The Physiological and Psychological Effects of Ashtanga Yoga

by

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ABSTRACT

The purpose of the research was to evaluate the physiological and stress-related psychological effects of three months of twice weekly ashtanga yoga training. The hypothesis was that three months of twice weekly ashtanga yoga practice would have positive effects on: blood pressure, upper body muscular endurance, trunk muscular endurance, flexibility, and perceived stress, as supported by previous research. The participants included seven college-age, untrained females who composed the yoga group, and five moderately active college-age females who composed the control group. Participants in the yoga group engaged in 60-90 minutes of ashtanga yoga, two times weekly, over a three month period, while the control group engaged in more traditional physical activity. Statistical analysis revealed some significant effects of ashtanga yoga practice. The yoga group participants were shown to have increased upper body muscular endurance and increased trunk flexibility. There was additional evidence supporting positive effects on cardiovascular fitness, perceived stress, and mental health. It was concluded that twice weekly ashtanga yoga training, for a period of three months, provides a sufficient stimulus to improve all three components of physical fitness in untrained females, while additionally yielding improvements in stress-related psychological health.

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CHAPTER 1

INTRODUCTION

The practice of yoga has existed for thousands of years, and has been gaining in popularity in Western societies over the last several decades. A 2008 poll commissioned by Yoga Journal reported that 6.9 percent of U.S. adults (15.8 million people), currently practice yoga, with half of the practitioners indicating that they began practicing yoga to improve overall health (YogaJournal.com, 2008). Yoga has seemingly found a place within the fitness industry as evidenced by a survey of North American health clubs (Club Programs: IHRSA member census and 1208 North American clubs, 2003) that found 86% of member clubs offered yoga classes, and the increasing number of DVDs on the market promoting yoga as means for total body strengthening and weight loss. This increased presence in the fitness industry has not however been supported by research validating yoga as a form of exercise, leaving many consumers and fitness professionals unable to make educated decisions as to where yoga fits into a physical fitness program.

Although yoga has established itself as a part of the exercise industry, it historically has been considered to be much more than a physical practice. Yoga has been defined as yoke, union, or discipline, representing that which is united or bound together, commonly being thought of as the union of the mind with the physical body. In Western society, yoga might be considered as a system of poses, breathing exercises, and seated meditation, performed to reduce stress and gain flexibility. These aspects of yoga are actually just a small part of what yoga encompasses. Yoga, as described by Pantanjali in the Yoga Sutras, is an eight-limbed path consisting of: yamas (ethical restraints), niyamas (moral observances), asana (physical postures), pranayama (breath

control), pratyhara (withdrawal of the senses), dharana (concentration), dhyana (meditation), and samadhi (enlightenment). (Satchidananda, 2004) Traditionally, one practices the limbs in succession, culminating in the attainment of enlightenment. Presently in the United States the practice of yoga consists primarily of the practice of asana (physical postures), with some types of yoga also including the practices of pranayama (breath control), and dhyana (meditation). Although these three limbs are only part of what is traditionally the practice of yoga, for the purposes of this paper and in reference to the body of research on the topic, yoga will be defined as the practice of asana, pranayama, and dhyana.

The varied practices of asana, pranayama, and dhyana, have manifested a great number of yoga styles. The styles one might presently find in yoga studios and fitness centers in the U.S. include, but are not limited to: ashtanga, bikram, gentle, hatha, iyengar, kundalini, power, and vinyasa flow. All these styles have distinguishing characteristics, with varying levels of physical fitness required. Given this wide variety of yoga styles, it would seem that each could offer varying physical health benefits, or perhaps the same benefits at varying degrees. Yet, there have been only two studies to date that have compared physiological responses to different styles of yoga (Cohen & Adams, 2005; Cohen & Adams, 2006).

Yoga has been investigated in relation to a variety of topics with focus in the reduction of symptoms of various diseases and ailments, such as lower back pain, arthritis, diabetes and heart disease (Raub, 2002), as well as the treatment of mental health issues, principally the reduction of stress (Granath, 2006; McCaffrey, 2005). There has been limited research regarding yoga's effect on body composition, as well a

cardiovascular and muscular endurance. In particular, there is a lack of evidence as to whether the practice of yoga can provide sufficient physical activity to improve and/or maintain body composition, cardiorespiratory endurance and muscular fitness. Additionally, there is a lack of research evaluating the most vigorous styles of yoga (ashtanga, power), as the predominance of research that will be referenced evaluated hatha yoga, which is generally a gentle to moderate style of yoga consisting of any variety of asanas practiced statically. With the growing popularity of yoga as means of exercise there is an increasing need to identify the physiological effects of yoga practice, and the extent to which yoga can be used to improve or maintain physical fitness.

Statement of the Problem

The purpose of this study was to determine the physiological and psychological effects of three months of ashtanga yoga training in untrained individuals. The physiological parameters examined were muscular strength/endurance, cardiovascular endurance, body composition and flexibility. The psychological parameters examined were perceived stress and health.

Significance of Study

This study is significant as it is only the second study that examined the physiological and psychological effects of ashtanga yoga, often considered the most vigorous style of yoga. This study used a longer training period than the study conducted by Cowen and Adams (2005), allowing for an increased likelihood of effects. With the growing popularity of yoga it is increasingly important to determine the effects of varied styles of yoga practice. The mental health benefits of hatha yoga and meditation have been well-established but there is no evidence that more vigorous forms of yoga offer the

same mental health benefit as gentle styles of yoga. The results of this study could help instructors and practitioners of yoga make educated decisions regarding where more vigorous forms of yoga fit into ones physical fitness regimen.

Hypothesis

It was hypothesized that three months of twice weekly ashtanga yoga practice would have positive effects on: blood pressure, upper body muscular endurance, trunk muscular endurance, flexibility, and perceived stress, as supported by previous research. There was no hypothesis as to whether ashtanga yoga practice would have positive effects on cardiovascular fitness or body composition, as the current body of research had inconclusive findings.

Delimitations

The following delimitations were made to narrow the scope of the study.

1. Participants for the experimental group were recruited from a power yoga physical education course at Binghamton University. This limited the experimental group to college-age students.
2. Participants for the control group were recruited from a lecture-based health course at Binghamton University and from an exercise science course at SUNY Cortland. This limited the control group to college-age students.
3. Participants who engaged in limited ongoing physical activity were recruited to participate.
4. Participants for the experimental group were recruited from a physical education course in which attendance was required to receive credit for the course. As a result

participant retention and attendance issues were limited. If a student dropped the course or had excessive absences the student was not included in the study.

Limitations

1. This study included only female participants. Both male and female participants were recruited for the study, however no males responded to invitations to participate.
2. The experimental group was recruited from a participant pool of approximately 42 students. After eliminating students whom lacked interest in participation and those whom were too physically active to be deemed untrained, the experimental group consisted of nine participants. Additionally, two of the nine experimental group participants did not complete post-training assessments due to illness.
3. The control group recruited was gender-matched to the experimental group and consisted of only females. Due to a lack of untrained potential participants, the control group was as a whole, not matched to the experimental group in regards to amount of weekly exercise prior to the training period.
4. The experimental group attended two, 90-minute power yoga classes per week. The course included a lecture component with many sessions including only 60 minutes of yoga practice. This presented a limitation in that engaging in 60-90 minutes of exercise, two days weekly, may not be enough of a stimulus to produce statistically significant changes in untrained participants, over a three month period.
5. The study took place over a full college semester and thus it may have been difficult to accurately assess changes in perceived stress and health. The beginning of the college semester typically will not present stress to a student and the end of the semester is often stressful for the typical college student. As a result, an accurate

assessment of stress reduction due to yoga may have not been possible. Cowen and Adams (2005) stated this as a limitation in their comparable pilot study that also used college students and concluded at the end of the semester.

Assumptions

Several assumptions were made about the behavior of the participants during the course of the study.

1. It was assumed that the only physical activity that the experimental group engaged in throughout the course of the study occurred in the power yoga course.
2. It was assumed that the only physical activity that the control group engaged in throughout the course of the study was whatever physical activity they were engaged in prior to the start of the study.
3. It was assumed that the participants answered all questions honestly and performed fitness tests to their maximum ability.
4. It was assumed that the participants in the experimental group attended all scheduled classes and that they gave their maximum effort during the power yoga classes.
5. It was assumed that all participants did not make any drastic changes to their diet during the course of the study.

Definition of Terms

1. Asana: physical postures; third limb of Patanjal's eight-limbed path.
2. Ashtanga yoga: yoga style developed by Pattabhi Jois; a dynamic, set series of postures are performed, characterized by ten rounds of sun salutations performed as a warm-up, followed by standing postures, and seated postures in which a vinyasa is performed between each side of each seated posture, with most postures held for five

breaths only. Practitioners first start with the primary series of postures and when those postures are mastered the second series is introduced.

3. Bikram yoga: yoga style developed by Bikram Choudhury. It is a set sequence of 24 postures, including backbends, standing poses, one-legged balances, and twists, held for up to one minute each, and performed in a humid room, heated to 100 degrees (F).
4. Body composition: absolute and relative amounts of muscle, bone, and fat tissues composing body mass. (Heyward, 2006)
5. Body mass index: a crude index of obesity, computed by dividing body mass (kg) by height squared (m^2). (Heyward, 2006)
6. Cardiovascular endurance: ability of heart, lungs, and circulatory system to supply oxygen to working muscles efficiently. (Heyward, 2006)
7. Dharana: intense concentration; sixth limb of Patanjali's eight-limbed path.
8. Dhyana: practice of meditation; seventh limb of Patanjali's eight-limbed path.
9. Eight-limbed or Eight-fold path: the practice of eight limbs (yamas, niyamas, asana, pranayama, pratyahara, dharana, dhyana, samadhi) as described by Pantajali as a means to attain enlightenment; combines physical practices to strengthen and purify the body with meditation techniques to control the mind.
10. Flexibility: ability to move joints fluidly through complete range of motion without injury. (Heyward, 2006)
11. Gentle yoga: includes different styles (restorative, svaroopa and others) light to moderate intensity postures are performed, with rest typically performed between the postures; classes are meant to be relaxing in nature, and would not present a great physical stimulus to healthy individuals.

12. Hatha yoga: used to describe any physical practice of yoga, encompassing all asana practices; classes titled hatha yoga, typically consist of a variety of standing and seated postures, as well as controlled breathing techniques, often serving as a basic or introductory type of class; sequencing of postures is dependent on the instructor.
13. Iyengar yoga: style developed by B.K.S Iyengar; combination of standing and seated postures, dependent upon the instructor are performed, with great attention paid to precise alignment in the postures, often by the use of props, with postures held for up to several minutes.
14. Kundalini yoga: style developed by Yogi Bhajan; combines asana with breath work, chanting, and meditation, designed to clear the energy channels found within the body.
15. Meditation: release of all sense of attachment, whether physical, mental, emotional, or spiritual; expanded awareness of the interconnectedness of all things; and an abiding state of blissful tranquility that is indifferent to joy as well as to sorrow and totally absorbed in the moment.
16. Muscular Endurance: ability of muscle to maintain submaximal force levels for extended periods. (Heyward, 2006)
17. Niyamas: second limb of Patanjali's eight-limbed path; observances; the practice of cleanliness, contentment, self-discipline, self-study, and surrender to God.
18. Power yoga/Vinyasa flow yoga: a more free style form of ashtanga; the sequence of postures is dependent upon the instructor, but is characterized by the use of vinyasas to string postures together, creating a "flowing practice," in which one posture leads into the other.

19. Pranayama: control of the breath achieved through varied breathing techniques; the fourth limb of Patanjali's eight-limbed path.
20. Pratyahara: withdrawal of the senses with attention focused inwardly and not on worldly things; the fifth limb of Patanjali's eight-limbed path.
21. Samadhi: enlightenment; union with universal spirit; the eighth limb of Patanjali's eight-limbed path.
22. Stress: condition that results when person-environment transactions lead the individual to perceive a discrepancy between the demands of a situation and the resources of the person's biological, psychological or social systems. (Selye, 1956)
23. Ujjayi Pranayama: specialized breathing technique meaning victorious, believed to generate heat in the body; performed by creating a soft sound in the back of the throat while inhaling and exhaling through the nose. (Swenson, 1999)
24. Untrained: characterized by a minimal amount of physical activity over the last three months and minimal current physical activity. For the purposes of this study, untrained will be defined by the engaging of 60 minutes or less of exercise per week for a period of 3 months.
25. Vinyasa: the unique linking of one asana to the next in a flow; also refers to specific flow of postures in the ashtanga yoga primary series, that is performed between most seated postures.
26. VO_2max: maximum rate of oxygen utilization of muscles during exercise. (Heyward, 2006)
27. VO_2reserve (VO_2R): VO_2 max minus VO_2rest. (Heyward, 2006)

28. Yamas: restraints; the practice of nonviolence, truthfulness, nonstealing, control of sensual pleasure, and freedom from desire and greed; the first limb of Patanjali's eight-limbed path. (Sparrowe, 2002)
29. Yoga: 1) yoke, union, or discipline, representing that which is united or bound together, commonly being thought of as the union of the mind with the physical body. 2) an eight-limbed path as described by Patanjali, by which a practitioner learns to steady both the body and mind, ultimately achieving enlightenment. (Sparrowe, 2002)

CHAPTER 2

REVIEW OF LITERATURE

The purpose of the study was to evaluate the physiological and stress-related psychological effects of power yoga. A review of the current research on the physical practice of all styles of yoga is presented in this chapter. With the inherent flexibility response to yoga, much of the current research examining yoga has not included evaluations of flexibility; therefore the review of literature presented will focus primarily on the cardiovascular and muscular responses to yoga, as well as the perceived stress response. The chapter concludes with a review of research concerning the validity of testing procedures.

Cardiovascular Response to Yoga

Clay, Lloyd, Walker, Sharp, and Pankey (2005), measured both oxygen consumption (VO_2), and heart rate (HR) in 26 female participants (19 – 40 years), during a hatha yoga routine and found the yoga routine elicited a lower cardiovascular response than walking at 3.5 mph. Additionally, they found that hatha yoga did not yield the percent maximum heart rate (MHR), or the percent VO_2 max recommended by the American College of Sports Medicine (ACSM) to improve cardiovascular fitness and promote weight control. However, when evaluating HR and VO_2 at different points throughout the 30 minute routine they found that the percent MHR was significantly higher during sun salutation postures (a dynamic series of poses that were repeated for 5 minutes at the beginning of the routine) than during the non-sun salutation postures, but did not find significant increases in percent VO_2 max.

Increases in HR during yoga without reciprocal increases in VO_2 were found in two studies. Sinha, Ray, Pathak, and Selvamurthy (2004) had 21 males, mean age of 21.7 years, recruited from the Indian army, engage in a yoga practice six days per week for three months. The participants engaged in suns salutations in the laboratory and a mean participant peak HR of 102 bpm and a peak VO_2 of 1.2 liters per minute, were recorded. This HR was lower and the VO_2 higher, than that recorded for sun salutations in the Clay et al. (2005) study, but showed a similar trend in that HR increases were not accompanied by expected increases in VO_2. Similar results were observed by DiCarlo, Sparling, Hinson, Snow, and Rosskopf (1995), who examined the HR and VO_2 of ten participants, ranging in age from 38 – 47 years, during both a 32 minute iyengar yoga routine and walking at 4.0 mph. The routine by DiCarlo et al. consisted of only standing postures, and participants' HR, blood pressure, VO_2, and rate of perceived exertion were measured at four times during the yoga routine, and the same four times during walking. Participants exercised at a significantly higher percent MHR and a greater rate of perceived exertion during the yoga routine than they did during walking. As with the other studies their higher percent MHR was not accompanied by a higher percent VO_2 max, with the participants exercising at a higher percent VO_2 max walking than during yoga.

Previous research on the topic of MHR and VO_2, reported that the percent VO_2max achieved during exercise is expected to increase proportionally with the percent of MHR achieved (Pollock et al., 2001). This relationship did not apply to the three studies conducted that measured both HR and VO_2 max during yoga. DiCarlo et al. (1995) hypothesized that the higher HR coupled with lower VO_2 may be due to the

amount of muscle mass involved during yoga. For example, balancing the weight of the body on one leg versus two, requires activation of a greater number of muscle fibers within the active leg. The work being done on one leg versus two is not different, as the weight of the body is the same, this results in a greater force per unit mass when standing on one leg, which ultimately results in an increased HR, without increases in VO_2. Additionally, DiCarlo et al. and Clay et al. (2005) both hypothesized that the increases in HR may exist during yoga as a result of venous pooling, caused by the isometric contractions associated with the holding of static postures for long periods of time. Due to the excessive HR observed with no reciprocal increase in percent VO_2 max, Clay et al. suggested that percent VO_2 max is a better measure than percent MHR to determine intensity of hatha yoga, and that perhaps future studies should investigate whether rate of perceived exertion would be a more appropriate indication of intensity. DiCarlo et al. did however use the measure of perceived exertion in their study, and participants reported significantly higher rates of perceived exertion during yoga as compared to walking.

Cowen and Adams (2006) compared the HR of 12 mostly female participants, aged 20 – 61 years, during three different styled yoga routines. They found the most vigorous type of yoga tested (ashtanga) yielded a significantly higher mean HR than both the hatha and gentle yoga routines, supporting the conclusion made by Clay et al. (2005) that more vigorous styles of yoga would elicit a greater cardiovascular response. In Cowen and Adams study, the ashtanga yoga routine yielded a mean HR of 101 bpm, which was significantly higher than the HRs recorded during hatha and gentle yoga routines, which were 83 bpm and 78 bpm respectively. The participants exercised at 54% MHR on average during the ashtanga yoga routine. Although this MHR did not meet

ACSM recommendations, the authors concluded that vigorous styles of yoga are the heart rate equivalent of moderate exercise. Walls (2007) also examined heart rate response during yoga. Three females and one male (mean age = 20.0 yrs) were reported to have a heart rate range of 73 – 116 bpm, during a 75 minute, hatha yoga class. The mean peak heart rate was observed during sun salutations, with the lowest heart rates observed during relaxation pose. This supports the findings of Clay et al. (2005) and Cowen and Adams (2006), that yoga styles in which sun salutations are performed elicit a moderate heart rate response.

The amount of research evaluating the VO_2 response to yoga is limited, with Cowen and Adams (2006) mentioned the option of measuring VO_2 to evaluate intensity as not feasible. Given the variety of postures and positions of the body during a yoga practice, and the emphasis of long inhalations and exhalations through the nose, it is hard to conceive how a yoga routine could be performed while attached to a metabolic cart, or even a portable analyzer. Given that the studies by Clay et al. (2005), DiCarlo et al. (1995), and Sinha et al. (2004) were the only studies found that measured VO_2 during yoga, and given the apparent obstacles to measuring VO_2 raised by Cowen and Adam (2006), it seems that the measure of VO_2 as an indicator of intensity during yoga may be flawed, or too difficult to measure at all.

With conflicting research regarding how to appropriately measure cardiovascular response during yoga, some researchers have relied on evaluating the changes in cardiovascular response after both short-term (1-2 months) and long-term (more than one year) yoga practice. Cowen and Adams (2005) evaluated pre and post yoga training measures recorded for participants engaged in ashtanga yoga training and another

participant group engaged in hatha yoga training. The participants consisted of 20 women and 6 men, mean age 31.8 years, with the two separate yoga groups not significantly different in age or gender distribution. Predicitive cardiorespiratory fitness was determined using the YMCA step test protocol. Following a six week training period in which participants attended an average of 9.15 sessions, there were found to be no significant changes in cardiorespiratory fitness. Indicating that approximately 9, 90-minute yoga sessions over a six week period is not a sufficient stimulus to yield changes in cardiovascular response to exercise.

Madanmohan, Udupa, Bhavanani, Shatapathy, and Sahai (2004) had 21 male participants (age: 17 – 19 years) engage in 45 minutes of yoga daily for two months. After the two month period the participants displayed a decrease in exercise induced measures of HR, systolic BP, and work done by the heart, as determined by the Harvard step test, indicating a milder cardiovascular response to exercise and a greater exercise tolerance, as a result of yoga training. Similar improvements in cardiovascular endurance, as determined by the Harvard step test, were also found in 40 male participants, age 12 – 15 years who engaged in 45 minutes of yoga, three days per week, for a period of one year (Bera & Rajapurkar, 1993). Aslan and Livanelioglu (2002) studied ten female and eight male participants, with a mean age of 20 years, whom engaged in a 60 minute iyengar yoga routine, four days per week, for a period of six weeks. After the training the yoga participants showed a 9.8% increase in aerobic power, as determined by the Cooper 12 minute run test.

Tran, Robert, Holly, Lashbrook, and Amsterdam (2001) evaluated ten mostly female, untrained participants ranging in age from 18 – 27 years, on the health-related

aspects of physical fitness after eight weeks of twice weekly hatha yoga sessions. Cardiorespiratory fitness was assessed using a graded treadmill test in which VO_2max was determined prior to and following the eight week training period. Participants on average completed 21.5, 75 minute yoga sessions over the eight week period and were found to have increases in both absolute and relative VO_2max, of 7% and 6% respectively. An additional study showed greater exercise tolerance after 90 days of yoga training, in 6 males, aged 18 – 28 years, as determined by the participants decreased levels of post-exercise blood lactate, and decreased post-exercise VO_2 (Raju et al., 2002).

Ray, Sinha, Tomer, Pathak, Dasgupta, and Selvamurthy (2001) evaluated changes in aerobic capacity and perceived exertion in 17 males from the Indian army following six months of six time weekly yoga practice. The participants engaged in one-hour hatha yoga sessions while a matched control group of 11 males engaged in standard military exercises for the same duration. The control groups' daily exercise consisted of 30 minutes of slow running (4 km/hr), 10 minutes of flexibility exercises, 5 minutes of pull-ups, and 15 minutes of games. The study commenced following a two-month annual leave taken by all participants. VO_2max was predicted using a graded bicycle ergometer test and there were no significant differences between the two groups prior to the training period. Following the six month training period the yoga group had a significant increase in VO_2max, while the control also showed an increase it was not significant. A perceived exertion score following graded exercise testing was also recorded and only the yoga group showed a significant reduction in post exercise perceived exertion after the six month training period.

Several studies also examined resting cardiovascular variables, such as heart rate and blood pressure prior to and following a yoga training period. Cowen and Adams (2005) found significant decreases in resting diastolic blood pressure following only 9, 90 minute yoga sessions over a six-week training period. Telles, Nagarathna, Nagendra, and Desiraju (1993) also found decreases in diastolic blood pressure as well as systolic blood pressure and decreased resting heart rate in 40 male physical education teachers (aged 25-48 year), whom attended a three month residential yoga training camp and engaged in 90 minutes of yoga daily.

Konar, Latha, and Bhuvaneswaran (2000) observed a significant decrease in resting heart rate in 8 healthy males (aged 17 – 18 years) following the practice of one yoga posture for approximately 8 minutes daily for a period of two weeks. The participants engaged in shoulderstand, a posture in which the body is inverted with the legs perpendicular to the floor, hands resting on the lower-back and the upper-arms and shoulders are pressing into the floor. Shoulderstand is a highly regarded yoga posture in which health benefits to the cardiovascular system are received due to the inverting of the body, thereby reducing the work performed by the heart. Konar et al. hypothesized that regular practice of shoulderstand may provide a non-pharmacological treatment for hypertension.

McCaffrey, Ruknui, Hatthakit, and Kasetsomboon (2005) observed decreases in both systolic and diastolic blood pressure, as well as a decrease in resting heart rate in 27 male and female, hypertensive participants (average age of 56.7 years) whom engaged in yoga for a period of 8 weeks. The participants were given educational material on yoga and a practice routine with instructional demonstrations of the postures. Participants

followed an instructional tape, practicing yoga on their own for approximately 60 minutes, three times weekly. A matched hypertensive control group that received typical outpatient teaching about hypertension, including suggestions for diet and exercise did not show any positive changes in blood pressure and resting heart rate following the eight week intervention.

Muscular Response to Yoga

The studies reviewed regarding the muscular response to yoga, used various assessments to determine changes in muscular strength and endurance in response to yoga training, but only one study examined muscular activity during yoga. Cowen and Adams (2005) evaluated muscular endurance in 26 participants following six weeks of either hatha or ashtanga yoga practice. After six weeks of training, twice per week, both groups showed significant improvements in trunk muscular endurance, with the ashtanga group also showing improvements in upper body muscular endurance and diastolic blood pressure. Additionally, in the two categories in which both groups had significant improvements, the ashtanga group showed greater improvements than the hatha group. Tran et al. (2001) evaluated muscular strength isokinetically in their ten participants and found significant increases for elbow extension, elbow flexion, and knee extension strength, and also found that isometric muscular endurance for knee flexion increased. In total, Tran et al. found muscular strength increases of up to 31% in three out of the four categories measured over the eight week training period.

Aslan and Livanelioglu (2002) assessed anaerobic power using a vertical jump test, and found that ten female and eight male participants had significant increases in jump performance after six weeks of iyengar yoga sessions four times weekly. These

increases were greater than those of participants in a control group who engaged in calisthenics for the same time period, with the control group showing no significant increases in vertical jump performance. Bera and Rajapurkar (1992) also used vertical jump performance as a measure of anaerobic power and found significant increases in 40 males, aged 12 – 15 years, who practiced hatha yoga, three days weekly, for a period of one year. It should however be considered that increases in joint range of motion associated with the practice of yoga, could have also enhanced vertical jump performance. In an additional study, Mandanmohan, Jatiya, Udupa, and Bhavanani (2003), found significant increases in strength and endurance, (determined by hang grip strength) in 40 males, aged 12 – 15 years, after six months of daily hatha yoga sessions.

Many researchers have examined the effects of yoga on muscular strength and endurance; few have examined muscular activity during the practice of yoga. Petrofsky, Cuneo, Dial, and Morris (2005) examined abdominal muscular activity during a particular yoga breathing technique by using surface electrodes in electromyogram (EMG). The abdominal muscular activity of twenty-nine male and female participants, aged 17 – 49 years, was recorded during both traditional abdominal crunches and a specific yoga breathing technique, characterized by rapid, forceful exhalations through the mouth, using the abdominal muscles and diaphragm. Although there were similar levels of muscular activity measured between the two exercises, the breathing exercises required greater work for each muscle, with the work performed in a single breathing exercise equivalent to five crunches. Petrofsky et al. concluded that because yoga breathing exercises can be conducted in a seated position, that they should be considered

a better alternative than traditional abdominal exercises for individuals who have difficulty working from a supine position.

Flexibility Response to Yoga

It is commonly accepted that stretching increases flexibility, and this is perhaps the most widely acknowledged physical benefit of yoga. For this reason, it seems most studies conducted to evaluate the physiological effects of yoga practice, have not included measurements of flexibility. Although flexibility benefits have been established, when assessed, measurements have been limited to the sit and reach test, which predominantly evaluates flexibility of the hamstrings, hips, and trunk. The previously mentioned study by Cowen and Adams (2005) used the sit and reach test to evaluate flexibility, and recorded significant increases after six weeks of yoga training. Walls (2007) also found significant increases in trunk flexibility following once weekly yoga sessions over a period of 8 weeks, but found no significant increases in shoulder flexibility.

Tran et al. (2001) used flexibility assessments beyond that of the sit and reach test. They assessed flexibility in four areas: ankle flexibility, shoulder elevation, trunk extension, and trunk flexion. They found significant increases in all measurements after eight weeks of yoga training. The most impressive increases were seen in shoulder elevation and trunk extension, increasing 155% and 188% respectively. The flexibility increases shown by Tran et al. further support previous documentation of increased trunk flexibility, and validate assumed flexibility increases throughout the entire body, as a result of yoga practice.

Body Composition Response to Yoga

Effects of the practice of yoga on body composition include effects on body weight, body mass index, and both body fat and lean mass percent. Bera and Rajapukar (1993) evaluated both body weight and body fat percent response in 20 males (age 12-15 years) after one year of thrice weekly, 45 minute yoga sessions. A control group of sedentary males of the same age was utilized. All subjects resided at a residential high school, in which all meals were provided and no outside food was allowed. After one year of yoga training the experimental group showed a decrease in percent body fat, with significant improvement in ideal body weight and density. Reduction in all but one of seven skin-fold sites was observed as well as a reduction in waist, umbilical, and hip circumferences. It is worth noting that an increase in lean body mass would often indicate greater circumferences due to muscular growth. This was not the case as the only significant changes in the measured body circumferences were the reductions of the trunk mentioned above. One could conclude as suggested by Bera and Rajapukar, that yoga tends in particular to reduce abdominal circumference by elimination of excess fat, while increasing overall body density. Ray et al. (2001) found a similar decrease in body fat percent (determined by skinfold thickness) with an increase in lean body mass in a group of male soldiers that engaged in one hour of yoga, daily for a period of six months. A matched control whom engaged in standard military exercises for the same duration did not show significant changes in either body fat percent or lean body mass.

Telles, Nagarathna, Nagendra, and Desiraju (1993) evaluated body weight in 40 male physical education teachers, aged 25-48 years, whom had engaged in diverse physical activity for an average of 8.9 years. The participants attended a three month

residential yoga training camp, for the purpose of learning how to teach yoga. The participants practiced yoga for 90 minutes daily and were found to have a significant reduction in weight (approximately 1.0 kg) following the three month period. Although this reduction was not large, given that the subjects were physically active at the start of the study it could also be inferred that the practice of yoga is a legitimate means to weight maintenance in place of more traditional exercises.

Raju, Prasad, Venkata, Murthy, and Reddy (1997) also conducted a study utilizing physical education teachers enrolled in a residential yoga training program. Six healthy, adult female physical education teachers (mean age=25.6 years, SD=5.11) engaged in two, 90 minute yoga sessions daily for a period of four weeks. Following four weeks of training, all participants showed a significant reduction in body fat mass as well as body fat percent, with corresponding increases in lean body mass. Although the amount of yoga practice could be deemed intense, the duration for which the postures were performed and therefore the intensity of each posture was not clear. One methodological flaw of this study and the study by Telles et al., is that the commencement of yoga training coincided with the commencement of a residential program in which participant food was supplied. It is likely this controlled diet resulted in a participant caloric intake during the study that varied from their caloric intake prior to the study. Although this insured that there was a homogenous diet for all participants, with no control group utilized in either study it is difficult to attribute changes in body composition solely to yoga practice.

Tran, Robert, Holly, Lashbrook, and Amsterdam (2001) had 10 untrained participants (1 male, 9 female), aged 18-27 years engage in hatha yoga for an eight week

period. Participants attended on average a total of 21.5 sessions (2.7 per week) over the eight week period, with participants required to attend a minimum of two sessions per week, amounting to 16 total sessions over the eight weeks. Although there were improvements in muscular strength and flexibility there were no changes in body weight or composition as measured using hydrostatic weighing. Similar results were observed by Cowen and Adams (2005) who evaluated the effects of both hatha and ashtanga yoga over a six week period. A total of 17 participants (9 ashtanga, 8 hatha) both male and female, ranging in age from 20-58 years (mean 31.8, SD=10.6) attended twice weekly, 90 minute hatha or ashtanga yoga sessions. The participants on average attended 9.15 of the 12 sessions offered. The only body composition variable evaluated during the six week period was body weight, which yielded no significant changes. It is likely as evidenced in the studies conducted by Tran et al. and Cowen and Adams that less than three sessions of yoga over a six to eight week period is not enough of a physical stimulus to alter body composition.

McCaffrey et al. (2005) did however observe small yet significant decreases in body mass index (BMI) in 27 male and female, hypertensive participants (mean age of 56.7 years) as compared to a matched hypertensive control group. Participants practiced yoga on their own for approximately 60 minutes, three times weekly over the eight week period. Body composition was assessed using body mass index and was found to have decreased as a result of the eight week time period. Interestingly, the main purpose of the study was to evaluate stress, with what might be considered a light to moderate intensity yoga program used. Even with the use of an, at best, moderate intensity yoga practice positive changes in BMI were observed in this demographic.

Given that Cowen and Adam and Tran et al. utilized participants that were on average 38.1 and 22.1 years of age respectively, whereas McCaffrey et al. participants had a mean age of 56.7 years, one might infer that the likelihood of a positive body composition response to two or three time weekly yoga practice over a two month or less time period, may be related to participant age. This could potentially be supported by the cross-sectional questionnaire based study conducted by Kristal, Littman, Benitez, and White (2005) that found yoga practice to be associated with attenuated weight gain in healthy, middle-aged adults. Approximately 15,000 male and female participants (50-76 years of age) were included in the study in which participants were asked to report their physical activity habits and weight over the last 10 years. The questionnaire asked about regular engagement in three specific physical activities (walking, lifting weights, and practicing yoga) and two specific intensities (mild-moderate and strenuous). Questions regarding diet and overall health were asked to homogenous the participant pool. The results of the study indicated that adults regularly engaging in yoga for four or more years were less likely to have gained weight since the age of 45 years compared to non-yoga practicing adults. This tendency to maintain and/or lose weight was even greater among participants who were overweight at 45 years of age.

Since most of the studies reviewed so far did not utilize control groups, the study conducted by Bera et al. provides the strongest evidence of yoga having a positive effect on body composition. Both the use of a control group and the one year length of the study allow strong conclusions to be made regarding yoga's positive effect on body composition. Additionally, although the questionnaire based study was not experimental if data reported by the subjects were accurate, Kristal et al. (2005) provided strong

evidence of yoga's ability to aid weight maintenance, especially in middle-aged persons over a multi-year period of time.

Stress Response to Yoga

The scientific community is becoming increasingly aware of the connection between psychological stress and physical health. This has brought greater awareness to mind-body practices such as yoga which is being increasingly touted as a means to reduce stress. The literature reviewed regarding the reduction of stress as related to yoga will only include studies that utilized yoga asana practice or a combination of asana (physical postures), pranayama (breath control) and meditation. Studies utilizing only pranayama or meditation were not included. Hans Selye (1956) defined stress as a condition that results when person-environment transactions lead the individual to perceive a discrepancy between the demands of a situation and the resources of the person's biological, psychological or social systems. For the purposes of this paper anxiety and overall sense of well-being will be included under the umbrella term stress. The stress response to yoga has been assessed both qualitatively through the use of questionnaires and physiologically through measurement of hormones levels retrieved through blood or salvia samples.

Cowen and Adams (2005) examined perceived stress and health perception in 17 participants whom were practicing in either ashtanga or hatha yoga. Both perceieved stress and health were assessed via three separate questionnaires. Following six weeks of twice weekly, 90 minute yoga sessions only the participants engaging in ashtanga yoga had significant improvements in the variables measured, with a 20% reduction in stress and a 9% increase in health perception. The participants engaging in the less vigorous

hatha yoga sessions of the same duration showed no signigicant differences in the psychological variables measured. McCaffrey et al. (2005) however found a reduction in stress levels among 27 hypertensive participants practicing hatha yoga over an eight week time period, as compared to a matched control group. Prior to commencement of the training period McCaffrey et al. cited no significant differences in stress levels between the yoga and control group. Following the three time weekly training period the yoga group displayed a significant reduction in mean stress levels as compared to the control group. The hatha yoga practice described by McCaffery et al. appeared to be comparable or perhaps slightly less intense than the hatha program in the Cowen and Adam (2005) study. Therefore any conclusions regarding differences in stress reduction benefit in differing styles of yoga could not be made soley on the results of the Cowen and Adam study.

Gupta, Khera, Vempati, Sharma, and Bijlani (2006) evaluated anxiety levels in 175 male and female participants, ranging in age from 19-76 years, considered to be either healthy or diseased. The unhealthy participant group had diseases such as: hypertension, coronary artery disease, diabetes, obesity, psychiatric disorders (depression, anxiety, stress), gastrointestinal problems and thyroid disorders. The participants engaged in an eight day yoga intervention, consisting of approximately one hour of asana practice followed by a discussion on the principles of yoga and yoga techniques. Anxiety levels were assessed using a questionnaire which subdividing anxiety into feelings of apprehension, tension, nervousness, and worry. Following the eight day yoga intervention there was a significant decrease in participant anxiety levels as compared to a matched control group.

Schell, Allolio, and Schonecke (1994) examined changes in both physiological and psychological parameters in 12 experienced yoga practitioners (age range of 27-55 years) over the course of a two hour hatha yoga session. A matched control group was asked to sit in a comfortable posture and read the newspaper during the experimental period. Serum cortisol levels were used to assess physiological stress response and were measured five times throughout the two hour session. Cortisol, a stress-related hormone, was found to decrease in both groups throughout the session, with the yoga group having consistently lower, although not significant, cortisol levels. West, Otte, Geher, Johnson, and Mohr (2004) also reported cortisol decreases in participants following a 90 minute hatha yoga session. They had 69 healthy college students engage in either hatha yoga, African dance, or a biology lecture over a 90 minute time period. Participants provided a saliva sample and completed three separate stress-related questionnaires and/or scales prior to and after the session. Both African dance and hatha yoga were found to reduce perceived stress and negative affect, yet only the hatha yoga yielded decreases in cortisol levels, with the African dance participants conversely showing increases. Although dance and yoga may often be grouped into the same mind-body activity category, it is apparent there may be striking differences in how they effect physiological stress.

Validity of Testing Procedures

Resting heart rate is variable among individuals with heart rate dependent on age, cardiovascular endurance, time of day measured and many other factors. Resting heart rate alone is not used to assess cardiovascular functioning, but is essential for establishing a baseline for assessing heart rate response to exercise. The American College of Sports Medicine (2006) provides guidelines for the measurement of heart rate by auscultation,

palpation, and electronic devices. Measurement of heart rate by palpation of the radial artery requires no equipment and is widely used in the field setting. Correct placement of the tips of the middle and index finger on the anterolateral aspect of the wrist directly in line with the thumb will yield an accurate assessment of heart rate. For accurate assessment of total beats per minute the radial pulse should be palpated for a period of one minute.

Measurement of blood pressure is an integral component of any physical examination or exercise testing. Normal blood pressure has been defined as a systolic pressure of less than 120 mmHg and a diastolic pressure of less than 80 mmHg. Hypertension is defined as blood pressure equaling or exceeding a systolic pressure of 140 mmHg and a diastolic pressure equaling or exceeding 90 mmHg. Hypertension is a risk factor for stroke and heart attack and is a strong indicator of ones response to cardiovascular stimulus as well as overall cardiac health. The most accurate assessment of blood pressure is the direct measurement of intra-arterial blood pressure. As this is very invasive, indirect measurement using auscultation techniques is most common in clinical and field settings. When performed by a trained individual with common sources of error (miscuffing, improper cuff size, arm unsupported etc.) avoided, auscultation is the most accurate field assessment of blood pressure (American College of Sports Medicine [ACSM], 2006).

The assessment of body composition is a critical component in the determination of ones overall health, as excess body fat is associated with a greater risk for hypertension, type 2 diabetes, coronary heart disease, and hyperlipidemia. Body mass index (BMI) assesses weight relative to height and is calculated by dividing body mass in

kilograms by height in meters squared. An individual is classified as overweight if BMI is greater than or equal to 25 kgm^{-2} and is classified as obese if the BMI is greater than or equal to 30kgm^{-2}. (ACSM, 2006) Although BMI can be a useful indicator for establishing normal weight versus overweight, this measurement is not sensitive to body fat percent with estimates of body fat percent from BMI accompanied by a standard error of ±5%.

Body fat percent is commonly measured in the field via circumference measurements, skinfold measurements, and handheld bioelectrical impedance analyzers. Estimation of body fat percent utilizing circumference measurements yield error of 2.5-4.0%, and can potentially be deemed intrusive for the subject. Estimation of body fat percent utilizing skinfold measurement is even more intrusive to the subject, yields error of ±3.5%, and is highly sensitive to the experience level of the technician. The amount of error is dependent on the skinfold site examined with between technician error reported to be as high as 8.8% for the abdomen and 7.1% for the thigh.

Bioelectrical impedance analyzers are one of the most recent technologies developed to measure body fat percent. This technique sends a low-level electrical current through the body and fat free mass is estimated based on the differences in muscle and fats tendency to resist current. The greater the resistance to current flow the greater the subjects percent body fat. Both lower body and upper body analyzers have been developed with handheld analyzers measuring upper-body impedance between the left and right arms. This method is typically as accurate in estimation of percent body fat as skinfold measures as long as proper procedure is followed and accurate prediction equations are utilized. (ACSM, 2006) Given the ease of use and noninvasiveness,

bioelectrical impedance analyzers are becoming a common method of body fat assessment when in the field. As bioelectrical impedance analyzers are very sensitive to hydration levels it is critical that the subject follows pre-testing instructions to yield the most accurate body fat measurement. (Heyward, 2006)

The most accurate assessment of VO_2 max should be obtained in a laboratory setting using a metabolic cart, however when this not available step tests are an accessible means to test large numbers of subjects in a short period of time. A variety of step tests estimate VO_2 max by monitoring heart rate response throughout graded exercise. The YMCA step test however evaluates cardiovascular fitness based on heart rate recovery following three minutes of stepping at a submaximal work rate. Although this type of testing does not provide an estimation of VO_2 max, it can accurately provide a qualitative rating of cardiovascular fitness and can be effectively used to monitor changes in cardiovascular fitness. (ACSM, 2006)

The ACSM (2006) recommends the assessment of muscular fitness by testing muscular strength and/or muscular endurance. Muscular strength is traditionally tested using a 1-repetition maximum testing protocol, with traditional gym equipment required. For the assessment of upper body muscular endurance the ACSM recommends a push-up test in which the maximum number of push-ups are performed until fatigue. For the assessment of trunk muscular endurance the ACSM recommends a curl-up (crunch) test in which curl-ups are performed until fatigue at a rate of 50 per minute for a period of one minute.

The assessment of flexibility can best be measured using goniometers which measure joint angles and the extremes of the joint range of motion. However the most

commonly used and most accessible method is the sit-and-reach test, which primarily assesses hip, low back, and hamstring flexibility. Although this test does not include assessment of upper body flexibility it is the most accessible field assessment recommended by the ACSM (2006) and is assumed to represent a gross estimation of flexibility.

The assessment of perceived stress and health cannot be measured quantitatively and is most often measured qualitatively through the use of questionnaires. The short-form-20 health survey was designed as a health status measure, covering physical, social, and role function as well as mental health, pain, and health perceptions. McDowell and Newell (1996) cited the short-form-20 to have a high internal consistency, and when compared to other questionnaires showed a higher validity in the role scale, overall scale, and in particular the emotional scale. The perceived stress scale (PSS) measures the degree to which situations in one's life are deemed stressful. In particular the scale was designed to assess the degree to which subjects found their lives to be unpredictable, uncontrollable, and overloading. Cohen et al. (1983) cited that the PSS has adequate internal and test-retest reliability and correlates as expected with a range of self-report and behavioral criteria. They also cited the PSS to be a better predictor of health and health-related outcomes as compared to similar stress-related life-event scales.

Summary

The current body of research on the topic of yoga indicates that physiological changes as a result of varied types of yoga practice can occur in as little as six weeks of training. Tran et al. (2001) and Ray et al. (2001) both observed increases in VO_2max in participants practicing yoga for eight weeks and six months respectively. Madanmohan

et al. (2004), and Bera and Rajapurkar (1993), both observed improvements in cardiovascular endurance as measured by step tests following six weeks, eight weeks, and one year of yoga practice respectively. Improvements in muscular endurance and flexibility following six weeks and eight weeks of yoga training were observed by Cowen and Adam (2005) and Tran et al. (2001) respectively. Improvements in body composition required a training period of at least eight weeks (McCaffrey et al, 2005; Tran et al., 2001), with changes in body composition most often observed following three plus months of yoga practice (Bera & Rajapukar, 1993; Ray et al., 2001). Mental health variables, and in particular perceived stress, were found to be positively effected following just one session of yoga (West et al., 2004). Cowen and Adam (2005) and McCaffrey et al. (2005) both found improvements in perceived stress following eight weeks of yoga practice. The sum of the body of research on yoga indicates that the practice of yoga can improve cardiovascular fitness, muscular fitness, flexibility, and some aspects of mental health.

CHAPTER 3

METHODS AND PROCEDURES

The purpose of the study was to determine the physiological and psychological effects of three months of ashtanga yoga training in untrained individuals. The physiological parameters examined were muscular strength/endurance, cardiovascular endurance, body composition and flexibility. The psychological parameters examined were perceived stress and health. This chapter includes description of the subjects, the pre and post testing procedures and the statistical treatment of the data.

Participants

Participants were recruited from two physical/health education courses at Binghamton University and an exercise science course at SUNY Cortland during the 2007 fall semester. The experimental group was recruited from a course titled "Wellness Through Power Yoga," at Binghamton University. The control group was recruited from a course titled "Pyschophysiological Awareness," at Binghamton University and a course titled "Biomechanics," at SUNY Cortland (See Appendix A for course descriptions). Students registered for the courses were verbally invited to participate by the lead researcher on the first day each class met. The lead researcher informed the students as to what their participation would include, as well as the risks and benefits involved with the study. Students interested in participating were asked to complete a physical activity history questionnaire (Appendix B). The questionnaire also asked for participant contact information (phone number and/or email address). Completed questionnaires were collected by the lead researcher. Following evaluation of the questionnaire by the lead

researcher, students who met physical activity criteria were invited to participate via email.

The experimental group consisted of seven females whom attended "Wellness Through Power Yoga" for the entirety of the fall 2007 semester. The mean age of participants in the experimental group was 21.6 years. Participants in the experimental group reported an average of 51 minutes of physical activity per week in the three months prior to the commencement of the college semester. On average the experimental group participants attended 25.4 power yoga classes out of the 29 offered over the course of the semester (approximately 15 weeks). All participants attended no less than 25 out of the 29 classes.

A total of eight female control subjects were recruited and completed pre and post-training assessments. Three of the control group participants were eliminated from the study after reporting a significant increase in their weekly exercise from the pre to post-training period. Therefore the control group consisted of a total of five females, with a mean age of 20.0 years. Two of the control participants were enrolled in "Pyschophysiological Awareness," at Binghamton University and the other three were enrolled in a course titled "Biomechanics," at SUNY Cortland. Participants in the control group reported an average of 162 minutes of physical activity per week in the three months prior to the commencement of the college semester.

Instrumentation

A blood pressure cuff and stethoscope were used to measure participant blood pressure. Resting heart rate was measured by radial pulse palpation. Weight was measured by a standardized electronic scale and height was measured by a measuring

tape affixed to a wall. Body fat percent was measured using a handheld bioimpedance analyzer. The YMCA step test was performed using a Reebok step aerobics step and risers. A metronome was used in both the step test and curl-up test. The Perceived Stress Scale (Cohen, Kamarck, & Mermelstein, 1983) was used to measure the degree to which situations in one's life are appraised as stressful. The Short-Form-20 Health Survey was used to measure health status and specifically covered physical, social, and role functioning as well as mental health, pain, and health perceptions. (McDowell & Newell, 1996)

Procedures

Prior to testing all procedures were approved by Binghamton University's and SUNY Cortland's human subjects institutional review board (See Appendix C). Participants were required to meet with the lead researcher two times for a period of approximately 30 minutes, during which the participants completed questionnaires and had a physical fitness assessment. The first assessment was conducted within the first week of the start of the semester, and the second assessment was conducted within the last week of the end of the semester. The first assessment was conducted at a time of day that was convenient for the participant, and the second assessment was conducted at the same time of day as the first assessment. Participants individually met with the lead researcher for all assessments, and all assessments were conducted by the lead researcher. Participants from Binghamton University met the lead researcher at the campus gymnasium and the participants from SUNY Cortland met the lead researcher in an exercise science classroom. Participants were emailed testing instructions at least 72 hours prior to testing. The instructions (Appendix D) indicated that the participant refrain

from the consumption of caffeine or food one hour prior to testing, and refrain from the consumption of alcohol 24 hours prior to testing.

Upon arrival at the testing site a participant completed an informed consent (Appendix E) and a Physical Activity Readiness Questionnaire (Appendix F). The participant then sat quietly while they completed the Perceived Stress Scale (Appendix G). The Perceived Stress Scale is a 14 item questionnaire that was scored as follows: for questions 1, 2, 3, 8, 11, 12, and 14 a response of never = 0, almost never = 1, sometimes = 2, fairly often = 3, very often = 4, for questions 4, 5, 6, 7, 9, 10, and 13 responses were scored in the reverse direction, with a response of never = 4, almost never = 3, sometimes = 2, fairly often = 1, and never = 0. The scores for all questions were summed, with low scores indicating low levels of perceived stress and high scores indicating higher levels of perceived stress.

The participant then completed the Short-Form-20 Health Survey (Appendix H). The Short-Form 20 Health Survey is a 20 item survey that encompasses 6 scales differentiated as follows: Questions 2a to 2f form the physical functioning scale, questions 4 and 5 form the role function scale, question 6 forms the social function scale, questions 7 through 11 form the mental health scale, questions 1a, and 12a to 12d form the health perception scale, and pain is measured by question 3. The survey was scored as follows: Questions 2 through 7, 9, 11, 12a and 12d were scored positively and questions 1, 8, 10, 12b, and 12c had reverse scoring. Scores were summed with higher scores (with the exception of the pain scale) indicating better health.

The participant remained seated and had their resting heart rate measured using radial pulse palpation for a period of one minute, with the total beats recorded. Resting

blood pressure was measured two times with a minimum of one minute between measurements. The participants' height and weight were measured, age recorded and body fat percentage measured.

The participant then performed the YMCA step test to evaluate cardiovascular endurance. This required the participant to step up and down on a 12 inch step, at a rate of 24 steps per minute, for a period of three minutes. At the completion of the three minutes the participant immediately sat down, and their heart rate was recorded via radial pulse palpation for a period of one minute, with the total beats recorded.

The participant then performed a push-up test to determine upper body muscular endurance, with the maximum number of push-ups performed without breaking form recorded. Participants performed the test using a standard push-up position: hands pointing forward and placed under the shoulders, back straight, and head up. As all participants were female a modified push-up protocol was followed, in which the knees were placed on the floor. The participant was required to raise the body by straightening the elbows and was to return to the down position, until the chin touched the mat.

The participant then performed a curl-up test to determine trunk muscular endurance. They assumed supine position on a mat with the knees at 90 degrees. The arms were at their sides, palms faced down with the middle fingers touching a piece of masking tape. The participant performed slow, controlled curl-ups to lift the shoulder blades off the mat, reaching the middle fingers to a second piece of tape placed 10 cm away. Curl-ups were performed at a rate of 25 per minute, for two minutes, with the maximum number performed (up to 50) recorded.

The participants then performed a sit-and-reach test to determine flexibility. The participant placed their feet flat against the sit-and-reach box at the 26-cm mark. The participant slowly reached forward, kept both hands parallel, held the position for approximately 2 seconds, and the most distant point reached was recorded. The test was performed two times, with the better of the two trials recorded.

During the course of the study participants in the experimental group attended their regularly scheduled power yoga course for which they were registered. The course met for the length of the semester (approximately 15 weeks) and consisted of 29 meetings. The course met twice weekly for a period of 90 minutes and consisted of both physical activity (power yoga) and lecture. Participants in both groups were not given instructions regarding their diet or physical activity habits for the course of the semester. It was assumed that the participants would maintain their normal level of physical activity and would not make any drastic changes to their diet.

All of the above stated assessments were repeated for the follow-up (post-training) assessment, with the exception of an additional questionnaire. Prior to completing the Perceived Stress Scale and Short-Form 20 Health survey the participants completed a follow-up physical activity and diet questionnaire. The control group follow-up questionnaire (Appendix I) required participants to indicate the amount and type of exercise they engaged in over the course of the semester and to also indicate any changes they made to their diet. The experimental group completed a different follow-up questionnaire (Appendix J), which consisted of the questions posed to the control group and additional questions in which they were to report any perceptual effects (both physical and psychological) of power yoga practice.

If participants in the yoga group made any drastic changes in their diet or engaged in additional exercise beyond the power yoga class and beyond that of the exercise they were engaged in prior to the study they were not included. Additionally, if participants in the control group made any drastic changes to their diet or engaged in an amount of exercise that was greater than that of their pre-study exercise they were not included. For both groups an increase in exercise was deemed as an increase of 25% or more of their total minutes of exercise per week. Three control subjects whom completed both pre and post-training assessments were not included in data analysis due to an increase in weekly exercise of 25% or more.

At the start of the training period participants in the experimental group engaged in approximately 45 minutes of power yoga and 45 minutes of lecture on the eight-limbed yogic philosophy. The 45 minutes of asana (postures) consisted of surya namaskara A and surya namaskara B performed at the beginning of the series, three and two times respectively and select postures from the ashtanga yoga primary series (Appendix G & H). By approximately week six of the training period the participants engaged in 60 minutes or more of power yoga and approximately 30 minutes of lecture. By the end of the training period participants engaged in approximately 75-90 minutes of power yoga. The 75 to 90 minute sessions consisted of surya namaskara A and surya namaskara B performed up to five and no less than three times each at the beginning of the 45 minute flow referenced above with additional postures inserted into the flow (see Appendix K & L). Most postures performed were held for approximately five breaths, with the exception of postures performed during surya namaskara A and B and postures performed during vinyasas (see Appendix K & L). Participants were instructed to utilize

ujjayi pranayama during all postures. Traditionally all postures in ashtanga yoga are performed using ujjayi pranayama. This technique is characterized by an audible breath, compared to an ocean like sound generated in the back of the throat, with inhalations and exhalations performed through the nose.

Statistical Analysis

A mixed 2 X 2 Analysis of Variance (ANOVA) was performed to evaluate differences between and within the groups in the pre-training period and post-training assessments. The first factor was the within subjects factor of test and the second factor was the between-subjects factor of group. Statistical analysis was conducted at the .05 significance level to reveal significant interactions and effects of the treatment. Statistical analysis was also conducted at the .10 significance level to reveal interactions and effects that warrant future study. Secondarily, paired *t*-tests were performed for the experimental group to reveal any significant effects of yoga practice that may warrant future research.

CHAPTER 4

RESULTS AND DISCUSSION

The purpose of the research was to evaluate the physiological and psychological effects of power yoga. Participants underwent physical fitness testing and completed perceived stress/perceived health questionnaires during the first or second week of the fall college semester and then repeated the same testing during the final week of the fall semester. Participants in the yoga group also completed a follow-up questionnaire at the completion of the study. The participants were asked to report any perceived effects of the training, providing anecdotal evidence of the effects of power yoga training,

Results of Physical Fitness Testing

The mean values and standard deviations of all the physiological variables measured for the pre-training and post-training conditions in the yoga group and control group are shown in Table 1. Variables for which there was a significant group interaction or a significant main effect of group, at either the .10 or .05 alpha level, are indicated in column 1. A 2 X 2 mixed ANOVA ($p < .05$, $p < .10$), in which the first factor was the within- subjects factor of test and the second factor was the between-subjects factor of group was used. A mixed ANOVA was run for each dependent variable and some significant differences were found. The pushup by group interaction was significant at the .10 alpha level: $F(1,10) = 4.91$, $p = .051$, partial $\eta^2 = .329$. The main effect of group was significant at the .05 alpha level: $F(1,10) = 6.55$, $p = .028$, partial $\eta^2 = .396$. The yoga group increased (+6) the number of push-ups performed from the pre to the post condition, while the control had a small decrease (-1) in the number of push-ups performed, as shown in figure 1. The main effect of group on curl-up performance was

significant at the .05 alpha level: $F(1,10) = 7.49$, $p = .021$, partial $\eta^2 = .428$. As seen in figure 2, the control group performed more curl-ups than the yoga group in both the pre and post condition. The group by sit-and-reach interaction was significant at the .05 alpha level: $F(1,10) = 33.75$, $p < .0001$, partial $\eta^2 = .771$. There was an increase (+2 cm) in the sit-and-reach score of the yoga group and a decrease (-1 cm) in the sit-and-reach score of the control group, as shown in figure 3.

Table 1

Means and Standard Deviations of the Physiological Variables Measured

	Yoga Group		Control Group	
	Pre-Training	Post-Training	Pre-Training	Post-Training
Weight (lbs)	130 (17)	130 (18)	136 (15)	137 (17)
BMI (kg/m^2)	22.47 (1.87)	22.44 (2.08)	23.40 (2.25)	23.08 (2.24)
Body Fat (%)	22.51 (3.54)	22.53 (4.15)	24.72 (3.41)	25.00 (2.98)
Resting HR (bpm)	75 (10)	75 (6)	70 (13)	68 (9)
Systolic BP (mm Hg)	97 (10)	100 (11)	102 (4)	108 (11)
Diastolic BP (mm Hg)	64 (4)	67 (5)	70 (4)	69 (7)
Step-test HR (bpm)	106 (12)	99 (10)	96 (18)	96 (13)
Push-ups (# reps) ^{XYY}	11 (4)	17 (7)	22 (5)	22 (4)
Curl-ups (# reps) ^{YY}	31 (14)	32 (11)	43 (9)	50 (0)
Sit-&-Reach (cm) ^{XX}	36 (7)	38 (7)	37 (6)	36 (5)

Note. Values enclosed in parentheses represent the standard deviations. ^{X} represents a group interaction significant at the .10 alpha level, and ^{XX} represents a group interaction significant at the .05 alpha level. ^{Y} represents a main effect of group significant at the .10 alpha level, and ^{YY} represents a main effect of group significant at the .05 alpha level.

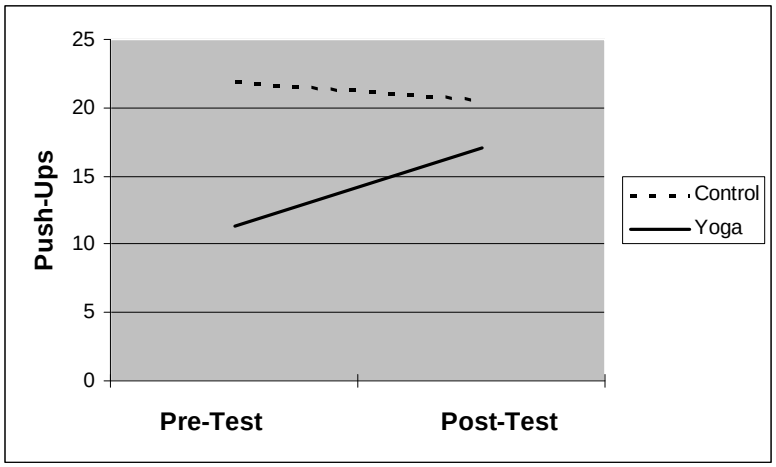

Figure 1. Pre-test and post-test mean push-ups performed by the yoga and control groups.

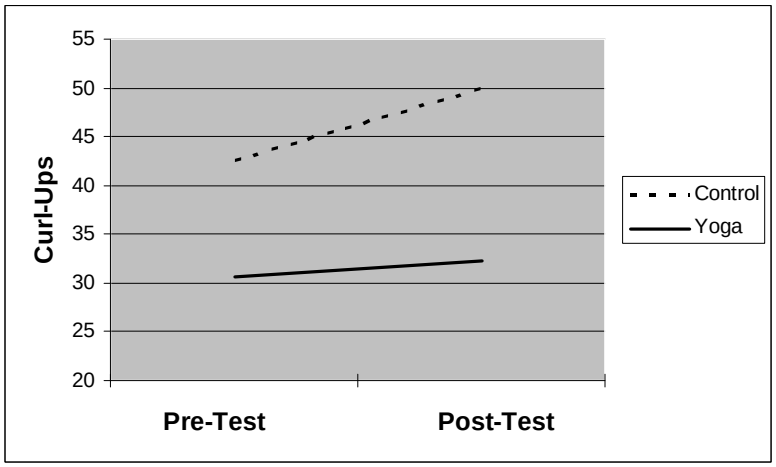

Figure 2. Pre-test and post-test mean curl-ups performed by the yoga and control groups.

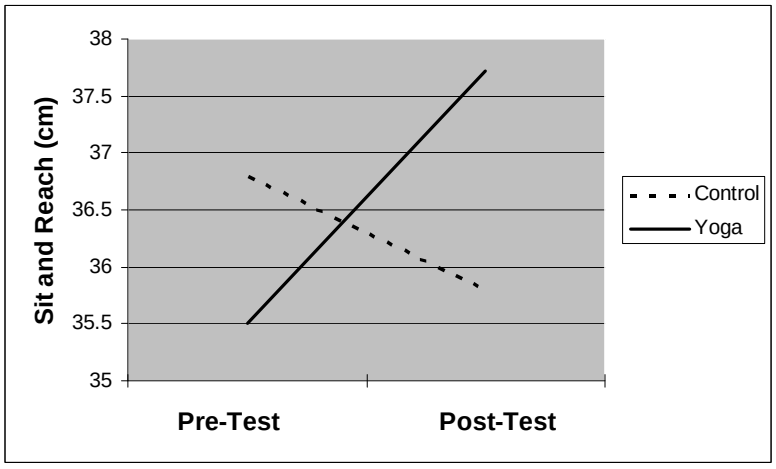

Figure 3. Pre-test and post-test mean sit-and-reach score by the yoga and control groups.

It should be noted that there was a noticeable improvement (-7.71 bpm) from pre-training to post-training for the yoga group in step test performance, while there was no change observed in the step test performance of the control group. Although this did not yield a significant group interaction: $F(1,10) = 1.73$, $p = .218$, partial $\eta^2 = .147$, a paired *t*-test ($p < .10$) did reveal a significant difference in step-test performance in the yoga group ($t = 2.19$, $df = 6$, $p = .071$, two tailed).

Results of Perceived Health and Stress Testing

The mean values of all the psychological variables measured for the pre-training and post-training conditions in the yoga group and control group are shown in Table 2. Variables for which there was a significant group interaction or a significant main effect of group, at either the .10 or .05 alpha level, are indicated in column 1. A 2 X 2 mixed ANOVA ($p < .10$) revealed some significant differences within the yoga group and control group from pre-training to post-training. The group by perceived stress score interaction was significant: $F(1,10) = 3.82$, $p = .079$, partial $\eta^2 = .277$. There was a decrease (-1.57) in perceived stress score for the yoga group from the pre to the post condition and an increase (+2.20) in the control group, as shown in figure 4. The group by mental health score interaction was significant: $F(1,10) = 4.73$, $p = .055$, partial $\eta^2 = .321$. There was an increase (+2.14) in mental health score among the yoga group between the pre and post condition and a decrease (-1.00) in the control group, as shown in figure 5.

Table 2

Means and Standard Deviations of the Psychological Variables Measured

	Yoga Group		Control Group	
	Pre-Training	Post-Training	Pre-Training	Post-Training
Perceived Stress [X]	23.57 (5.83)	22.00 (6.71)	20.80 (5.67)	23.00 (4.69)
Mental Health [X]	21.86 (3.72)	24.00 (3.46)	23.80 (4.44)	22.80 (3.35)
Health Perception	21.34 (2.26)	21.54 (2.73)	19.20 (3.60)	19.62 (3.24)
Bodily Pain	1.71 (0.76)	1.43 (0.79)	2.20 (0.45)	2.00 (0.71)

Note. Values enclosed in parentheses represent the standard deviations. [X] represents a group interaction significant at the .10 alpha level.

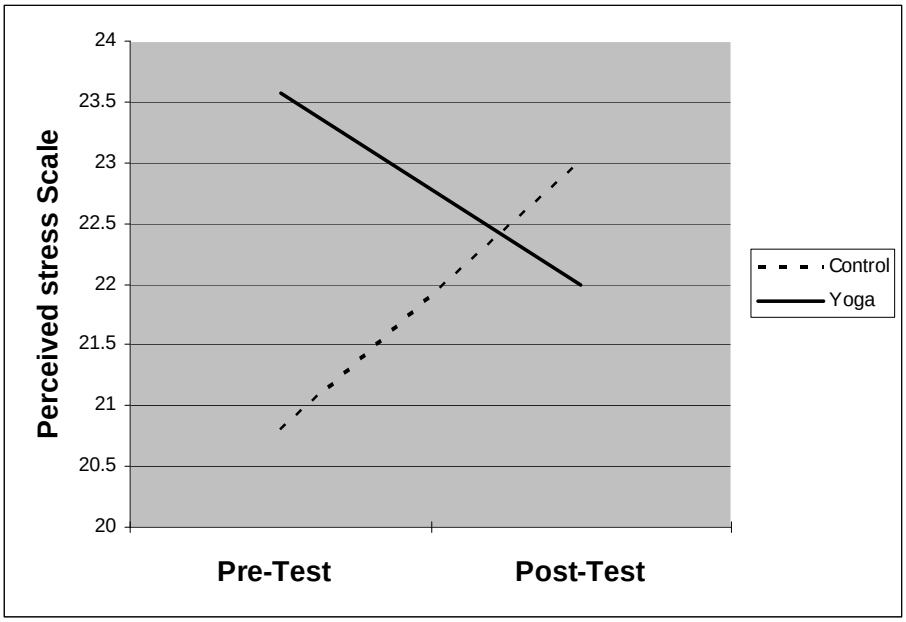

Figure 4. Pre-test and post-test mean perceived stress scale score for the yoga and control groups.

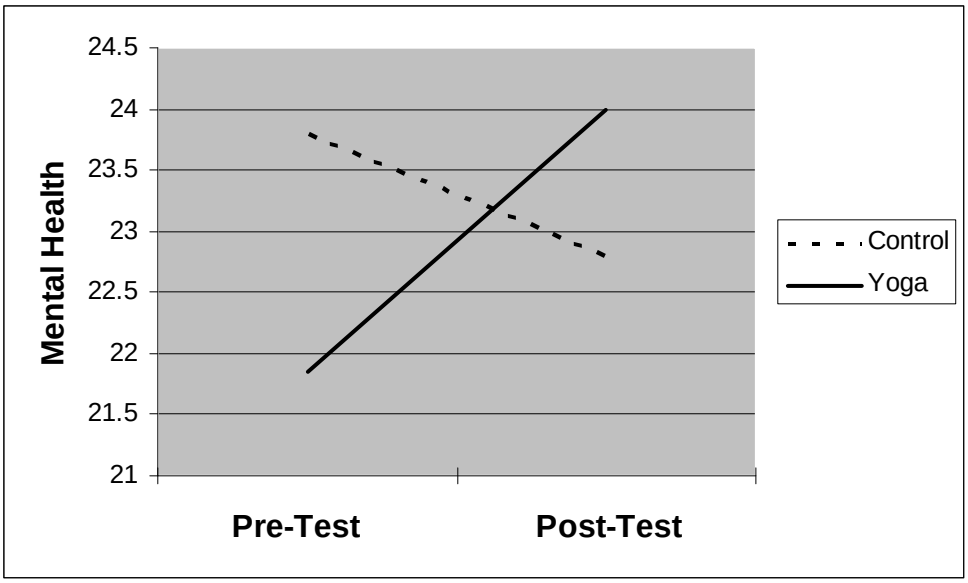

Figure 5. Pre-test and post-test mean mental health score for the yoga and control groups.

Results of Yoga Group Perceived Effects

All yoga group participants completed a follow-up questionnaire (refer to Appendix J) designed to reveal the perceived physical and psychological effects of yoga practice. The participants were presented with a statement and they were to indicate the strength of their agreement with the statement. All seven participants answered all questions, with results of a portion of the questionnaire shown in table 2. For example, when presented with the statement: "Following three months of power yoga practice, I am physically stronger," two participants strongly agreed with the statement, four agreed and one was undecided. Participants were also asked whether they considered the yoga they engaged in to be light, moderate or vigorous exercise. Five out of seven participants considered the power yoga practice to be moderate exercise and two out of seven considered it to be vigorous exercise. Additionally, six out of the seven participants stated that they planned to continue practicing yoga. In general, the majority of

participants indicated some level of agreement with statements related to the positive effects of yoga. In particular, participants felt they had improved strength, flexiblility, and cardiovascular fitness, while they also indicated a greater interest in favorable health practices and a greater ability to cope with stress. The statements with the least agreement from the participants were those related to decreased bodily pain and a improved body image.

Table 3

Results of Yoga Group Follow-up Questionnaire

Statement	Str. Agr.	Agr.	UD	Dgr.	Str. Dgr.	N/A
Physically Stronger	2	4	1			
Increased Flexibility	2	4	1			
Improved CRV Fitness	1	4	2			
Less Bodily Pain		3	1	1		2
Improved Body Image		4	1	1		1
Incr. Int. in Favorable Health Practices	4	2	1			
Greater Ability to Cope With Stress		5	2			

Note. Str. Agr. = strongly agree, Agr. = Agree, UD = undecided, Dgr. = Disagree, Str. Dgr. = Strongly Disagree, and N/A = Not Applicable. CRV = Cardiovascular and Incr. Int. = Increased Interest.

Discussion

The results of this study indicate that twice weekly power yoga practice, for a period of approximately three months can yield significant physiological and psychological effects in untrained, college-age females. Power yoga practice was shown to have positive effects on upper body muscular endurance and flexibility in this group.

There is additional evidence that there were positive effects on cardiovascular endurance, perceived stress and mental health perception. Although the three latter mentioned variables were only significant at the .10 level, they provide an indication of positive effects that should be researched further.

These results support the findings of prior research that examined the effects of yoga training for a comparable frequency and duration. Cowen and Adam (2005) who observed the effects of power yoga training, twice weekly for a period of eight weeks found significant increases in upper body muscular endurance as measured by a push-up test and significant increases in trunk flexibility as measured by the sit-and-reach test. Tran et al. (2001) also observed positive changes in upper body muscular strength, trunk flexibility, as well as ankle and shoulder flexibility in a group of females practicing yoga twice weekly, for a period of eight weeks. Walls (2007) also found significant increases in trunk flexibility following once weekly yoga sessions over a period of 8 weeks.

Cowen and Adam (2005) also found increases in trunk muscular endurance as measured by a curl-up test, which were not observed in this study. There were no other studies found that examined trunk muscular endurance. Although there was not a significant increase in the number of curl-ups performed by the participants in this study, it should be noted that participants in both groups cited strain on the neck and back following the test, also commenting that they did not feel their abdominal strength was assessed. The lead researcher whom carried out all fitness testing, did however notice a distinct difference in the yoga groups ability to maintain a straight back while performing the push-up test. During the assessment at the beginning of the semester numerous yoga group participants were unable to maintain a straight back while performing push-ups and

were given verbal instruction to straighten their back. During the assessment at the end of the semester there was a distinct difference observed in the yoga groups ability to maintain a straight back while performing push-ups. Although, this observation only provides anecdotal evidence, it does indicate that there were potential differences in abdominal strength that may have not been revealed by the curl-up test.

The moderate improvement in cardiovascular endurance observed in this study was comparable to that found by Cowen and Adam (2005). They observed improved, although not significant changes in cardiovascular endurance, as measured by a step test, following 9 yoga sessions over a period of 8 weeks. Madanmohan et al. (2004) also used an 8 week training period, but with a greater training frequency (45 minutes/day) and observed significant improvements in cardiovascular endurance. Given the greater training frequency of the Mandanmohan et al. study it is likely that a greater training frequency in the Cowen and Adams study and in this study would have yielded significant positive effects on cardiovascular endurance.

The finding of no significant changes in body composition following three months of twice weekly yoga practice is supported by previous research that found a longer training period and greater frequency is required to elicit positive changes in body composition. Telles et al. (1993), whom also used a three month training period found significant positive effects on body composition, however the subjects were engaging in daily yoga practice, a much higher training frequency than the current study. Raju et al. (1997) found positive effects on body composition following only four weeks of yoga training in a group of females. The Raju et al. study however had a much greater training frequency and intensity with the participants engaging in 180 minutes of yoga daily for a

period of four weeks, which amounted to twice the number of sessions of the present study. Bera and Rajapukar (1993) found positive changes in body composition following one year of thrice weekly yoga practice. Ray et al. (2001) found positive effects on body composition following six months of daily yoga practice.

The finding of decreased perceived stress in the yoga group is supported by the research of Cowen and Adam (2005) who also observed a decrease in perceived stress score as measured by the same perceived stress scale that was used in this study. McCaffrey et al. (2005) also observed decreases in stress as measured by questionnaire, following eight weeks, of thrice weekly yoga training. Schell et al. (1994) and West et al. (2004) both observed decreases in the stress hormone cortisol, following one session of yoga, with West et al. also observing decreases in perceived stress as measured by questionnaire. Although these studies examined stress response following one yoga session, one could infer that if there were positive effects on stress following 60 to 90 minutes of yoga, there would likely be measurable positive effects following three months of yoga training.

The results of the cited prior research in combination with the findings of the current research, support the efficacy of power yoga training as physical exercise. The subjects were shown to have increases in upper-body muscular endurance and increases in flexibility, with additional evidence supporting improvement in cardiovascular endurance, perceived stress and perceived mental health. It is likely that these results were due to the yoga training as subjects were required to report all exercise performed over the course of the semester, as well as any changes to their diet. No subjects reported any additional (non-yoga) exercise beyond what they had been engaged in prior to the

commencement of the study, with five out of seven subjects engaging in less non-yoga exercise during the study than prior to the study. Furthermore, no subjects in the yoga group reported any major changes in diet.

An additional point of interest is that the control group was at the start a more physically active group than the yoga group. Although, this presented a limitation in regards to group comparisons, at the completion of the study it created an opportunity to compare the yoga group to a group whom had also on average been exercising twice weekly. The control was engaging in more traditional exercise (aerobics, running, cycling, and weightlifting), while the experimental group was engaging in yoga, an unconventional form of exercise. It is interesting to note that the yoga group, started with a higher perceived stress score and lower perceived mental health score than the control, and at the completion of the study the yoga group improved in both variables while the control had an increase in perceived stress and a decrease in perceived mental health. One could infer, as both groups were exercising, that yoga has a greater positive effect on some psychological variables than traditional exercise in college-age females.

CHAPTER 5

SUMMARY, CONCLUSIONS, IMPLICATIONS AND RECOMMENDATIONS

Summary

The purpose of the research was to evaluate the physiological and stress-related psychological effects of three months of twice weekly ashtanga yoga training. The hypothesis was that three months of twice weekly ashtanga yoga practice would have positive effects on: blood pressure, upper body muscular endurance, trunk muscular endurance, flexibility, and perceived stress, as supported by previous research. The participants included seven college-age, untrained females whom composed the yoga group, and five moderately active college-age females whom composed the control group. Participants in the yoga group engaged in 60-90 minutes of ashtanga yoga, two times weekly, over a three month period, while the control group engaged in more traditional physical activity. Statistical analysis revealed some significant effects of ashtanga yoga practice. The yoga group participants were shown to have increased upper body muscular endurance and increased trunk flexibility. There was additional evidence supporting positive effects on cardiovascular fitness, perceived stress, and mental health.

Conclusion

Results of this study provide evidence supporting the effectiveness of ashtanga yoga training in improving upper body muscular endurance, and trunk flexibility. Additional evidence provided a strong indication that ashtanga yoga training may also have positive effects on cardiovascular fitness, perceived stress, and mental health. These results indicate that twice weekly, ashtanga yoga provides a sufficient stimulus to

improve all three components of physical fitness in untrained females, while additionally yielding improvements in stress-related psychological health.

Implications

The results of this study could have great implications on yoga's place within the exercise industry. It seems that yoga is most often discussed in regards to stress reduction, improving flexibility and as a means to manage symptoms of various ailments and diseases, but this research provides sufficient evidence that more vigorous forms of yoga can be used to improve physical fitness. As ashtanga yoga yields a muscular endurance stimulus, flexibility stimulus, and apparent cardiovascular stimulus, it provides all three components of physical activity recommended by the American College of Sports Medicine (ACSM). Although it is likely that yoga may not be the most effective means to increase strength or the most effective means to increase cardiovascular fitness, that this one form of physical activity can train all aspects of physical fitness concurrently, while improving mental health, makes it a very efficient exercise modality. In today's society people are always wanting the greatest effects in a short amount of time, especially in regards to exercise, with this in mind, ashtanga yoga may be the answer for individuals seeking an efficient fitness practice.

The psychological benefits that resulted from ashtanga yoga practice make it even more desirable as a form of exercise. Although most forms of exercise have been credited with improving varied aspects of mental health and sense of well being, the results of this study indicate that ashtanga yoga training may have a greater effect on some aspects of mental health as compared to more traditional forms of exercise. Given the increasing association of the role of stress in the genesis of chronic disease, and in

particular heart disease (Nielson, Kristensen, Prescott, Larsen, Schnohr, & Gronbaek, 2006) the inclusion of stress reduction as part of one's fitness and wellness regimen is of great importance. Evidence supporting yoga's use in the reduction of insulin resistance-related risk factors for cardiovascular disease has been additionally reported in a review by Innes, Bourguignon, and Taylor (2005). With yoga providing a physical fitness stimulus, stress reduction, and possible protection from heart disease, one could state a strong case for yoga's use in promoting long term health and wellness.

It is important to note that this study looked only at ashtanga yoga, one of the most, if not the most vigorous form of yoga. Using the umbrella term yoga is misleading in that the physical fitness demands of ashtanga yoga are more comparable to gymnastics or dance, whereas the physical fitness demands of gentle yoga are more comparable to watching television. Given the wide range of yoga styles and the resulting wide range of physical demands of each style, the results of this study should only be considered a validation of ashtanga yoga as a sufficient physical stimulus to improve fitness. Accordingly, any research conducted that shows gentle yoga to yield mental health benefits, should not lead to conclusions that more vigorous forms of yoga would have the same mental health benefits.

Recommendations

Future research should be conducted to further elucidate the physical fitness and psychological effects of yoga practice. Larger, gender diverse groups will need to be used as this study and a predominance of those reviewed, had small participant pools (less than 15 subjects) that consisted of either all males (most studies conducted in India) or all females (most studies conducted in the U.S.). In addition to larger participant

pools, future research should utilize longer training periods and/or higher training frequencies. The previously cited research demonstrated that training daily yielded greater effects than training twice weekly for a comparable training period. The ideal training frequency, duration, and intensity required to elicit positive changes in physical fitness or to maintain current levels of fitness will need to be determined in both trained and untrained individuals. Longitudinal studies following yoga practitioners over many years may also provide information as to the long-term effects of regular yoga practice. Although even the most vigorous forms of yoga may likely be proven to be a lesser cardiovascular stimulus than running and a lesser muscular stimulus than weight training, it is possible that yoga's moderate physical stimulus in combination with its mental health benefits may have a greater impact on long-term health outcomes than traditional exercise.

In addition to determining the ideal training frequency and duration, yoga will need to be compared to other forms of exercise. The cardiovascular demands of yoga have been compared to walking yielding varied results, with Clay et al. (2005) finding yoga was a lesser stimulus than walking and DiCarlo et al. (1995) finding yoga was a greater cardiovascular stimulus than walking. Only two studies (Aslan et al., 2002, Ray et al., 2001) have compared yoga to a similarly well-rounded exercise, such as calisthenics, and both found that yoga yielded greater cardiovascular improvements than calisthenics. As the most vigorous forms of yoga provide a combination of cardiovascular, muscular, and flexibility stimulus, it would be of interest to compare the most vigorous forms of yoga to circuit training in untrained subjects.

Prior research (Saper, Eisenberg, Davis, Culpepper, & Phillips, 2004) found that individuals most likely to engage in yoga in the United States are college-educated females, residing in large and small metropolitan areas. However, the reasons why people practice yoga have been not well documented. While some may practice for physical fitness reasons others may practice for stress reduction or reduction of bodily pain. Future research should examine the reasons that people engage in yoga, what the perceived benefits are as a result of the practice and ultimately whether or not these perceived benefits are indeed occurring and are measurable.

The greatest obstacle future research will need to address is the variety of yoga styles that exist and how these styles should be uniquely defined. Historically the term "hatha yoga" was used to describe the physical practice of postures. Under the umbrella term hatha yoga, there are numerous documented and undocumented styles of yoga. Many studies previously mentioned, stated that the subjects performed hatha yoga, with limited descriptions given. Future research should better document the exact style or series of postures used in the treatment. Given the range of yoga styles and the subsequent range of fitness demands, the body of research on the topic of yoga should be divided by style of yoga, with the gentlest forms of yoga treated as a different form of physical activity than ashtanga yoga. Between these two extremes of yoga there lies a whole range of styles that may offer anywhere from light to vigorous exercise. The lack of research differentiating the varied styles of yoga has created a barrier to true understanding of the benefits of yoga. It seems likely that the most vigorous forms of yoga may offer a moderate physical stimulus and some stress reduction, while gentle forms of yoga may offer a limited physical stimulus, yet substantially greater stress

reduction. The potentially inherent differences from one yoga style to the next will need to be examined in research designed to compare a wide range of yoga styles.

It is becoming increasingly more common for medical professionals to recommend yoga to their patients with a recent survey citing that 6.1 percent of Americans had a doctor or therapist recommend yoga to them (YogaJournal.com, 2008). Yet with the varied styles of yoga that exist these doctors and therapists may not be able to recommend the style of yoga that would be most appropriate for their patient. For example, it would not be appropriate for someone with chronic low back pain to engage in ashtanga yoga, as it would also not be appropriate for someone wanting to improve muscular strength to engage in gentle yoga. Professionals in the medical, health, and fitness industry need more information regarding yoga, its varied practices, and the inherent risks and benefits associated with each style. If more research is conducted and more information becomes available, health professionals will be able to most appropriately use and recommend yoga to meet the health and fitness needs of diverse populations.

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APPENDIX A

(retrieved from *www.binghamton.edu/schedclass* and http://studentinfo.cortland.edu)

Description of courses for participant pool

Wellness Through Power Yoga
Course Description: Also known as Ashtanga Yoga, a high-energy flow series of classical yoga poses melded together in an uninterrupted flow of movement. The particular series taught is called yoga therapy, a vigorous practice designed to align the body and spine while building strength and flexibility. Classes include study/discussion segments on diet and health through the approach of Ayurveda, yoga philosophy and ethics, breathing and beginning meditation.

Psychophysiological Awareness
Course Description: Develops awareness and appreciation of total human organism; teaches psychological aspects of mind vs. matter, mind vs. mind, imagination vs. reality (psychosomatic disorders, etc.), powers of suggestion, meditation, relaxation, etc.; physiological aspects of aerobic and anaerobic metabolism, oxygen debt, breathing, posture, body mechanics, muscular strength and endurance, nutrition and weight control, joint mobility, cardiovascular system and stress management.

Biomechanics
Course Description: Analysis, evaluation and application of anatomical and mechanical factors influencing motor skill activities.

APPENDIX B

Physical Activity History Questionnaire

Please read the questions carefully and answer each honestly, circling the most accurate answer, or providing the most accurate answer when necessary.

1. Have you regularly engaged in exercise over the last three months?

YES NO

2. Over the last three months, on average, how many days per week did you exercise?

0 1 2 3 4 5 6 7

3. On average how long does your typical exercise session last?

15 30 45 60 90 (minutes)

4. Please circle any activity below that you engage in a minimum of once weekly. Please provide any other activities in the "other" space provided. Please additionally indicate on how many times per week you engage in this activity and on average the total time (in minutes) devoted to this activity per week.

	# times/week	minutes/week
Aerobics	_____	_____
Cycling	_____	_____
Running	_____	_____
Walking	_____	_____
Pilates	_____	_____
Weightlifting	_____	_____
Swimming	_____	_____
Yoga _____	_____	_____
Other _____	_____	_____
Other _____	_____	_____
Other _____	_____	_____

APPENDIX C

SUNY Cortland Approval for Projects Using Human Research Participants

DATE RECEIVED: _____

07/08-501
PROTOCOL #: _____

OFFICE OF RESEARCH & SPONSORED PROGRAMS

8

APPLICATION FOR REVIEW OF PROJECTS USING HUMAN RESEARCH PARTICIPANTS

SUBMIT THIS FORM WITH A COPY OF THE RESEARCH PROPOSAL TO:
ASSISTANT VICE PRESIDENT OFRESEARCH AND SPONSORED PROGRAMS, MILLER BUILDING, ROOM 402

Investigator: Please Complete This Coversheet up to and Including the Category of Review Section

APPLICANT IS: (circle one): FACULTY (STUDENT)
INVESTIGATOR NAME: Kimberly Gruber DEPARTMENT: Ex. Science PHONE: (607) 725-8389
TITLE OF PROPOSAL: The Effects of Power Yoga Training on Physical Fitness & Perceived Health
DURATION OF PROJECT: 3 months
(Faculty projects only): NON-FUNDED_____ FUNDED_____ FUNDING AGENCY:_____
(Student projects only): PROJECT PURPOSE: ___Class Project X Thesis Course Number and Title _____

The proposed investigation (or training, or demonstration program) involves the use of human research participants, and I am submitting the required information and this form to the Institutional Review Board (IRB) for the Protection of Human Research Participants for review and approval. **If the IRB approves this application and if the project is undertaken, I agree:**

1. To review the Guidelines of the State University of New York at Cortland for the Protection of Human Research Participants on Research Investigations (See Research Using Human Participants at www.cortland.edu/osp/).
2. To report to the IRB any change in the research plan which affects the method of using human research participants before such change is instituted.
3. To report to the IRB any problems which arise in connection with the use of human research participants.
4. To cooperate with the IRB, and/or any sub-committee designated, in their efforts to provide a continuing review after investigations have been initiated.

I agree to the principles outlined in the aforementioned Guidelines and will adhere to these policies and procedures in my investigation.

For Faculty Projects:

_____ _____ _____ _____
Signature of Principal Investigator(s) Date Signature of Department Chairperson Date

For Student Projects: [Note: Topics of a sensitive nature should be avoided by student researchers who are not sufficiently experienced in such research]

Kimberly Gruber 7/23/07
Signature of Student Date

Patty M. MacInnis 7/23/07
Signature of Faculty Sponsor Date

Jo Hoover 7/24/07
Signature of Department Chairperson Date

CHECK APPROPRIATE CATEGORY OF REVIEW (please see attached guidelines for information regarding categories)

___Category I (Exempt), Section _____ (Identify which one of the six exemption categories in the instructions apply). Also, answer questions 1-5 in the the instructions and attach information and/or approvals as requested.

X Category II (Expedited Review) CAT 4-7 (AM) Answer questions 1-10 in the instructions and attach information and/or approvals as requested.

___Category III (Full Review) Answer questions 1-12 in the instructions and attach information and/or approvals as requested.

_____ _____ _____
EXEMPT FROM REVIEW Date APPROVAL DATE
Amy Henderson-Harr, IRB Designee

7/24/07

CERTIFICATION OF INSTITUTIONAL REVIEW BOARD

The Institutional Review Board for the Protection of Human Participants has reviewed this application. The Board believes that the research plan provides adequate safeguards of the rights and welfare of human research participants involved in the investigation and uses appropriate methods to obtain informed consent.

N.J. Aumann 8-15-07
EXPEDITED AND/OR FULL BOARD REVIEW Date
APPROVED BY: IRB Chair,
Nancy Aumann, Associate Provost for Academic Affairs,
and/or an Appropriate IRB Representative

APPROVED FOR THE PERIOD OF:
8/15/07 to 8/14/08
Any changes in the protocol or extensions beyond the one year must be presented in writing and approved by the IRB.

Binghamton University Approval for Projects Using Human Research Subjects

Date: July 20, 2007

To: Kim Gruber

From: Anne M. Casella, Administrator

Human Subjects Research Review Committee

Subject: Human Subjects Research Approval

Protocol Number: 668-07
Protocol title:

Your project identified above was reviewed by the HSRRC and has received an expedited approval pursuant to the Department of Health and Human Services (DHHS) regulations, 45 CFR Part 46 section 110(7) .

An expedited status requires that you will be required to submit a Continuing Review application annually as outlined by Federal Guidelines: *46.109 (e) An IRB shall conduct continuing review of research covered by this policy at intervals appropriate to the degree of risk, but not less than once per year, and shall have authority to observe or have a third party observe the consent process and the research.*

If your project undergoes any changes or modifications these changes must be reported to our office prior to implementation.

Any unanticipated problems and/or complaints related to your use of human subjects in this project must be reported, using the form listed below, http://humansubjects.binghamton.edu/Forms/Forms/Adverse%20Event%20Form.rtf

and delivered to the Human Subjects Research Review Office within five days. This is required so that the HSRRC can institute or update protective measures for human subjects as may be necessary. In addition, under the University's Assurance with the U.S. Department of Health and Human Services, Binghamton University must report certain events to the federal government. These reportable events include deaths, injuries, adverse reactions or unforeseen risks to human subjects. These reports must be made regardless of the source of funding or exempt status of your project.

University policy requires you to maintain as a part of your records, any documents pertaining to the use of human subjects in your research. This includes any information or materials conveyed to, and received from, the subjects, as well as any executed consent forms, data and analysis results. These records must be maintained for at least six years after project completion or termination. If this is a funded project, you should be aware that these records are subject to inspection and review by authorized representative of the University, State and Federal governments.

Please notify this office when you project is complete by completing and forwarding to our office the following form:

http://humansubjects.binghamton.edu/Forms/Forms/Protocol%20Closure%20Form.rtf

Upon notification we will close the above referenced file. Any reactivation of the project will require a new application.

This documentation is being provided to you via email. A hard copy will not be mailed unless you request us to do so.

Thank you for your cooperation, I wish you success in your research, and please do not hesitate to contact our office if you have any questions or require further assistance.

Cc: file

APPENDIX D

Participant Testing Instructions

Location of testing:

Day and Time:

1) Please arrive on time.
2) Wear clothes appropriate for moderate exercise. Please wear sneakers.
3) Do not consume caffeine or eat within 4 hours prior to testing.
4) Do not consume alcohol within 24 hours prior to testing.
5) Do not engage in moderate to vigorous exercise within 12 hours prior to testing.

*** Please make me aware if you have not been able to follow the above instructions.

If you are unable to come at your scheduled time please contact me as soon as possible. My contact info:

Kim Gruber
(607) 725-8389
Kimgruber21@yahoo.com

APPENDIX E

Informed Consent

1. "Kim Gruber, who is a graduate student at SUNY Cortland, has requested my participation in a research study at Binghamton University, Binghamton, NY. The title of the research is *The Effects of Power Yoga Training on Physical Fitness and Perceived Health.*"
2. "I have been informed that the purpose of the research is to determine the effects of approximately three months of power yoga practice on physical fitness and perceived health."
3. "My participation will involve engaging in a 30 minute physical fitness assessment prior to and at the end of the three month training period. I will also complete two questionnaires prior to and after the training period to assess perceived stress and health."
4. "I understand that there is some risk of injury to me, associated with engaging in physical activity, if I agree to participate in the study."
5. "I understand that the possible benefit of my participation in the study is a free physical fitness and perceived stress assessment ."
6. "I understand that the results of the research study may be published but that my name or identity will not be revealed. In order to maintain confidentiality of my records, Kim Gruber will have each participant identified by a randomly assigned number, and only she will have access to the files indicating which number is associated with each participant."
7. "I have been advised that the research in which I will be participating does not involve more than minimal risk, as the risk involved with physical activity is minimal, in healthy individuals."
8. "I have been informed that I will not be compensated for my participation."
9. "I have been informed that any questions I have concerning the research study or my participation in it, before or after my consent, will be answered by Kim Gruber, SUNY Cortland, (607) 725-8389, and/or Dr. Peter McGinnis, SUNY Cortland, (607) 753-4909."
10. "I understand that in case of injury, if I have any questions about my rights as a participant in this research, or if I feel I have been placed at risk, I can contact the Chair of the Human Research Review Committee, Binghamton University at (607) 777-3818 or Amy Henderson-Harr, Office of Sponsored Programs, SUNY Cortland at (607) 753-2511."
11. "I have read the above information. The nature, demands, risks, and benefits of the project have been explained to me. I knowingly assume the risks involved and understand that I may withdraw my consent and discontinue participation at any time without penalty or loss of benefit to myself. In signing this consent form, I am not waiving any legal claims, rights, or remedies. A copy of this consent form will be given to me."

Subject's signature _____ Date_____

12. "I certify that I have explained to the above individual the nature and purpose, the potential benefits, and possible risks associated with participation in this research study, have answered any questions that have been raised, and have witnessed the above signature."
13. "These elements of informed consent conform to the Assurance given by SUNY Cortland to the Department of Health and Human Services to protect the rights of human subjects."
14. "I have provided the participant a copy of this signed consent document."

Signature of Investigator _____ Date _____

APPENDIX F

Physical Activity Readiness Questionnaire (PAR-Q)

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

Y N Has your doctor ever said that you have a heart condition and that you should only do physical activity recommended by a doctor?

Y N Do you feel pain in your chest when you do physical activity?

Y N In the past month, have you had chest pain when you were not doing physical activity?

Y N Do you lose your balance because of dizziness or do you ever lose consciousness?

Y N Do you have a bone or joint problem that could be made worse by a change in your physical activity?

Y N Is your doctor currently prescribing drugs (for example, water pills) for your blood pressure or heart condition?

Y N Do you know of any other reason why you should not do physical activity?

If you answered YES to one or more of questions, talk to your doctor by phone or in person before you start becoming more physically active or before you have a fitness appraisal. Tell your doctor about the PAR-Q and the questions to which you answered YES.

If you answered NO to all PAR-Q questions, you can be reasonably sure that you can: start becoming more physically active – begin slowly and build up gradually.

I have read the above information or had it explained to me and understand that I am completely liable for any injury as well as my personal well-being while participating in this study.

_____ _____

Signature Date

APPENDIX G

Perceived Stress Scale

The questions in this scale ask you about your feelings and thoughts during the last month. In each case, you will be asked to indicate *how often* you felt or thought a certain way. Although some of the questions are similar, there are differences between them and you should treat each one as a separate question. The best approach is to answer each question fairly quickly. That is, don't try to count up the number of times you felt a particular way, but rather indicate the alternative that seems like a reasonable estimate.

For each question choose from the following alternatives:

never almost never sometimes fairly often very often

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

   never almost never sometimes fairly often very often

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

   never almost never sometimes fairly often very often

3. In the last month, how often have you felt nervous and "stressed"?

   never almost never sometimes fairly often very often

4. In the last month, how often have you dealt successfully with irritating life hassles?

   never almost never sometimes fairly often very often

5. In the last month, how often have you felt that you were effectively coping with important changes that were occurring in your life?

   never almost never sometimes fairly often very often

6. In the last month, how often have you felt confident about your ability to handle your personal problems?

   never almost never sometimes fairly often very often

7. In the last month, how often have you felt that things were going your way?
   never almost never sometimes fairly often very often

8. In the last month, how often have you found that you could not cope with all the things that you had to do?

   never almost never sometimes fairly often very often

9. In the last month, how often have you been able to control irritations in your life?

   never almost never sometimes fairly often very often

10. In the last month, how often have you felt that you were on top of things?

    never almost never sometimes fairly often very often

11. In the last month, how often have you been angered because of things that happened that were outside of your control?

    never almost never sometimes fairly often very often

12. In the last month, how often have you found yourself thinking about things that you have to accomplish?

    never almost never sometimes fairly often very often

13. In the last month, how often have you been able to control the way you spend your time?

    never almost never sometimes fairly often very often

14. In the last month, how often have you felt difficulties were piling up so high that you could not overcome them?

    never almost never sometimes fairly often very often

APPENDIX H

The Short-Form-20 Health Survey

1. In general, would you say your health is:
   - ❑ Excellent
   - ❑ Very Good
   - ❑ Good
   - ❑ Fairy
   - ❑ Poor

2. For how long (if at all) has your health limited you in each of the following activities? (Check one box on each line)

	Limited for More than 3 months	Limited for 3 months or less	Not limited at all
a. The kinds or amounts of vigorous activities you can do, like lifting heavy objects, running or participating in strenuous sports	0	0	0
b. The kinds or amounts of moderate activities you can do, Like moving a table, carrying groceries or bowling	0	0	0
c. Walking up hill or climbing a few flights of stairs	0	0	0
d. Bending, lifting, or stooping	0	0	0
e. Walking one block	0	0	0
f. Eating, dressing, bathing, or using the toilet	0	0	0

3. How much bodily pain have you had during the past 4 weeks?
   - ❑ None
   - ❑ Very Mild
   - ❑ Moderate
   - ❑ Severe
   - ❑ Very Severe

4. Does your health keep you from working at a job, doing work around the house or going to school?
   - ❑ Yes, for more than 3 months
   - ❑ Yes, for 3 months or less
   - ❑ No

5. Have you been unable to do certain kinds or amounts of work, housework or schoolwork because of your health?
   - ❑ Yes, for more than 3 months
   - ❑ Yes, for 3 months or less
   - ❑ No

For each of the following questions, please check the box for the one answer that comes closest to the way you have been feeling during the past month. (Check one box on each line)

	All of the time	Most of the time	A Good bit of the time	Some of the time	A Little of the time	None of the time
6. How much of the time, during the past month, has your health limited your social activities (like visiting with friends or close relatives)?	0	0	0	0	0	0
7. How much of the time, during the past month, have you been a very nervous person?	0	0	0	0	0	0
8. During the past month, how much of the time have you felt calm and peaceful?	0	0	0	0	0	0
9. How much of the time, during the the past month, have you felt downhearted and blue?	0	0	0	0	0	0
10. During the past month, how much of the time have you been a happy person.	0	0	0	0	0	0
11. How often, during the past month, have you felt so down in the dumps that nothing could cheer you up?	0	0	0	0	0	0

12. Please check the box that best describes whether each of the following statements is true or false for you. (Check one box on each line)

	Definitely True	Mostly True	Not Sure	Mostly False	Definitely False
a. I am somewhat ill	0	0	0	0	0
b. I am as health as anybody I know	0	0	0	0	0
c. My health is excellent	0	0	0	0	0
d. I have been feeling bad lately	0	0	0	0	0

APPENDIX I

Physical Activity Questionnaire

Please read the questions carefully and answer each honestly, circling the most accurate answer, or providing the most accurate answer when necessary.

1. Over the last three months, on average, how many days per week did you exercise?

0 1 2 3 4 5 6 7

2. On average how long did your typical exercise session last?

15 30 45 60 90 (minutes)

3. Please circle any activity below that you engaged in a minimum of once weekly. Please provide any other activities in the "other" space provided. Please additionally indicate on average how many times per week you engaged in this activity and on average the total time devoted to this activity per week.

	# times/week	total time/week
Aerobics	_____	_____
Cycling	_____	_____
Running	_____	_____
Walking	_____	_____
Weightlifting	_____	_____
Swimming	_____	_____
Yoga _____	_____	_____
Other _____	_____	_____
Other _____	_____	_____

4. Over the last three months have you knowingly changed your diet for the purpose of weight management? (a change in diet would include a deliberate change in caloric intake, a restriction of a particular food group, and/or the use of any dietary supplements taken for the purpose of weight loss)

YES NO

If you answered "YES" to question #4, please describe in a few words how your diet has changed over the last three months.

_____

_____

_____

APPENDIX J

Follow-Up Questionnaire

Please read the questions carefully and answer each honestly, circling the most accurate answer, or providing the most accurate answer when necessary.

When answering questions 1 – 3 do not account for the time spent exercising in the physical education class for which you are registered.

1. Over the last three months, on average, how many days per week did you exercise?

0 1 2 3 4 5 6 7

2. On average how long does your typical exercise session last?

15 30 45 60 90 (minutes)

3. Please circle any activity below that you engaged in a minimum of once weekly. Indicate on average how many times per week you engaged in this activity and on average the total time devoted to this activity per week.
(if you engaged in yoga outside of your PE class please indicate below)

	# times/week	total time/week
Aerobics	_____	_____
Cycling	_____	_____
Running	_____	_____
Walking	_____	_____
Weightlifting	_____	_____
Swimming	_____	_____
Yoga _____	_____	_____
Other _____	_____	_____
Other _____	_____	_____

4. Over the last three months have you knowingly changed your diet for the purpose of weight management? (a change in diet would include a deliberate change in caloric intake, a restriction of a particular food group, and/or the use of any dietary supplements taken for the purpose of weight loss)

YES NO

If you answered "YES" to question #4, please describe in a few words how your diet has changed over the last three months.

For the statements below please circle the appropriate feeling you have for each statement. Following each question there will be space for comments, please take your time and provide any additional response or feeling related to the question.

Following three months of power yoga practice . . .

1. I am physically stronger.

Strongly Agree *Agree* *Undecided* *Disagree* *Strongly Disagree* *N/A*

Comments:

2. I am more flexible.

Strongly Agree *Agree* *Undecided* *Disagree* *Strongly Disagree* *N/A*

Comments:

3. I can better perform cardiovascular activities (for example, not getting winded when walking up stairs).

Strongly Agree ***Agree*** ***Undecided*** ***Disagree*** ***Strongly Disagree*** ***N/A***

Comments:

4. I have less bodily pain.

Strongly Agree ***Agree*** ***Undecided*** ***Disagree*** ***Strongly Disagree*** ***N/A***

Comments:

5. I have an improved body image.

Strongly Agree ***Agree*** ***Undecided*** ***Disagree*** ***Strongly Disagree***
N/A

Comments:

_____

_____

6. I have developed a greater interest in favorable health practices.

Strongly Agree ***Agree*** ***Undecided*** ***Disagree*** ***Strongly Disagree***
N/A

Comments:

_____

_____

7. I am better able to cope with stressful events.

Strongly Agree ***Agree*** ***Undecided*** ***Disagree*** ***Strongly Disagree***
N/A

Comments:

_____

_____

For the following questions please circle or provide your response where appropriate.

8. Would you consider the yoga you engaged in to be . . .

Light *Moderate* or *Vigorous* exercise?

9. Why did you choose to register for this course?

_____

_____

10. What benefits if any were you expecting as a result of the power yoga course?

_____

_____

_____

11. What physical and/or mental benefits did you experience as a result of taking this power yoga course?

_____

_____

_____

12. Did you experience any negative effects as a result of the power yoga course?

_____

_____

13. Do you plan on continuing to practice yoga?

YES NO

Thank you for your feedback and participation!

APPENDIX K

Outline of Asanas

Asana names and spellings referenced from Swenson (1999).

The postures are listed in the order, in which they are performed, with the Sanskrit name in parentheses, following the common name.

45 Minute Flow

Attention Position (*Sama-sthiti*) beginning of Ujjayi breathing, used throughout the series
Sun Salutation A (*Surya Namaskara A*)
Sun Salutation B (*Surya Namaskara B)*
Standing Head to Knee (*Padangusthasana*)
Triangle (*Utthita Trikonasana*)
Extended Side Angle (*Utthita Parsvakonasana*)
Expanded Leg, Intense Stretch (*Prasarita Padottanasana A & C)*
Intense Side Stretch (*Parsvottanasana*)
Extended Standing, Hand to Big Toe (*Utthita Hasta Padangusthasana A*
Standing Half Bound Lotus (*Ardha Baddha Padmottanasana*)
Fierce Posture (*Utkatasana*)[v]
Crane (*Bakasana)*
Warrior I (*Virabhadrasana I*)
Warrior II (*Virabhadrasana II*)[v]
Staff (*Dandasana*)
Seated Forward Bend (*Paschimottanasana A)*[v]
Seated Half Bound Lotus (*Ardha Baddha Padma Paschimottanasana*)[v]
Bent Leg Intense Stretch (*Trianga Mukhaikapada Paschimottanasana*)[v]
Seated Head to Knee (*Janu Sirasana A*)[v]
Marichi's Postures (*Marichyasana A-C*)[v]
Boat (*Navasana*)[v]
Bound Angle (*Baddha Konasana*)[v]
Wide Angle (*Upavishta Konasana*)[v]
Upward Bow (*Urdhva Dhanurasana*)[v]
Seated Forward Bend (*Paschimottanasana A*)[v]
Shoulder Stand (*Salamba Sarvangasana*)
Plow (*Halasana)*
Ear Pressure Posture (*Karnapidasana*)
Fish (*Matsyasana*)[v]
Headstand Prep (Dolphin)
Bound Lotus (*Baddha Padmasana*)
Lotus (*Padmasana*)
Scale Posture (*Tolasana*)[v]
Corpse (*Savasana*)

[v] Vinyasa between postures

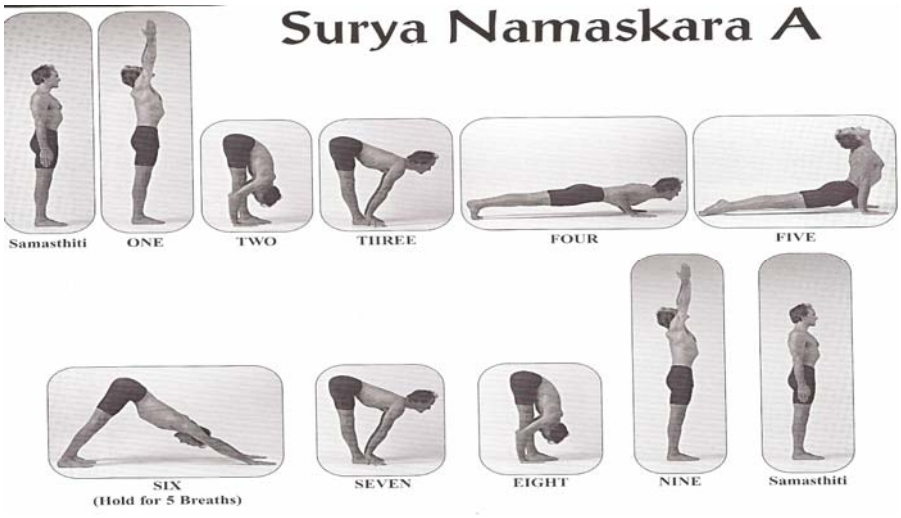
Additional Postures Performed (inserted within the 45 minute flow)
Arm Pressure Posture(*Bhujapidasana*)
One Foot Behind Head Posture(*Eka Pada Sirasana*)
Tortoise Pose (*Kurmasana*)
Heron (*Krounchasana*)
Locust Pose(*Shalabhasana*)
Frog Pose(*Bhekasana*)
Bow Pose(*Dhanurasana*)
Camel Pose(*Ustrasana*)
Little Thunderbolt Pose (*Laghuvajrasana*)
Pigeon Pose (*Kapotasana*)

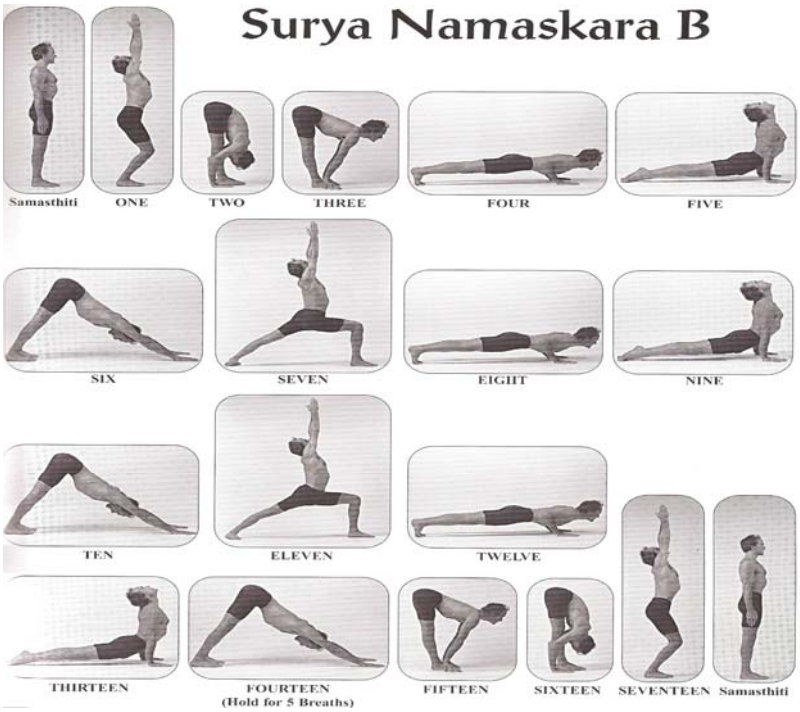
APPENDIX L

Pictures of Asanas

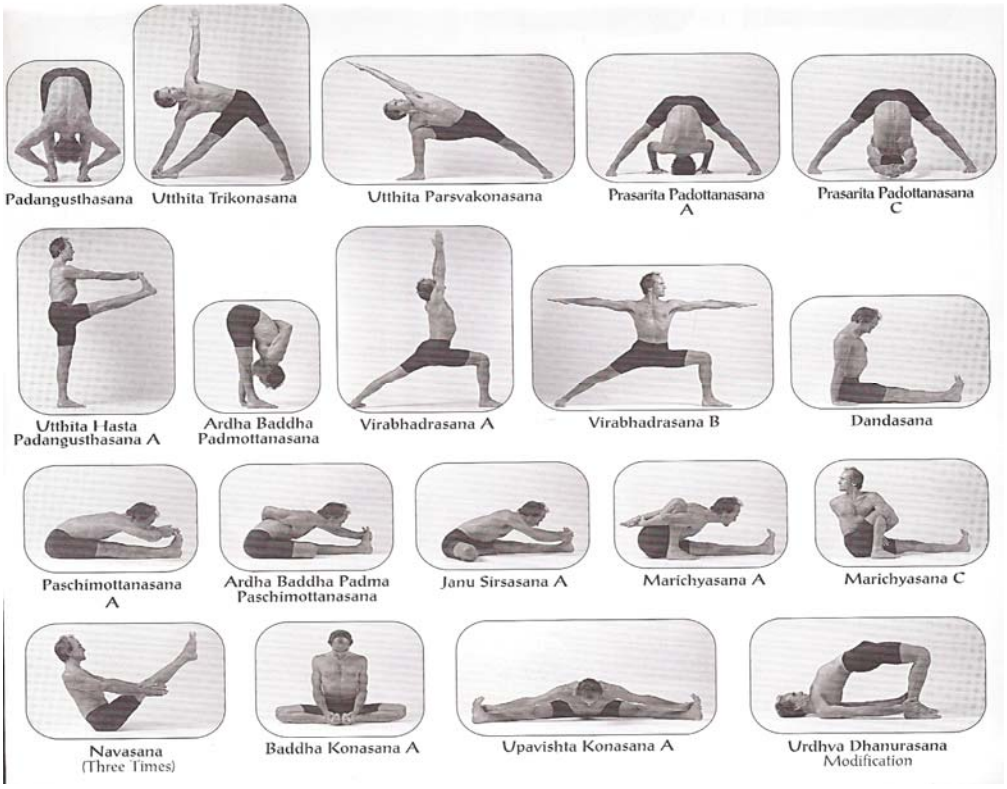
(Reprinted with permission; Swenson, 1999)

While performing surya namaskara A and B all postures are performed dynamically with the breath and the only postured that is to be held for 5 breaths is downward facing dog as shown in frame 6 in A and frame 14 in B.



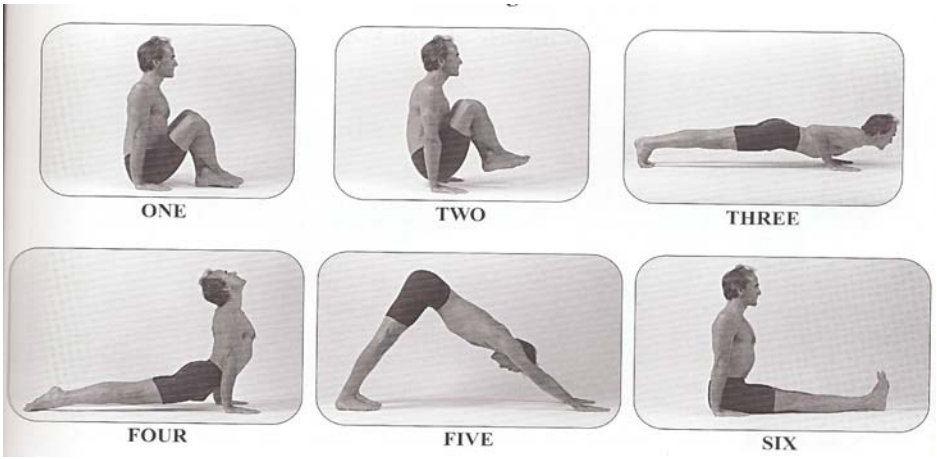


45 Minute Flow
(All postures held for 5 breaths)



Vinyasa

(Performed between all seated postures. Postures are not held, but performed dynamically with the breath.)



Additional Postures Performed