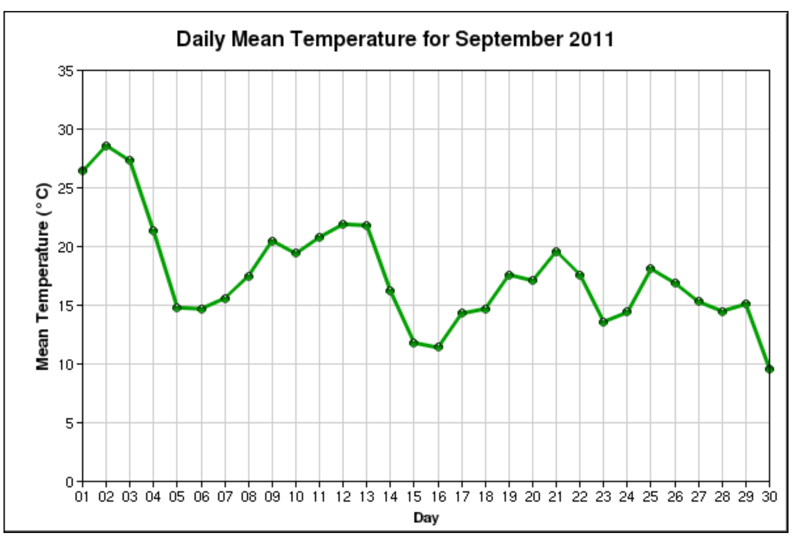
Obtained from the National Climate Data and Information Archive produced by Environment Canada.






Daily Mean Temperature for November 2011
Mean Temperature (°C)
Day


Daily Mean Temperature for October 2011
Mean Temperature (°C)
Day


Daily Mean Temperature for September 2011
Mean Temperature (°C)
Day

Vita Auctoris

Kalin Hamilton Shepherd Gawinski was born in 1987 in Toronto, Ontario. She graduated from Widdifield Secondary School in 2005 in North Bay, ON. From there she went on to the University of Windsor where she obtained a sense of adventure in 2007 and a B.H.K. in Movement Science co-op in 2010. She is currently a candidate for the Master's degree in Human Kinetics at the University of Windsor and hopes to graduate in Spring 2012.