THE EFFECT OF VINYASA FLOW YOGA ON AEROBIC CAPACITY

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by
Sheena L. Flores
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DEDICATION

I would like to dedicate my thesis to all beings that have stimulated my growth and development. My soul, a still, soft, boundless pond, ripples outward by all individuals whose karmic energy stimulated my universe transcending time. To the universe (God), and every atom intertwining with love and hate it has been my fate.

Dedicated to

Sienna L. Seward, &

My family
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ABSTRACT

THE EFFECT OF VINYASA FLOW YOGA ON AEROBIC CAPACITY

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Vinyasa Flow yoga may be effective in preventing the chronic diseases associated with modern civilization as an alternative form of exercise for improving health and fitness levels. The purpose of this study was to determine if Vinyasa Flow yoga improves aerobic capacity and meets the ACSM’s guidelines for exercise intensity that improves and maintains cardiovascular health and fitness in healthy adults.

Ten healthy beginning level male and female yoga students (19 to 25 years old) participated in the study. A 45-minute Vinyasa Flow yoga routine was implemented twice a week for six weeks. Aerobic capacity was assessed pre and post study using a graded exercise test and open-circuit indirect calorimetry. HR data was recorded to assess $\%HR_{\text{max}}$ during Vinyasa Flow yoga to determine the exercise intensity.

The results showed no significant ($p > 0.05$) difference in pre and post $VO_{2\text{max}}$ after 6 weeks for the treatment or control group using repeated measures ANOVA, and
no significant difference in VO$_{2\text{max}}$ between groups, ($p = 0.85$). HR data suggests.

Vinyasa Flow yoga is a light intensity exercise (~52% HR$_{\text{max}}$) for healthy fit adults ($n = 4$), and does not appear to improve health and fitness levels for protection against cardiovascular disease and pre-mature mortality associated with moderate and vigorous-intensity physical activity.
CHAPTER I
INTRODUCTION

Modernization and the consequent lack of physical activity are attributable to the chronic diseases afflicting Western civilization (Roberts & Barnard, 2005; Blair, LaMonte, & Nichaman, 2004). The primary causes of death (mortality) from chronic disease in our civilization, as stated by Roberts & Barnard (2005), are the result of “cardiovascular diseases [i.e., coronary artery disease (CAD), hypertension, stroke, and heart failure], type 2 diabetes (diabetes), metabolic syndrome, and cancer” (p. 3). In the beginning of the 21st century the Center for Disease Control (CDC) reported that 70% of all cases of mortality in the states were from “cardiovascular disease, various forms of cancer, and diabetes,” and that about 60% of adults where either “overweight” or “obese,” not to mention the youth who are currently affected by obesity and chronic disease (Roberts & Barnard, 2005, p. 3). In the U. S. it is reported that obesity affects 17% of children (Ogden, Carroll, Kit, & Flegal, 2014, p. 806). Obesity is a precursor of chronic disease, as Jones & Greene (2013) inform, it enhances “the risk of death from diabetes, heart disease, and cancer” (p. 5).

Chronic diseases are linked to sedentary lifestyles and unhealthy dietary consumption, which cause a financial encumbrance for humanity and augment existential distress (Roberts & Barnard, 2005). The American Heart Association (AHA) reported that every day in 2006 roughly 2300 US citizens died from cardiovascular diseases
(CVD), and that by 2010 $503.2 billion would be spent on CVD and stroke expenses (2010, p. 47, 206). The AHA stated that CVD had decreased in incidence of mortality, with a 29.2% decrease from 1996-2006 (2010, p. 47). However, in the United States, CVD remains the number one cause of mortality (Jones & Greene, 2013; Roberts & Bernard, 2005; Santulli, 2013; Yoon, Bastian, Anderson, Collins, & Jaffe, 2014). CVD is also the number one cause of death worldwide, and is preventable (Jones & Greene, 2013; Santulli, 2013). Diseases of our civilization (e.g., cardiovascular diseases, type 2 diabetes, metabolic syndrome, etc.) in the U.S. have been linked to a lack of physical activity and/or exercise (Roberts & Barnard, 2005).

Physical activity and exercise have been connected to aerobic capacity, or VO$_{2\text{max}}$, as a sign of cardiovascular health and fitness. Cardiorespiratory fitness (CRF) defines the limits of aerobic capacity, and is an indication of cardiovascular health. Aerobic capacity is directly correlated to the ability of the cardiovascular system, and has become the hallmark of cardiovascular health and fitness. CRF is elemental in understanding and preventing the CVD associated with modern civilization (ACSM, 2010; Brooks, Fahey, & Baldwin, 2005).

The American College of Sports Medicine (ACSM) (2014) reported that a sedentary lifestyle and low levels of physical activity increase the risk of morbidity and premature mortality. Physical activity or exercise that enhances cardiorespiratory fitness (CRF) has shown to reduce the chance of premature mortality and chronic disease from all causes, demonstrating both an inverse and a dose-response relationship to physical activity. In order to benefit from the inverse and dose-response relationship to physical activity a certain degree of CRF must be maintained.
The inverse relationship linked to physical activity is reported by the ACSM (2014) for “premature mortality, CVD/CAD, hypertension, stroke, osteoporosis, Type 2 diabetes mellitus, metabolic syndrome, obesity, colon cancer, breast cancer, depression, functional health, falls, and cognitive function” (p. 9). Thereby, increased amounts of CRF indicate a decrease in the chance of morbidity and premature mortality, and improved health.

The dose-response relationship to physical activity, premature mortality, and CVD/CAD is characterized by the amount of physical activity performed beyond the minimal suggestions for increased health outcomes, weight loss, and the prevention of obesity (ACSM, 2014, p. 7-8). Therefore, by increasing the frequency (i.e., days per week), intensity (e.g., moderate to vigorous), and length of aerobic physical activity an individual may experience enhanced health outcomes and increased protection from premature mortality and morbidity (ACSM, 2014; Pollock et al., 1998).

The ACSM (2014) collaborated with AHA to publish current guidelines that inform of the minimal suggestions for health and fitness in “healthy adults,” of at least a half hour of “moderate intensity aerobic physical activity” on five or more days per week, or twenty minutes of “vigorous intensity aerobic activity” on three or more days per week (p. 8). Exercise intensity may be determined from heart rate (HR), heart rate reserve (HRR), metabolic equivalents (METs), oxygen uptake reserve (VO₂R), or by maximum volume of oxygen consumed per minute (VO₂max) (ACSM, 2014, p.2). Moderate intensity aerobic activity determined from HR is classified as 64-%<77 % of HRmax, and “vigorous (hard)” intensity is 77-%<94 % HRmax (ACSM, 2014, p. 5).
Statement of the Problem

There is limited research concerning the aerobic benefits of Vinyasa Flow yoga. The aerobic capacity of Vinyasa Flow yoga and its influence on health and cardiovascular fitness in beginning level yoga students is unknown. Vinyasa Flow yoga may be effective as an alternative exercise that improves and maintains cardiorespiratory fitness decreasing the chance of pre-mature mortality and morbidity associated with modern civilization. There is considerable controversy regarding the physical practice of modern yoga and its effect on aerobic capacity. Existing literature has studied less intense styles of yoga.

Purpose of the Study

The purpose of this study was to evaluate the aerobic capacity of beginning level Vinyasa Flow yoga students to determine if this style of modern yoga is effective in improving VO\textsubscript{2max}, and to assess the average heart rate (HR) response during a 45-minute class. The exercise intensity was determined from mean %HR\textsubscript{max} and compared to the exercise guidelines established by the ACSM for improving and maintaining cardiovascular health and fitness in healthy adults.

Rationale

Heart disease is the leading cause of death in the U. S. Vinyasa Flow yoga may be effective in the prevention of cardiovascular disease as an alternative form of exercise that improves and maintains cardiorespiratory health and fitness. It is uncertain how Vinyasa Flow yoga influences health and cardiovascular fitness. Moderate and vigorous exercise help reduce the chance of all cause mortality and morbidity in healthy
adults. Cardiorespiratory fitness is an important aspect of quality of life affecting individual health and longevity. Enhanced knowledge of how Vinyasa Flow yoga affects cardiorespiratory fitness and health will contribute to and shape the understanding of yoga and fitness.

Hypotheses

- The null hypothesis is:

  \[ H_0 : \text{There will be no difference in aerobic capacity as result of Vinyasa Flow yoga.} \]

  There will be no difference in aerobic capacity between treatment and control groups.

  The \( %HR_{\text{max}} \) response of Vinyasa Flow yoga will not meet ACSM guidelines for exercise intensity in healthy adults needed to improve cardiovascular health and fitness.

- The research hypothesis is:

  \[ H_1 : \text{There will be a difference in aerobic capacity as a result of Vinyasa Flow yoga.} \]

  There will be a difference in aerobic capacity between treatment and control groups. The \( %HR_{\text{max}} \) response of Vinyasa Flow yoga will meet ACSM guidelines for exercise intensity in healthy adults needed to improve cardiovascular health and fitness.

Limitations of the Study

- Small sample size

- With the exception of one participant, all participants shared a high level of cardiorespiratory fitness coming into the study

- Funding was limited resulting in a lack of heart rate monitors, and the Cosmed K4 b2 (portable indirect calorimetry)
• No learning curve for treadmill testing was allocated

Delimitations of the Study

• The control group was not instructed by the primary investigator
• Both treatment and control groups were held in an instructional learning environment including other students taking the same class who were not participating in the study
• The study design implemented Vinyasa Flow yoga twice per week

Definition of Terms

**Aerobic Capacity**

Maximal oxygen consumption (VO_{2max}).

**Arteriovenous Oxygen Difference (a-v) O$_2$**

Difference in O$_2$ between arteries & veins; expressed in ml of O$_2$ per 100 ml of blood (a-v)$_{O2}$ (Brooks et al., 2005, p. 343).

**Ashtanga**

Pattabhi Jois, who acknowledged the influence of his teacher, T. Krishnamacharya, created the Ashtanga Vinyasa style of yoga. Ashtanga is known as a “rigorous system of asana flow (vinyasa)” that “resonates with Western practitioners who go for the burn” (Sparrowe, 2002, p. 53).

**Cardiovascular Disease (CVD)**

“Coronary artery disease (CAD), hypertension, stroke, and heart failure” (Roberts & Barnard, 2005, p. 3).
**Cardiorespiratory Fitness (CRF)**

“The ability to perform large muscle, dynamic, moderate- to high intensity exercise for prolonged periods of time and reflects the functional capabilities of the heart, blood vessels, blood, lungs, and relevant muscles during various types of exercise demands” (ACSM, 2010, p. 289).

**Cardiac Output (Q)**

“The amount of blood pumped by the left ventricle of the heart; expressed in liters · per min” (Brooks et al., 2005, p. 343).

**Cardiovascular System (CVS)**

The CVS provides O2 and substrate to tissues and eliminates metabolites (Brooks et al., 2005).

**Gentle Yoga**

Gentle yoga is “relaxing in nature,” appropriate for people with physical limitations, uses focused breathing exercises (pranayama), excludes advanced poses, and often includes a long Savasana (relaxation pose) (Cowen & Adams, 2007, p. 93).

**Hatha**

Hatha yoga pertains to the physical practice of the yoga poses (asana) (Sparrowe, 2002, p. 30). Modern Hatha yoga is recognized as a slow meditative exercise in which poses are held for an extended period of time focusing on controlled breathing. Modern Hatha yoga “cannot really be considered a direct successor” of the Indian Hatha yogic tradition (Singleton, 2010, p. 5).

**Heart Rate (HR)**

The number of times the heart beats per minute.
Iyengar

A style of yoga popularized by B. K. S. Iyengar that centers awareness on proper alignment, and implements yoga props (i.e., bolsters, blankets, straps, blocks) (Sparrowe, 2002, p 53).

Maximal Oxygen Consumption (VO$_{2\text{max}}$)

“The point at which oxygen consumption fails to rise despite an increased exercise intensity or power output” (Brooks, Fahey, & Baldwin, 2005, p. 349) The equation for maximal oxygen consumption: $\text{VO}_{2\text{max}} = Q_{\text{max}} \times (a-v)_{O2\text{max}}$. Maximum cardiac output ($Q_{\text{max}}$) times maximum arteriovenous oxygen difference ($(a-v)_{O2\text{max}}$) results in $\text{VO}_{2\text{max}}$ (Brookes et al., 2005).

Maximum Heart Rate (HR$_{\text{max}}$)

$HR_{\text{max}}$ is the equivalent of 220 – age ($\pm$12 bpm) for an adult and are “affected by fitness, age, and sex” (Brooks, 2005, p. 345).

Metabolic Equivalents (METs)

An expression of exercise intensity, the volume of oxygen consumed divided by 3.5 the average amount of oxygen utilized by the cells per ml/kg/min (ACSM, 2014).

Oxygen Uptake Reserve (VO$_{2\text{R}}$)

“The difference between maximal oxygen consumption (VO$_{2\text{max}}$) and resting (VO$_{2\text{rest}}$)” (ACSM, 2010, p. 368).

Power Yoga

Sanskrit

Sanskrit is the “language of the Vedas and classical Hindu texts as well as a cosmopolitan literary language in South and Southeast Asia” (Diamond, 2013, p. 303).

Stroke Volume (SV)

The volume of blood pumped from the left ventricle of the heart in ml per beat (ml · beat⁻¹).

Vinyasa Flow

T. Krishnamacharya created Vinyasa yoga. He “focused on athleticism by incorporating the power of the breath and the element of the meditative gaze (drishti) in a dynamic flow of poses called vinyasa” (Sparrowe, 2002, p. 53). A dynamic style of yoga formed of sequenced poses that build upon one another and are thread into sun salutations; a series of movements linked together and synchronized by breath creating a constant state of fluidity.

VO₂peak

Is the “direct measurement of VO₂” and “the most accurate measurement of functional capacity” used as an “index of overall cardiopulmonary health” (ACSM, 2010, p. 121).

Yoga

“Yoga means yoke, union, or discipline --- what gets united or bound together,” known as “a system of specific poses, breathing exercises, and behaviors designed to purify, heal, and awaken” (Sparrowe, 2002, p. 9).
CHAPTER II

REVIEW OF LITERATURE

Research addressing the physical practice of yoga and oxygen consumption varies considerably with many controversial findings and study designs exploring differing styles of yoga. This review defines aerobic capacity and discusses the limits to maximal oxygen consumption, gives a brief overview of the history of yoga and its integration into Western culture, and examines the oldest to most recent research pertaining to the physical practice of modern yoga and oxygen consumption, and yoga and heart rate response (HRR). Review of the limits to aerobic capacity, and research on the physical practice of yoga and oxygen consumption provide a deeper understanding of the contextual framework for this study.

Aerobic capacity, known as VO\(_{2\text{max}}\), was originally introduced by the hypotheses of A.V. Hill and refined later by numerous researchers. Aerobic capacity is the standard measure of CRF, and is defined as “the point at which oxygen consumption fails to rise despite an increased exercise intensity or power output,” (Brooks, Fahey, & Baldwin, 2005, p. 349) and is limited by central and peripheral mechanisms (ACSM, 2010; Brooks, et al., 2005). Maximum oxygen consumption (VO\(_{2\text{max}}\)) is the result of maximum cardiac output (Q) times maximum arteriovenous oxygen difference, (a-v)\(_{O2\text{max}}\). The formula for VO\(_{2\text{max}}\) is the result of the Fick equation (oxygen consumption (VO\(_2\)) = heart rate (HR) x stroke volume (SV) x arteriovenous oxygen difference (a-v)\(_{O2}\)) (ACSM, 2010, p. 131). VO\(_{2\text{max}}\) testing is the
renowned method for determining improvements in aerobic capacity, and is used to illustrate a training effect (Bassett & Howley, 2000).

The central limitations of maximal aerobic capacity are the mechanisms involved in the cardiorespiratory systems capacity to transport oxygen through pulmonary diffusion, cardiac output, and the O\textsubscript{2} carrying capacity of the blood (Bassett & Howley, 2000; Brooks et al., 2005). The pulmonary system supplies oxygen to arterial blood, and in untrained athletes at sea level there is no limitation to the diffusion capacity of oxygen into the blood. Contemporary research shows a limitation to pulmonary diffusion capacity in elite athletes who have a greater maximal cardiac output, which causes desaturation of O\textsubscript{2} in arterial blood. As the heart pumps blood more efficiently the rate at which red blood cells diffuse through the pulmonary capillaries and become saturated with O\textsubscript{2} decreases, as there is less time for this process, resulting in the desaturation of O\textsubscript{2} in arterial blood (Bassett & Howley, 2000, pp. 72-73).

Cardiac output (Q), the capacity of the heart to pump blood during maximal exercise, is the main limiting central mechanism of aerobic capacity (Bassett & Howley, 2000; Bergh, Ekblom, & Astrand, 2000; Brooks et al., 2005). Cardiac output is equivalent to a given heart rate (HR) times stroke volume (SV), and increases as HR and SV increase. Cardiac output, HR, and SV increase due to increasing dynamic exercise intensity, and after about 50\% of maximal exercise capacity, increasing HR solely drives cardiac output (ACSM, 2010, p. 130; Brooks et al., 2005). The increase in cardiac output is essential in supplying the heart and working muscles with O\textsubscript{2} and fuel, as well to eliminate CO\textsubscript{2} and the by products of metabolism (Brooks et al., 2005 p. 341). Bassett & Howley (2000) stated that about 70-85\% (p. 73) of aerobic capacity is limited by cardiac
output, and that the differences in aerobic capacity observed in sedentary individuals equal in age, versus trained athletes is the result of SV, because HR and systemic oxygen $O_2$ uptake at maximum show less variance. It is believed that cardiac output, which supplies the blood flow needed to oxygenate skeletal muscle and fuel maximal exercise is the main central limiting mechanism of aerobic capacity because the oxygen of arterial blood is roughly $\sim 200 \, \text{mL} \, O_2 \cdot \text{L}^{-1}$ (p. 73), and venous blood leaving skeletal muscle at maximal is $\sim 20-30 \, \text{mL} \, O_2 \cdot \text{L}^{-1}$ (p. 73) indicating that increased oxygenated blood flow is needed to supply oxygen to working skeletal muscle via cardiac output (Bassett & Howley, 2000).

The last central limiting mechanism involved in aerobic capacity is the oxygen carrying capacity of the blood. Hemoglobin, the protein molecule responsible for the transfer of $O_2$ from red blood cells to skeletal muscle may be increased through blood doping techniques, which increase red blood cell concentrations and have been shown in several studies to improve aerobic capacity. Blood doping techniques have resulted in 4-9% (p. 74) increases in aerobic capacity and show a clear relationship between performance and the oxygen carrying capacity of the blood (Bassett & Howley, 2000). Therefore, an increase or decrease in hemoglobin concentration may slightly affect aerobic performance.

The peripheral limitations of aerobic capacity stated by Brooks et al. (2005) are related to the mechanisms involving arteriovenous oxygen difference $(a-v)_{O2}$. Maximum arteriovenous oxygen difference $(a-v)_{O2\text{max}}$ accounts for about 25% of the rise in oxygen consumption, and is limited by mitochondrial density and the speed at which arterial oxygen diffuses into cells. It is also limited by “blood flow, the oxyhemoglobin
dissociation curve, hemoglobin, and myoglobin,” (Brooks, 2005, p. 344). These mechanisms are enhanced with training resulting in small increases in (a-v)-O\(_2\) (p. 358). During increasing exercise intensity skeletal muscles require more oxygen, resulting in the release of the oxygen and hemoglobin bind, allowing for red blood cells to transport oxygen to cells more effectively. This is characterized by a right shift of the oxyhemoglobin dissociation curve. (Brooks et al., 2005).

Further with training mitochondrial content in muscle becomes denser, allowing cells to utilize more oxygen, and increased hemoglobin and myoglobin concentrations allow for a faster process (Brooks et al., 2005). Bassett & Howley (2000) declared that research on mitochondria using human participants has resulted in 20-40\% (p. 75) increases in aerobic capacity by adding two times the amount of mitochondrial enzymes, which in “theory” (p. 75) should have doubled the amount of O\(_2\) consumed if the oxidative capacity of the muscles was a main limiting factor of aerobic capacity. The results from such studies support the belief that aerobic capacity is limited by oxygen supply instead of the oxidative capacity of muscles, yet “muscles set the demand for O\(_2\)” (Bassett & Howley, 2000, p. 76; Richardson, 2000).

The last peripheral limitation to aerobic capacity is the speed at which arterial oxygen diffuses into cells, which is affected by capillary density. The density of the capillaries increases with training decreasing the distance oxygen travels to enter the myocytes (muscle cells) resulting in a faster rate at which oxygen diffuses into cells (Brooks et al., 2005).

The concepts of VO\(_{2}\)\(_{\text{max}}\) first introduced by A. V. Hill and his colleagues still ring true today even after having been debated and tested by many scientists since the
The cardiorespiratory system and its ability to supply $O_2$ via the heart, lungs, and blood are the central limiting mechanisms of aerobic capacity, and have been challenged by numerous exercise physiologists. In the beginning of the 1970s the concept that the cardiorespiratory system was the main limiting factor of aerobic performance was debated and the oxidative capacity of the muscles was thought by many to be the central limiting mechanism behind maximal aerobic capacity (Blomqvist & Saltin, 1983, p. 169). However, modern science holds the widespread belief that aerobic capacity is centrally limited by the cardiorespiratory system instead of the oxidative capacity of skeletal muscle (Basset & Howley, 2000).

Similar to the history of VO$_{2\text{max}}$, the research on aerobic capacity of yoga has resulted in numerous controversial findings. Yoga is a very old and ambiguous practice originating from the Indus Valley Civilization in ancient India where it has remained heavily engrained in Indian culture, dating back approximately 3,500 to 5,000 years ago (Desai, 2004; Sparrowe, 2002). The roots of yoga stem from the “Harrapan culture,” an “ancient meditation heritage,” centered in the Indus Valley, which is presently the territory of “Pakistan and western India” (Sparrowe, 2002, p. 10). The Harrapan culture left behind what are believed to be depictions of yoga through carved images of “gods and men sitting in the cross-legged Lotus position” (Sparrowe, 2002, p. 11). Close to “1500 B.C.E,” “yoga” appeared as a term with the weakening of the “Harrapan culture,” which was eventually conquered by “Aryan barbarians” who introduced “Brahmanism” (modern-day Hinduism), and the “concept of yoga” through sacred scriptures in the Vedas (Rig, Sama, and Yajur) (Sparrowe, 2002, p. 11).
Yoga remained in South Asia, and did not branch out for thousands of years remaining in what is now present day “India, Pakistan, Bangladesh, Sri Lanka, Nepal, Tibet, and Bhutan” (Diamond, 2013, p. 95). By the modern period the practice of yoga started to branch out in a methodical style becoming a sensation early in the twenty-first century in nearly every city worldwide. The practice of yoga is now eminent in “North America, Europe, Australasia, but also in Central and South America, the Middle East, Asia, and parts of Africa” (Diamond, 2013, p. 95).

Yet, before the physical practice of yoga became such a global sensation it was heavily influenced and shaped by many people and time periods. The nineteenth century was influential and key in the worldwide progression of the Hatha yoga practiced today, and referred to as “the modern yoga renaissance” (Diamond, 2013, p. 95). This was a time of change affecting “cultural and religious foundations of Hinduism” (Diamond, 2013, p. 95). Important figures of the modern yoga renaissance were: “Rammohan Roy (1774-1833)” and “Keshubchandra Sen (1838-1884)” who spread the concept of neo-Hinduism, a term for the coming together of Western concepts (i.e., world religion, science, philosophy) and Indian Hindu custom, which were taken to the United States (Diamond, 2013, p. 95-96); “Swami Vivekananda” who was “the first yoga teacher in the West” (p. 96) and “Sri Ramakrishna” the guru of Vivekananda (p. 96); “Helena Petrovna Blavatsky (1831-1891) and Colonel Henry Steel Olcott (1832-1907)” (p. 97) were influential in the unfolding of worldwide yoga with their mystical establishment in “1875” called the “Theosophical Society” (p. 97); “Swami Sivananda (1887-1963)” who drew from the teachings of Vivekenanda created many “pamphlets and books” that were sent out worldwide (p. 97); “Parahamahansa Yogananda (1893-1952)” (p. 97) is credited
for his famous book, *Autobiography of a Yogi*, which was published not long after his arrival in the U.S. in 1920; “Sri Aurobindo Ghose (1872-1950)” has also contributed to our present day understanding of yoga (Diamond, 2013, pp. 95-97).

In the nineteenth century in America and Europe “spiritual gymnastics” was created, and infused with yoga as it came to the West (Diamond, 2013; Singleton, p. 98, 2010). Spiritual gymnastics was created as a form of exercise for women that comprised of stretching. Hatha yoga practiced by most in the West is really an extension of spiritual gymnastics in the twenty first-century (Diamond, 2013). During the early part of the twentieth-century numerous books were written from the allure of yoga to the European esoteric imagination (Diamond, 2013). Yogis were depicted as having supernatural powers, and who practiced tantric “sex magick” (p. 98). The misled perception of traditional yogic practices during the yoga renaissance may be the reason the physical practice of the yoga poses (asana) was not incorporated into the paradigm of the time period. The allure of yoga was eventually stripped away from its esoteric and tantric connotations and viewed as a form for health and fitness “from the 1920s and 1930s onward” (Diamond, 2013, p. 98). Hatha yoga was from then on seen as “an interpretive framework borrowed from modern medicine, health science, bodybuilding, and gymnastics” (Diamond, 2013, p. 98).

Crucial in the worldwide-progression of the physical practice of yoga known today, according to Diamond (2013) were “Swami Kuvalayananda (1883-1966) and Sri Yogendra (1897-1989)” who founded the first yoga schools where the discipline focused on implementing yoga as a routine for “health and fitness” and a method for “medicine” (p. 98). As well, Diamond (2013) declared that “Sri T. Krishnamacharya (1888-1989)”
was a central figure in the worldwide-progression of yoga, and created “similar rigorous, health- and healing-oriented modes of posture practice” as Kuvalayananda and Yogendra (p. 98). The students of Kirshnamacharya popularized a variety of yoga styles practiced today. Of these renowned teachers were B. K. S. Iyengar (1918-2014), Sri K. Pattabhi Jois (1915-2009), Indra Devi (1899-2002), and T. K. V. Desikachar the offspring of Krishnamacharya (Diamond, 2013, p. 98). Indra Devi, in particular, greatly influenced yoga in the U.S. “with the help of high-profile Hollywood students like Gloria Sawnson, Greta Garbo, and Marilyn Monroe” (Diamond, 2013, p. 98).

By the late twentieth century yoga was brought to the attention of American and European counterculture with “the rise of the flower power” in the 1960s (Diamond, 2013, p. 100). The Beatles helped influence “the hippy trail to India” with their “spiritual romance with Maharishi Mahesh Yogi,” and America became influenced by Indian gurus who came to the U. S. from “1965 onward” bringing “Eastern wisdom” (Diamond, 2013, p. 100). The gurus heavily influenced American minds, thus, leading to “increased media attention” through the use of “printed primers and television” (Singleton, 2010, p. 20). By the 1970s and 1980s the number of yoga schools grew, and several yoga institutes withdrew from the gurus of the 1960s. By the middle of the 1990s Hatha yoga could be found throughout the West with the more challenging forms of yoga becoming widespread, for example, “Jois’s Ashtanga Vinyasa method,” which are the main styles of yoga practiced in the U.S. are “variously referred to as Vinyasa Yoga, Flow Yoga, and Power Yoga” (Diamond, 2013, p. 101).

Modern yoga is far different than what was practiced 3,500 years ago (Desai, 2004). The physical practice of the yoga poses (asana) resembles less of ancient Indian
yogic tradition, and more closely relates to “British gymnastics, martial arts, and wrestling” (Sparrowe, 2002, p. 10). The many differing styles of modern Hatha yoga practiced by the West are relatively young, dating back ~120 to 150 years (Sparrowe, 2002, pp. 10-11). The practice of modern Hatha yoga “cannot really be considered a direct successor” of the Indian Hatha yogic tradition, since modern forms show no resemblance to the Indian Hatha yogic tradition prior to modern Hatha yoga (Singleton, 2010, p. 5).

Yoga, literally means to yoke, or unite in Sanskrit, and encompasses many styles. The growing popularity with yoga seems to be tied to its physical and mental health benefits, which are known to create a healthy body and a peaceful state of mind (Sparrowe, 2002). In the U.S. Birdee et al. (2008) stated that 5.1% of the population, consisting of more than 10 million citizens practiced yoga for health, and that yoga was practiced most by “caucasian (85%) females (76%), who were near middle-aged (39.5 years), and who had a college education” (p. 1653).

Today yoga classes can be found all over the Western world, in gyms, studios, spas, retreat centers, universities, and even in corporate offices (Sparrowe, 2002). People are practicing yoga to “stretch, sweat, and breathe their way to leaner, more flexible bodies, stronger muscles, and tighter abdominals” (Sparrowe, 2002, p. 9). Renowned styles of yoga are Hatha, Iyengar, Restorative, Hot (Bikram), Vinyasa, and Ashtanga. These styles of yoga may all be referred to as Hatha, the classical term denoting the physical practice of the yoga asana (poses). The term Hatha can be misleading, because it is also recognized as a certain style of yoga (Sparrowe, 2002). Modern Hatha yoga practiced in the West is known as a slow meditative exercise in which poses are held for
an extended period of time focusing on slow controlled breathing. Hatha yoga’s classical meaning may be easily mistaken for its various modern styles.

Vinyasa Flow yoga is not to be confused with modern Hatha yoga. It was created in India in the early 1900s by Sri T. Krishnamacharya who developed a sequence of flowing poses in a dynamic fashion from a style of yoga he was trained in, Sritattvanidhi, that focused only on the physical aspects of the practice. Krishnamacharya incorporated gymnastics and wrestling movements, as well as other non-traditional yoga poses, thus creating Vinyasa Flow (Sparrowe, 2002). This dynamic style of yoga is formed of sequenced poses that build upon one another and are thread into sun salutations; a series of movements linked together and synchronized by breath creating a constant state of fluidity. The effect is a practice of unbroken movement described by Broad as a “yoga ballet” (2012, p. xxvii).

Vinyasa Flow is considered to be one of the more intense styles of yoga, than modern Hatha yoga. According to Brooks et al. (2005) the “largest response from the cardiovascular system” comes from “dynamic exercise requiring large muscle mass (i.e., large muscle groups performing rhythmical contractions)” (p. 343). Sun salutations are performed with just the human body that must execute graceful movement throughout almost every joint (Omkar, Mour, & Das, 2009). One sun salutation involves a series of 10 movements synchronized with the breath (see Figure 1). Performing many sun salutations is claimed to be “very much aerobic” (Omkar et al., 2009, p. 62). Research on sun salutations has found significant improvements in muscular strength and endurance, and significant decreases in BMI in male \(n = 49\) and female \(n = 30\) participants who performed twenty-four cycles of sun salutations six days a week for twenty-four weeks
Figure 1. The sun salutation A cycle used in Vinyasa Flow yoga.

(Bhutkar, Taware, & Surdi, 2011). Sun salutations are believed to be an ideal way to maintain health and fitness comparable to aerobic exercise for those who are sedentary and unfit (Bhutkar et al., p. 264).

However, research studies on the aerobic benefits of yoga have shown few positive results primarily because of the style of yoga that was examined and/or the research design. Broad (2012) insists research studies assessing if yoga increases
individual cardiorespiratory fitness, which are limited in number, have not shown any change in aerobic capacity as a result of practicing yoga. The reported negative findings of these studies, as indicated in *The Science of Yoga*, are the result of no significant change, or, when broken down in their research design and method are due to factors such as small sample size, a lack of control group and generalizability (Broad, 2012).

**Aerobic Capacity of Hatha Yoga**

In 2013, a systematic review of studies on yoga and oxygen consumption was published confirming Broad’s assertions. Tyagi and Cohen (2013) declared, “the studies were generally of poor methodological quality and demonstrated great heterogeneity with different experimental designs, yoga practices, time periods, and small sample sizes” (p. 290). In the review, studies on the physical practice of yoga reported significant results with contrasting measures of oxygen consumption (Tyagi & Cohen, 2013). The style of yoga implemented, the number of days of yoga practiced, the study length, and the participants’ fitness level may be reason for the ambiguous research results concerning the aerobic capacity and the physical practice of yoga. The style of yoga used in most studies was Hatha, which does not meet sufficient exertion for an increased metabolic demand that would result in a cardiovascular response (Clay, Llyod, Walker, Sharp, & Pankey, 2005; Hagins, Moore, & Rundle, 2007).

According to Broad (2013) as yoga in the West increased in popularity in the “1970s and 1980s” so did the number of studies on yoga (p. 55). Broad (2012) emphasized “one of the first” and “one of the best” studies on Hatha yoga compared how yoga measured against aerobic exercise training (p. 55). The study lasted four months,
with 101 older males and females, who were divided into an aerobic exercise group, a yoga control, and a wait list control group. The yoga group practiced yoga at least two times per week for one hour. There were no improvements in cardiorespiratory fitness for the yoga control or the wait list control, and an 11.7% increase in $\text{VO}_{2\text{peak}}$ for the aerobic exercise group (Blumenthal et al., 1989, p. 147). However, the aerobic exercise group encountered one hour sessions three times per week, and the yoga control group practiced yoga at least twice per week.

The findings of Blumenthal et al. (above) were not mentioned in the Tyagi and Cohen review on oxygen consumption and yoga. However, Tyagi and Cohen (2013) noted four other studies that were performed prior to Blumenthal et al.’s research assessing Hatha yoga and oxygen consumption in comparison to physical activity. In 1975 it was shown that in 53 healthy males no change in oxygen consumption resulted at rest from a yoga group with physical training, an athletic group with physical training, or a control group with physical training after twelve months. Participants had no previous yoga experience and the physical training was considered submaximal (Tyagi & Cohen, 2013, p. 301). In 1978 it was shown that oxygen consumption did not increase after a one month yoga intervention with submaximal exercise, although a significant increase in oxygen consumption was observed for the fixed intensity submaximal exercise group at three and six months (Tyagi & Cohen, 2013, p. 300). In 1981 no change in oxygen consumption was observed from a small sample of 10 male participants with no previous yoga experience. Participants were tested at rest before and after a three month study with no control group (Tyagi & Cohen, 2013). In 1986 no significant changes in oxygen consumption for males or females were reported for students involved in a yoga teacher
training program during any part of the study. The first twenty days of the study included only pranayama (breathing exercises) and a pre and post submaximal exercise test to assess VO\textsubscript{2max}. Yoga poses were included after day twenty of the three month study followed by a submaximal exercise test. The sample size was small consisting of six young women and six young men with no prior yoga experience, and who were not fit. Yoga poses were practiced for twenty-five minutes, and the number of days per week was not stated (Raju et al. 1986).

The above studies integrating Hatha yoga all found no significant change in oxygen consumption. The specific style of yoga used was not addressed, and the research designs varied with small sample sizes, either with, or with out the use of control groups. Therefore, the results are insignificant, especially the study by Blumenthal et al., whose research design did not implement consistency between treatment and control groups.

Contrary to many of the previously-cited studies, some authors have found improvements in aerobic capacity. Balasubramanian & Pansare (1991) found that seven days per week of yoga for one hour each day over a six week period resulted in a significant increase in aerobic power (p. 282). These findings may indicate that there is a minimum amount of participation (frequency) required in order to elicit an increase in aerobic capacity. While the previous study was not very long (6 weeks), the participants engaged in yoga every day of the week. Interestingly, the previous study noted the increase in VO\textsubscript{2max} was thought to be the result of increased oxidative capacity of the muscles from enhanced blood flow, or “may be due to a generalized decrease in vascular tone resulting from stimulation of parasympathetic acitivity during yogic training” (p.
It is known that an enhanced endurance capacity is the result of an increase in the oxidative capacity of skeletal muscle (Blomqvist & Saltin, 1983, p. 170).

In another study a significant increase of 11% in VO$_{2\text{max}}$ was reported for a six week yoga intervention from a sample of twelve sedentary participants. Half of the participants were male and the other half female. Hatha yoga was practiced twice per week for an hour and a half. The control group consisted of fourteen participants with ten males and four females. The average age for the yoga and control group was 68 years. The control group practiced aerobic exercise on a bicycle resulting in a 24% increase in VO$_{2\text{max}}$ (Bowman et al., 1997, p. 443).

The above study assessed older participants (68 years old) practicing Hatha yoga twice per week. With younger participants it appears that increasing the frequency of Hatha yoga practiced produces significant results in oxygen consumption. Ragu et al. (1997) found that four weeks of Intensive Hatha Yoga (IHY) practiced for an hour and a half two times daily improved maximal work output and significantly lowered oxygen consumption per unit of work implying enhanced cardiorespiratory fitness (p. 293). The results were from a sample of six women without prior yoga experience with an average age of 25, and who were free from disease with similar physical activity patterns (Ragu et al., 1997).

Similarly, Ray et al. (2001) observed a significant increase in VO$_{2\text{max}}$ from Hatha yoga practiced for half a year six days a week for one hour, plus an hour of daily games (p. 215). These results were compared to a physical training and games control group that demonstrated no significant changes. The physical training was replicated to that of the Indian Army. The nature of the games were not addressed. The participants
consisted of 29 healthy males (19-23 yrs old) from the Indian Army with no prior yoga experience (Ray et al., 2001, p. 215).

It appears the participants’ cardiorespiratory fitness and/or age, and frequency of Hatha yoga practiced affect oxygen consumption. Tran, Holly, Lashbrook, and Amsterdam (2001) found a significant change in cardiorespiratory endurance with a 6% and 7% increase in relative and absolute VO$_{2\text{max}}$ from a sample of ten participants (p. 165). All of the participants were female except for one. Participants were recruited via flyers on campus with the requirements of no previous yoga experience and no physical activity regime within the last half year, or the start of a new physical activity regime during the study. The study lasted a total of eight weeks with two yoga classes per week lasting an hour and a half each (Tran et al., 2001). This study demonstrates how the participants’ cardiorespiratory fitness may be one reason for the ambiguous research results concerning Hatha yoga and oxygen consumption.

Another study illustrates how the participants’ cardiorespiratory fitness may influence an increase in oxygen consumption from practicing Hatha yoga. Pullen et al. (2008) reported a 17% increase in VO$_{2\text{peak}}$ from a sample of nine participants with congestive heart failure (CHF) who practiced yoga and “medical therapy” (p. 407). The yoga sessions lasted an hour and ten minutes two times per week and lasted eight weeks. The control group, with 10 CHF participants, practiced only medical therapy with the result of no significant change. The participants performed a graded exercise test pre and post study intervention. All participants were randomly selected from the same category of “Class I-III HF patients” (p. 407).
Likewise, increasing the frequency of Hatha yoga practice affects the research findings when assessing differing participant demographics. Intensive Hatha yoga performed for two months and three weeks increased relative VO$_{2\text{max}}$ significantly in four females with an average age of 43 years, and nine females with an average age of 62 years, for which the VO$_{2\text{max}}$ was higher (Ramos-Jiménez, Hernández-Torres, & Wall-Medrano, 2009, p. 52). Hatha yoga was practiced for an hour and a half five days per week. All participants were healthy, physically active, and practiced yoga for at least three years prior to the study. It was concluded that Hatha yoga performed at an intense level has a positive effect on VO$_{2\text{max}}$ and high-density lipoprotein cholesterol (HDL-C), and therefore reduces the chance of cardiovascular disease (Ramos-Jiménez et al., 2009, p. 49). In another study by Ramos-Jiménez et al. (2011) sixteen females with an average age of 56 years showed an increase in VO$_{2\text{peak}}$ of ~3ml/kg/min indicating an improvement in cardiorespiratory fitness and a decrease in “CVD risk factors” (p. 1). The 2011 study followed the same protocol as the 2009 study except with a different demographic of participants and factors contributing to the risk of CVD.

Cardiovascular Response to an Acute Bout of Hatha Yoga

Tyagi and Cohen (2013) reported five studies that claimed Hatha yoga stimulates a cardiovascular response less than or equal to mild exercise, and two studies equal to moderate exercise, when assessing the oxygen consumption of the poses. In 1995, a sample of ten participants and no control, demonstrated that Hatha yoga resulted in 34% of VO$_{2\text{max}}$ compared to walking on a treadmill at 46% of VO$_{2\text{max}}$ (p. 299). Hatha yoga is a milder form of exercise than walking on a treadmill.
In comparison, Ashtanga Vinyasa Yoga elicits a greater cardiovascular response than Hatha yoga, with similar results to walking on a treadmill at 46% of VO2max. Ashtanga Vinyasa yoga resulted in a response approximately 50% of VO2max and about 77% of HRmax (Carroll, Blansit, Otto, & Wygand, 2003, p. 1). Ashtanga Vinyasa yoga was classified as moderate intensity for thirteen healthy and fit (VO2max 46.6 ± 4.5 ml/kg/min) middle-aged participants with an average age of 37 whom had practiced yoga anywhere from twelve weeks to three years (Carroll et al., 2003, p. 1). The exercise intensity if classified by %HRmax would be considered vigorous intensity, yet, the VO2 consumed during the practice of the power yoga session was 23.4 ml/kg/min (~50% VO2max) the equivalent of 6.7 METs, and considered moderate intensity exercise (Carroll et al., 2003, p.1) Carroll et al. (2003) reasoned, “the anaerobic exercise and isometric muscle actions involved in Vinyasa Yoga, may in part be responsible for the disproportionate HR/VO2 response and thus preclude the use of HR to estimate exercise intensity” (p. 1). At any rate, these participants were already fit and were exercising at ~50% of their VO2max, which is considered moderate exercise intensity, and recommended by the ACSM for cardiovascular health and fitness.

Therefore, adjusting for the disproportionate HR/VO2 response, sun salutation based yoga styles seem like an ideal way for sedentary and/or unfit individuals to achieve moderate exercise intensity. Sinha, Ray, Pathak, & Selvamurthy (2004) studied twenty-one males from the Indian Army with an average age of 22 who practiced yoga for twenty-four weeks before being tested in the lab. Practice included pranayama, meditation, and sun salutations. Sun salutations were performed in the lab after twenty-four weeks and included Savasana (relaxation pose). An increase in VO2 of 207% while
performing sun salutations from relaxation pose was observed (Tyagi & Cohen, 2013, p. 298). In this study, sun salutations appear to be suited for an aerobic exercise if they are performed for the duration of a typical yoga class.

In another study Clay et al. (2005) found Hatha yoga to elicit less of a cardiovascular response than walking at 3.5 mph, which is a lower intensity than moderate exercise. The sample was limited by twenty-six females with an average age of 23 and no males, no control group, and a 30 min Hatha yoga video administered once. The participants shared a reasonable degree or more of cardiovascular fitness, and had at least one month or more of yoga experience, which may be the reason the results produced a cardiovascular response less than walking at 3.5 mph.

The results from Clay et al. (above) do not resonate with the previous research of Tran et al. who found an increase in VO$_{2\text{max}}$ as the result of practicing Hatha yoga. Clay et al. found Hatha yoga to stimulate less of a cardiovascular response than walking at 3.5 mph. The varying results of these two studies seem to stem from the length of the yoga sessions and the prior fitness level of the participants. Tran et al. studied participants who practiced Hatha yoga two times per week for an hour and a half, and who had no physical activity for half a year, versus Clay et al., who studied a sample of fit participants for 30 minutes.

Clay et al. (2005) reported that during the Hatha yoga session five minutes of sun salutations stimulated a HR$_{\text{max}}$ of 67%, which is considered moderate intensity physical activity by the ACSM (p. 607). However, VO$_{2\text{R}}$ was 33%, and does not meet the same criteria for moderate exercise at 50% VO$_{2\text{R}}$ (p. 607). Clay et al. (2005)
described possible intrinsic reasons why HR response is not representative of VO_{2R} measures and should not be used to classify exercise intensity:

This phenomenon may be due to the perception of an increase in strain relative to the size of musculature used when arm movements are integrated with lower body exercise. In other words, an increase in strain without a proportionate increase in muscle tissue augments peripheral feedback to the medulla, thereby resulting in an increase in HR without a concomitant increase in oxygen consumption. Additionally, disproportionate elevations in HR rate may be a response to the venous pooling that may occur while holding static standing postures for extended periods of time. Because of the excessive elevation in HR during hatha yoga using the \%MHR method may not be appropriate as the VO_{2R} method. (p. 608)

Therefore, sun salutations may not provide a cardiovascular stimulus for improving aerobic capacity and protection from morbidity and pre-mature mortality in fit healthy adults, but may for unfit and/or sedentary adults.

In another study the VO_{2} and HR response of an Iyengar yoga sequence was assessed (Blank, 2006). Fifteen female yoga practitioners participated in the study with an average age of 44 years. The participants had on average nine years of experience and recent practice of six hours of yoga per week. HR data suggests that the Iyengar yoga style, a form of Hatha, is either light or moderate at 55-85\% of HR_{max}, and remained within this range for approximately thirty minutes during the hour and a half Iyengar session (Blank, 2006, p. 7). The highest VO_{2} consumed during the Iyengar sequence was observed for warrior III pose at 4 METs, and is considered light intensity exercise; the HR_{max} was about 72\% and is considered moderate (Blank, 2006, p. 7). This clearly demonstrates the disproportionate relationship between HR and VO_{2} consumed.

In another study Hatha yoga was compared to walking on a treadmill, showing similar results to Clay et al.’s, who reported Hatha yoga stimulated less of a cardiovascular response than walking on a treadmill at 3.5 mph. Hagins, Moore, and
Rundle (2007) emphasized that Hatha yoga elicited the same effect as “walking on a treadmill at 3.2 kph,” and “represents low levels of physical activity” (p. 1). The average MET level was 2.5 for the 56 minute yoga session (Hagins et al., 2007, p. 1). Hatha yoga performed at a beginning level does not meet recommendations for cardiovascular health and fitness, with an average $HR_{max}$ of 49.4%, although adding sun salutations into a beginning Hatha yoga class for longer than 10 minutes in duration may provide an enhanced aerobic capacity for a large part of the population, the unfit (Hagins et al., 2007, p. 4).

The study by Hagins et al. (2007) was limited in that it was not generalizable, as the sample of twenty consisted of mainly women, with an average age of 31 years, and who were recruited from local studios (p.1). These participants were “intermediate to advanced” yoginis (female practitioners), and the style of yoga, though called ”Hatha,” was actually a beginners video of Ashtanga yoga (Hagins et al., 2007, p. 1). The results of this study definitely appear to be influenced by the participants’ fitness level. All were intermediate to advanced practicing beginning Ashtanga yoga.

Hagins et al. (2007) reported that subjects participating in Ashtanga yoga reached 54.8% of their $HR_{max}$ for twenty-four minutes when averaged across sun salutations. This is comparable to the ACSM recommendations for cardiovascular fitness at 55% $HR_{max}$ for sedentary and unfit adults (p. 6). Contrary to what was found by Hagins et al., others have found that yoga elicited ~57% (Clay, 2005) and 77% (Carroll, 2003) of $HR_{max}$. The difference, as reported by Carroll et al., may be due the 15-minute yoga sequence used, and not indicative of the average %$HR_{max}$ associated with a full-length class (Hagins et al., 2007, p. 5).
However, a full-length class might increase $\%HR_{\text{max}}$ if exercise intensity is maintained, which is the nature of Ashtanga Vinyasa (Power yoga). Apart from the style of yoga and participant fitness level, participant age may be reason for the ambiguous $\%HR_{\text{max}}$ results, because $VO_{2\text{max}}$ is known to decrease as we age. Thus, the relative intensity of activity experienced by an older individual during an acute bout of exercise may be higher simply by virtue of the decreased aerobic capacity (ACSM, 2014, p. 3). Therefore, the intensity of yoga will have differing physiological results for the different participant demographics.

The final study in review for this section addresses the oxygen consumption of various Hatha yoga poses. It has been found in young males that exercise intensity, based on $VO_{2\text{max}}$, is anywhere from 9.9-26.5% during Hatha yoga, with the poses equivalent of 1-2 METs (Ray, Pathak, and Tomer, 2011, p. 1). The MET level of the poses is not associated with moderate intensity exercise, which would result in an improved cardiovascular response, nor is the 52.3–54.5% $HR_{\text{max}}$ for the one hour yoga session (Ray et al., 2011, p. 9).

Heart Rate Response and Hatha Yoga

Two studies have assessed the HR response and the practice of yoga exclusively. Cowen and Adams (2007) studied male ($n = 5$) and female ($n = 11$) yoga participants with an average age of $31.8 \pm 11.96$ years, and with varying fitness levels (p. 92). The participants practiced Ashtanga, Hatha, and Gentle yoga. Results suggested Ashtanga yoga elicited $\sim54\%$ of $HR_{\text{max}}$, Hatha yoga $\sim45\%$ of $HR_{\text{max}}$, and Gentle yoga $\sim42\%$ of $HR_{\text{max}}$ (p. 94). As mentioned above, the response of exercise is due to a variety
of factors (e.g., CRF and age). Other researchers have found that Vinyasa Flow yoga elicited a variety of HR responses ranging from light to vigorous intensity exercise depending on the training status of the participants (Ward, McCluney, & Bosch, 2013, p. 1).

Conclusion

The ambiguous results presented in the above studies addressing the physical practice of yoga and oxygen consumption appear to be the result of differing research designs, study lengths, and participant demographics. In most studies the practice of Hatha yoga was used, which is supported by many researchers to not meet sufficient exertion for an increased metabolic demand that would result in a cardiovascular response (Clay, Llyod, Walker, Sharp, & Pankey, 2005; Hagins, Moore, & Rundle, 2007). However, the practice of Hatha yoga was found to elicit significant increases in aerobic capacity (Balasubramanian & Pansare, 1991; Bowman et al., 1997; Similarly, Ray et al., 2001; Tran et al., 2001; Pullen et al., 2008; Ramos-Jiménez et al., 2011). The above studies appear to be strongly influenced by the frequency and style of yoga implemented, and by participant age and/or cardiorespiratory fitness.

Presently, only two studies have assessed Vinyasa yoga. Carroll et al. studied the VO\textsubscript{2} and HR response of middle-aged participants with a high degree of cardiorespiratory fitness during a 15-minute Vinyasa yoga sequence, although it was actually Ashtanga Vinyasa (Power yoga). Ward et al. (2013) found varying exercise intensities from HR responses during Vinyasa yoga from participants with an average age of ~31 years. However, no studies have evaluated if aerobic capacity increases as a result
of Vinyasa Flow yoga. Also, no studies have assessed the HR response of college-aged students practicing Vinyasa Flow yoga. Ashtanga Vinyasa yoga resulted in a response approximately 50% of \( \text{VO}_2\text{max} \) and about 77% of \( \text{HR}_{\text{max}} \) (Carroll et al., p. 1). Therefore, the practice of Vinyasa yoga may increase aerobic capacity and meet the ACSM recommendations for cardiovascular health and fitness in unfit and/or sedentary individuals.
CHAPTER III

METHODOLOGY

Participants were recruited from a yoga class (Kinesiology 169, section 7, Spring 2014) at California State University, Chico, led by the primary investigator (P. I.). Vinyasa Flow yoga was choreographed and implemented twice a week for 50 minutes after the students were familiar with the poses in the sequence, and thereafter for the duration of the six week study (see Figure 2). The control group involved participants recruited from a traditional yoga class at California State University, Chico. To determine if aerobic capacity improved as a result of Vinyasa Flow yoga maximal aerobic capacity was assessed for both treatment and control groups before and after the intervention period. Height, weight, and HR_{max} were analyzed beginning and end of the semester for the treatment and control groups. HR data was collected by the treatment group and recorded to assess %HR_{max} in order to determine if the exercise intensity during Vinyasa Flow yoga met the ACSM physical activity requirements for moderate or vigorous intensity exercise.

Ten healthy physically active beginning level yoga students (19 to 25 years of age) participated in the study. The treatment group consisted of males (n = 2) and females (n = 3) with an average age of 20 ± 2 years. All participants in the treatment group had a high level of aerobic fitness (47.97 ± 6.88 ml/kg/min) determined from pre VO_{2max} data, except for one female (22.5 ml/kg/min). The control group, with males (n = 3) and
Figure 2. 45-minute Vinyasa Flow sequence.

females (n = 2) had an average age of 20.8 ± 2.38 years, and had a similar pre VO$_{2 \text{max}}$ (48.48 ± 12.22 ml/kg/min) as the treatment group. Participants were free of orthopedic injuries or severe pain, did not smoke cigarettes, did not have any positive risk factor for
cardiovascular disease as outlined by the ACSM, had no neurological disorders, had no metabolic disorders, and did not have more than one year of yoga practice.

The Human Subjects Committee at California State University, Chico, approved the study. All participants completed a health history questionnaire and an informed consent form prior to participating in the study. Enrollment in the class was not dependent upon participation in the study, and participants had the right to withdraw from the study at any time without any penalty. Exclusion criteria included: 1) orthopedic injuries or severe pain within the last year; 2) cigarette smoking; 3) having a positive risk factor for cardiovascular disease as outlined by the ACSM; 4) having any neurological disorders; 5) having any metabolic disorders; 6) consistently taking any prescription medications; 7) positively identifying with any one of the conditions listed in question 16 of the health history questionnaire; 8) more than one year of yoga practice; 9) currently participates in vigorous intensity exercise (e.g., running, spin, etc.). Twelve participants were excluded and two did not finish post testing. Two amendments were made for review from Human Subjects allowing for the inclusion of participants using birth control, and who were engaging in vigorous activity. This was not desired, as such participants originally met the exclusion criteria, as this study sought to assess sedentary participants who were not taking prescription medications.

The study was performed at California State University, Chico Human Performance Lab (graded exercise tests, GXT), and in Yolo 213 (yoga class). Prior to testing participants age, height, weight, and age predicted max heart rate were recorded. Aerobic capacity was measured mid-point, and at the end of the semester using a graded exercise test (GXT) (i.e. treadmill-based protocol) attached to an open-circuit indirect
calorimetry (TrueOne 2400, Parvomedics, Sandy, UT). The expired air from participants was collected via a mouth piece attached to a 1.5 inch diameter hose that ran into a mixing chamber. A pump drew expired air via a sampling line to gas analyzers. Expired gas samples were analyzed for carbon dioxide (CO₂) and oxygen (O₂). The gas analyzers were connected to an on-line computer, which then calculated oxygen consumption (VO₂). The gas analyzers were calibrated for efficiency throughout testing. VO₂max was determined when subjects could no longer keep pace with the motor-driven treadmill (i.e. volitional fatigue). Heart rates were constantly monitored during the course of the graded exercise test. Heart rate monitors were worn by a limited number of participants during the treatment. HR data was collected and recorded by the treatment participants beginning, middle, and end of every Vinyasa Flow yoga class. The data were averaged at the end of the study to determine %HRmax.

The results were analyzed using Excel for Mac (2011, version 14.3.8) and Vassar Stats. A t-test for dependent samples was used to calculate if there was a significant difference for the treatment group in pre and post VO₂max. An independent t-test and repeated measures ANOVA were performed to assess if their was a significant difference in VO₂max between treatment and control groups. Mean differences were considered significant if the two-tailed p-value was < 0.05. Average HR data for each participant in the treatment group was divided by age predicted max HR to determine %HRmax. Mean %HRmax for the treatment group was then recorded to determine exercise intensity.
CHAPTER IV

RESULTS

Mean age, height, pre/post weight, and pre/post VO\textsubscript{2max} for the treatment group was 20 ± 1.73 years, 66.4 ± 5.5, 158.6 ± 32.79 lbs. / 157.1 ± 33.24 lbs., and 3.05 ± 1.1 L/min / 2.92 ± 0.9 L/min, and the control group had a mean age, height, pre/post weight, and pre/post VO\textsubscript{2max} of 20.8 ± 2.38 years, 66.8 ± 3.7, 159.8 ± 43.23 lbs. / 160.2 ± 43.81 lbs., and 3.47 ± 1.1 L/min / 3.41 ± 1.1 L/min (Table 1). There was no significant difference ($p > 0.05$) between pre and post VO\textsubscript{2max} data at the end of six weeks for the treatment group, $p = 0.395$. There was no significant difference ($p > 0.05$) in VO\textsubscript{2max} between treatment and control group (Figure 3). Repeated measures ANOVA indicated there was no significant difference ($p > 0.05$) in VO\textsubscript{2max} between treatment or control, $p = 0.85$ (Table 1). Heart rate data from the treatment group indicated Vinyasa Flow yoga stimulates an average HR\textsubscript{max} of 55.94 ± 9.99% suggestive of light intensity exercise (Figure 4 & Table 2).
Table 1

*Physical Characteristics of Participants (n = 10)*

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<th>Treatment:</th>
<th>Mean ± SD</th>
<th>Control:</th>
<th>Mean ± SD</th>
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</tr>
<tr>
<td><strong>Post Weight</strong></td>
<td></td>
<td>157.1 ± 33.24</td>
<td></td>
<td>160.2 ± 43.81</td>
</tr>
<tr>
<td><strong>Pre VO₂max</strong></td>
<td></td>
<td>3.05 ± 1.1</td>
<td></td>
<td>3.47 ± 1.1</td>
</tr>
<tr>
<td><strong>Post VO₂max</strong></td>
<td></td>
<td>2.92 ± 0.9</td>
<td></td>
<td>3.41 ± 1.1</td>
</tr>
</tbody>
</table>
Figure 3. Average pre & post VO\textsubscript{2max} in L/min for treatment and control groups.
Figure 4. Vinyasa Flow yoga $\%HR_{\text{max}}$ for each participant.
Table 2

*Treatment Heart Rate Data*

<table>
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<th>Participant</th>
<th>Gender</th>
<th>Ave HR</th>
<th>Age</th>
<th>HR&lt;sub&gt;max&lt;/sub&gt;</th>
<th>%HR&lt;sub&gt;max&lt;/sub&gt;</th>
<th>Exercise Intensity</th>
</tr>
</thead>
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<tr>
<td>1</td>
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<td>100</td>
<td>20</td>
<td>200</td>
<td>50.0</td>
<td>Light</td>
</tr>
<tr>
<td>2</td>
<td>M</td>
<td>118</td>
<td>19</td>
<td>201</td>
<td>58.7</td>
<td>Light</td>
</tr>
<tr>
<td>3</td>
<td>F</td>
<td>98</td>
<td>23</td>
<td>197</td>
<td>49.6</td>
<td>Light</td>
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<td>F</td>
<td>145</td>
<td>19</td>
<td>201</td>
<td>72.3</td>
<td>Moderate</td>
</tr>
<tr>
<td>5</td>
<td>M</td>
<td>98.5</td>
<td>19</td>
<td>201</td>
<td>49.0</td>
<td>Light</td>
</tr>
</tbody>
</table>
CHAPTER V

DISCUSSION

The results of the present study showed no improvement in aerobic capacity as the result of Vinyasa Flow yoga, and no significant difference in aerobic capacity between treatment and control groups. A non-significant decrease in VO$_{2\text{max}}$ was found in both treatment and control groups, except for in one participant from the treatment group who demonstrated a non-significant increase in aerobic capacity. The negative findings appear to result from the participants’ fitness level, the frequency of yoga practiced, and the length of each yoga session.

All participants had a high level of cardiorespiratory fitness to start, except for one in the treatment group. Previous research findings supporting a significant increase in VO$_{2\text{max}}$ as the result of Hatha yoga studied healthy 16-18 year olds, sedentary, unfit, or older individuals who practiced yoga 5-7 days per week for at least one hour, or an hour and a half, and two times per week for an hour and a half (Balasubramanian & Pansare, 1991; Bowman et al., 1997; Ray et al., 2001; Tran et al., 2001; and Ramos-Jiménez et al., 2009 & 2011). This indicates that, VO$_{2\text{max}}$ may increase significantly in sedentary, unfit, and older adults if Vinyasa Flow yoga is practiced 5-7 days per week for one hour or more, or twice per week for an hour and a half.

Ramos-Jiménez et al. (2011) claimed “aerobic and resistance exercise from low-to-moderate intensity (40-70% $HR_{\text{max}}$) have shown to increase the VO$_{2\text{max}}$ in adults”
All studies assessing %HR\textsubscript{max} found modern Hatha yoga, Ashtanga yoga, Ashtanga Vinyasa yoga, Iyengar yoga, and Gentle yoga within this range or higher (Carroll et al., 2003, Clay et al., 2005; Blank et al., 2006; Cowen & Adams, 2007; Hagins et al., 2007; Ray et al., 2011; Ward et al., 2013). However, none of these studies evaluating %HR\textsubscript{max} determined if VO\textsubscript{2max} increased from the physical practice of yoga.

In the present study, Vinyasa Flow yoga practiced by fit young adults does not meet the ACSM recommendations for cardiovascular health and fitness associated with moderate (64-<77 % of HR\textsubscript{max}) and vigorous (77-<94 % HR\textsubscript{max}) intensity physical activity, which reduces the chance of pre-mature mortality and morbidity (ACSM, 2014, p. 5). The average HR\textsubscript{max} during the 45-minute Vinyasa Flow yoga session was ~52% for fit participants, and considered light intensity physical activity. However, sedentary and/or unfit individuals may elicit a %HR\textsubscript{max} that meets the ACSM’s recommendations for cardiovascular health and fitness. Since, the ACSM recommends a HR\textsubscript{max} of at least 55% for enhanced fitness in adults who are sedentary and unfit (Ray et al., 2011, p. 9).

One participant in the treatment group was particularly unfit. Aerobic capacity improved 4 ml/kg/min for this participant. The corresponding HR data recorded during the 45-minute Vinyasa Flow yoga session for this participant was ~72% of HR\textsubscript{max} (Figure 3). For this individual Vinyasa Flow yoga was moderate intensity physical activity meeting the ACSM recommendation for intensity of physical activity for cardiovascular health and fitness, and for decreasing the chance of pre-mature mortality and morbidity in sedentary and/or unfit adults. Even when considering the disproportionate relationship between HR and VO\textsubscript{2R} noted in previous studies the intensity for this participant may
well be within the ACSM recommendations for intensity of exercise for sedentary and/or unfit adults at 55% HR<sub>max</sub> (Ray et al., 2011, p. 9).

HR data were not collected from the control group since numerous studies had previously determined %HR<sub>max</sub> for the practice of Hatha yoga. Hatha yoga was found by Clay et al. (2005) to produce a mean 56.89 ± 8.37% HR<sub>max</sub> from university students with an average age of 23.39 ± 4.30 years, which is very similar to the Vinyasa Flow yoga participants in this study at 55.94 ± 9.99 %HR<sub>max</sub> and 20 ± 1.73 years. The reason for the lower percentage of HR<sub>max</sub> during Vinyasa Flow yoga, which is known to be more intense than Hatha yoga, may be the fact the participants were for the most part already quite fit (47.97 ± 6.88 ml/kg/min). When compared to the participants of Clay et al. (2005) (VO<sub>2max</sub> 32.70 ± 5.04 ml/kg/min) (p. 606) the participants in the present study were all recreationally active and exercised 4 to 5 days per week. Also, differences may be the result of variations in HR testing procedures.

Additionally, the results of the present study may have been weakened by the participants’ possible lack of kinesthetic awareness involving the anatomy of the yoga poses, and could have affected the degree to which their muscles were actively working in each pose. Kinesthetic awareness is something that takes time for beginning yoga students to develop. Even though cueing was used to safely guide and motivate the participants throughout every Vinyasa Flow yoga session it was hard to judge how hard each participant was actually working throughout the poses because the physical practice of yoga is an internal process.

Another issue, in the present study, was that participants self-selected on two levels. First, students were recruited from activity classes. Thus, only individuals who
were interested or enjoyed physical activities were recruited. Perhaps future research would recruit sedentary individuals, which may find an improvement in aerobic capacity. This hypothesis is supported by the single individual that was clearly untrained/unfit ($\text{VO}_{2\text{max}} = 22 \text{ ml O}_2/\text{kg min}$). Vinyasa Flow yoga practiced by fit young adults appears to be a light intensity exercise (~52% $\text{HR}_{\text{max}}$), and for one participant moderate intensity exercise (~72% $\text{HR}_{\text{max}}$, see above). Secondly, only the most motivated participants volunteer for laboratory studies, thus in the present study not only did participants self select to take the yoga class because of their interest in fitness, but only a subset volunteered to participate in the research study. If, as stated above, sedentary participants are motivated (e.g., financially compensated) to participate in a Vinyasa Flow yoga study, a positive impact on aerobic capacity may be observed.

Originally, this study sought to evaluate the effect of Vinyasa Flow yoga on unfit and/or sedentary beginning level yoga students who were free from disease. Two amendments were made through Human Subjects allowing for the inclusion of participants using birth control, and who were engaging in vigorous activity. This was not desired, but needed in order to have an adequate sample size. As well, the use of birth control may have affected the HR data. There was also limited funding, resulting in a lack of up to date HR monitors and the Cosmed K4 b2. There was no learning curve for treadmill testing, as time was a limiting factor for the busy college students who chose to participate. And additionally physical activity was not controlled for, which could have affected the results for aerobic capacity if they had been significant.
To conclude, the results of the present study do not appear to increase aerobic capacity as a result of Vinyasa Flow yoga when practiced by fit young adults for 45-minutes twice per week.

There were also no significant difference in aerobic capacity between treatment and control groups. There appears to be a non-significant decrease in VO$_{2\text{max}}$ in both treatment and control groups, except for in one participant from the treatment group who demonstrated a non-significant increase in aerobic capacity. The negative findings appear to result from the participants’ fitness level, the frequency of yoga practiced (twice per week), and the length of each yoga session (45-minutes). Considering the overestimation of $\%HR_{\text{max}}$ compared to VO$_2R$ Vinyasa Flow yoga may enhance cardiovascular health and fitness in older and younger adults who are unfit and/or sedentary, and meet the ACSM’s recommendations for exercise intensity, which is at least 55% of $HR_{\text{max}}$ for adults who are sedentary and unfit (Hagins et al., 2007, p. 6).
CHAPTER VI

SUMMARY

This study evaluated the aerobic capacity of beginning level Vinyasa Flow yoga students to determine if this style of modern yoga was effective in improving VO$_{2\text{max}}$, and assessed the average heart rate (HR) response during a 45-minute class to determine if the exercise intensity met the ACSM recommendations for cardiovascular health and fitness. The exercise intensity was determined from mean $\%\text{HR}_{\text{max}}$ and compared to the exercise guidelines established by the ACSM. Existing research has studied less intense styles of yoga with limited and ambiguous results pertaining to the possible aerobic benefits of the physical practice of yoga.

Participants were recruited from a 50-minute yoga class at California State University, Chico. A 45-minute Vinyasa Flow yoga routine was implemented twice a week for six weeks after the students were familiar with the poses in the sequence, and thereafter for the duration of the study. Aerobic capacity was measured mid-point, and at the end of the semester using a graded exercise test (GXT) to determine if VO$_{2\text{max}}$ improved. HR response during the Vinyasa Flow yoga class was recorded to determine exercise intensity from $\%\text{HR}_{\text{max}}$.

The control group involved participants recruited from a traditional yoga class at California State University, Chico. Ten healthy beginning level male and female yoga students (19 to 25 years of age) participated in the study. The treatment group consisted
of males \( n = 2 \) and females \( n = 3 \) with an average age of \( 20 \pm 2 \) years. Four of the five participants in the treatment group had a high level of aerobic fitness \( (47.97 \pm 6.88 \text{ ml/kg/min}) \) indicated by pre \( \text{VO}_2\max \) data, except for one female \( (22.5 \text{ ml/kg/min}) \). The control group, with males \( n = 3 \) and females \( n = 2 \) had an average age of \( 20.8 \pm 2.38 \) years, and had a similar pre \( \text{VO}_2\max \) \( (48.48 \pm 12.22 \text{ ml/kg/min}) \) as the treatment group.

There was no significant difference \( (p > 0.05) \) between pre and post \( \text{VO}_2\max \) data at the end of six weeks for the treatment group, \( p = 0.395 \). There was no significant difference \( (p > 0.05) \) in \( \text{VO}_2\max \) between treatment and control groups, \( p = 0.875 \) indicated by an independent \( t \)-test. As well, repeated measures ANOVA indicated no significant difference \( (p > 0.05) \) in \( \text{VO}_2\max \) between treatment or control, \( p = 0.85 \). Heart rate data from the treatment group determined Vinyasa Flow yoga stimulates an average \( \text{HR}_\text{max} \) of \( 55.94 \pm 9.99\% \), and is suggestive of light intensity exercise.

Conclusions

In this study aerobic capacity does not appear to increase as a result of Vinyasa Flow yoga, when practiced by fit young adults for 45-minutes twice per week, and there appears to be no significant difference in aerobic capacity between treatment and control groups. Vinyasa Flow yoga appears to be light intensity exercise \( (~52\% \text{ HR}_\text{max}) \). Although, when considering the overestimation of HR response compared to \( \text{VO}_2\text{R} \) the physical activity intensity may be considered very light. The ACSM requires moderate to vigorous exercise for cardiovascular health and fitness for healthy adults, and to prevent the chance of pre mature mortality and morbidity. Considering the overestimation of \( %\text{HR}_\text{max} \) older and younger adults who are unfit and/or sedentary may
enhance their fitness and meet the ACSM recommendations for moderate or vigorous exercise from the practice of Vinyasa Flow yoga.

There were several limitations of the present study. The sample size was too small, twelve participants were excluded because they did not meet the inclusion criteria, and two did not finish post testing, the study intervention does not appear to have been frequent enough to improve cardiorespiratory fitness, and all participants shared a high level of cardiorespiratory fitness, except one. Originally, this study sought to evaluate the effect of Vinyasa Flow yoga on unfit and/or sedentary beginning level yoga students who were free from disease. However, with an amendment was made through Human Subjects allowing for the inclusion of participants who were engaging in vigorous activity. This was not desired, but needed in order to have an adequate sample size.

Although in this study, aerobic capacity does not appear to increase as a result of Vinyasa Flow yoga there are many benefits to the physical practice of yoga: Sun salutations have been shown to improve muscular strength and endurance, and decrease BMI in males and females (Bhutkar et al., 2011); weight-bearing yoga decreases the rate of bone resorption leading to less brittle bones, thus postmenopausal women are less likely to develop osteoporosis (p. 102) (Phoosuwan, Kritpet, & Yuktanandana, 2009); yoga has been shown to be effective in increasing balance time and motor coordination of leg muscles (Hart, & Tracy, 2008); the practice of yoga creates a relaxed state of being and lowers levels of stimulation (Chaya, Kurpad, Nagendra, & Nagarathna, 2006); the use of yoga and meditation have shown to positively reduce the symptoms of metabolic syndrome (Khatri, Mathur, & Gahlot, 2007, p. 1); yogic exercises have also been found more effective than Physical Therapy in enhancing the quality of life of those with
chronic low back pain (CLBP) (Tekur, Chametcha, Hongasandra, & Raghuram, (2010). Therefore, there are other health benefits from the practice of yoga, regardless of whether or not yoga improves aerobic capacity. The health benefits listed above are a few examples.
CHAPTER VII

RECOMMENDATIONS FOR FUTURE RESEARCH

Yoga has become a sensation in the West and insights into the modern forms of the physical practice of yoga (Hatha) are relatively new in the health science field. Modern science is still discovering what lies beneath the widespread view of yoga as a form for health and fitness. The recommendations for future research addressed below concern the physical practice of yoga and are based on the insights and learning experienced as a result of the present study.

Future research should implement Vinyasa Flow yoga with a treatment group that practices 5-7 days a week, a control group that practices Vinyasa Flow four days per week, and another control group that practices Vinyasa Flow three days per week. This design should be implemented using the Cosmed K4 b2 (portable indirect calorimetry) on a large demographic of unfit and/or sedentary participants equal in gender, and both young and old to determine how frequent the practice of Vinyasa Flow yoga needs to be to see improvements in aerobic capacity. The Cosmed K4 b2 device used during the practice of Vinyasa yoga will provide a more accurate assessment of oxygen consumption and be able to determine the exact level of exercise intensity for differing demographics, as well, determine the exact difference in the disproportion of HR and VO$_2$R reported in other studies. HR response during Vinyasa yoga should be assessed from downloadable
HR monitors to determine if $\%HR_{\text{max}}$ is representative of moderate or vigorous physical activity intensity, as per the guidelines established by the ACSM for improving and maintaining health and fitness.

Future research is needed to elucidate exactly how the varying styles of yoga relate to cardiorespiratory fitness in all demographics, especially for clinical use, to explore new applications for yoga therapy to help individuals recover from heart surgery, stroke, and obesity. Longitudinal studies are needed to assess the long-term bone and joint implications from the physical practice of yoga (e.g., should yoga be practiced only three days per week for health, and do more vigorous styles and over-practice lead to the degeneration of joints?).

There are many unexplored facets of the physical practice of modern yoga. Modern yoga culture appears to change with time providing new insights for future research in many fields of study. However, with an enhanced knowledge of how yoga affects physiology modern science may influence commonly held views and interpretations of yoga as a form of health and fitness.
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REFERENCES


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HUMAN SUBJECTS PROCEDURES

California State University, Chico
Chico, California 95929-0875

Office of Graduate Studies
530-898-6480
Fax: 530-898-3342
www.csuchico.edu/graduatesudies

February 5, 2014

Sheana Flores
281 East First Ave
Chico, CA 95926

Dear Sheana Flores:

As the Chair of the Campus Institutional Review Board, I have determined that your research proposal entitled "THE EFFECTS OF VINYASA FLOW YOGA ON AEROSIC CAPACITY" has been granted clearance through an expedited review. This clearance allows you to proceed with your research.

I do ask that you notify our office should there be any further modifications to, or complications arising from or within, the study. In addition, should this project continue longer than the authorized date, you will need to apply for an extension from our office. When your data collection is complete, you will need to turn in the attached Post Data Collection Report for final approval. Students should be aware that failure to comply with any HSRC requirements will delay graduation. If you should have any questions regarding this clearance, please do not hesitate to contact me.

Sincerely,

[Signature]

John Mathoney, Ph.D., Chair
Human Subjects in Research Committee

Attachment: Post Data Collection Report

cc: John Azevedo (330)
HUMAN SUBJECTS IN REVIEW COMMITTEE

Amendment

Under Federal law relating to the protection of Human Subjects, this amendment is to be completed by the Principal Investigator if there are any changes to the original, approved application. Please return to HSRC Chair, c/o Marsha Osborne, HSRC Assistant (898-5413), Office of Graduate Studies, Student Services Center, Room 460, Zip 875.

Name: Sheena L. Flores
Empl ID #: 005148287

Phone(s) and Email: (530) 520-0905 sflores16@mail.csuchico.edu

Faculty Advisor (If student): John L. Azevedo

Phone and Email Address: (530) 898-5878

College/Department: Communication Education/ Kinesiology

Title of Project: The Effects of Vinyasa Flow Yoga on Aerobic Capacity

Changes to Original Approved Application:

I would like to change the exclusion criteria to include participants who currently participate in vigorous intensity exercise (e.g., running, spin, etc.) as stated in the informed consent.

Your Signature: Sheena L. Flores
Current Date: 3/10/14

Approved By: John Mahoney, Chair
Date: 3/11/2014
HUMAN SUBJECTS IN REVIEW COMMITTEE

Amendment

Under Federal law relating to the protection of Human Subjects, this amendment is to be completed by the Principal Investigator if there are any changes to the original, approved application. Please return to HSRC Chair, c/o Marsha Osborne, HSRC Assistant (898-5413), Office of Graduate Studies, Student Services Center, Room 460, Zip 875.

Name: Sheena Flores Empl ID #: 005148287

Phone(s) and Email: 530-520-0905 sflores16@mail.csuchico.edu

Faculty Advisor (If student): John L. Azevedo, Jr.

Phone and Email Address: 898-5878 jiazevedo@csuchico.edu

College/Department: Communication and Education/Kinesiology

Title of Project: The Effects of Vinyasa Flow Yoga on Aerobic Capacity

Changes to Original Approved Application: The original exclusion criteria included taking prescription drugs. Unfortunately, all the females who are interested in participating in the study take oral contraceptives. This amendment would be to allow all female subjects who take oral contraceptives to participate in the study.

Your Signature: _____________________________ Current Date: 3/12/14

Approved By: _____________________________ Date: 3/29/14

John Mahoney, Chair
HUMAN SUBJECTS IN REVIEW COMMITTEE
Post Data Collection Questionnaire

Under Federal law relating to the protection of Human Subjects, this report is to be completed by each Principal Investigator at the end of data collection.

Please return to: Marsha Osborne, HSRC Assistant
Office of Graduate Studies
Student Services Center (SSC), Room 460
CSU, Chico
Chico, CA 95929-0875

Or Fax to: Marsha Osborne, 530-898-3342

Name: Sheena Flores Chico State Portal ID#005148287

Phone(s) 530-520-0905 Email: sflores16@mail.csuchico.edu

Faculty Advisor name (if student): Jack Azevedo Phone 530-898-5878

College/Department: Kinesiology Department (KINE)

Title of Project: The Effects of Vinyasa Flow Yoga on Aerobic Capacity

Date application was approved (mo/yr.): 2/14 Date collection complete (mo/yr.): 5/14

How many subjects were recruited? 12 How many subjects actually completed the project? 10

*HARM--Did subjects have severe reactions or extreme emotional response? NO

If yes, please attach a detailed explanation:

Your signature: _______________________________ Date: 11/3/14

*Final clearance will not be granted without a complete answer to this question.

Approved By: _______________________________ Date: 11/9/14

John Mahoney, Chair

******************************************************************************

VERY IMPORTANT: If you will or have used this research in your project or thesis you are required to provide a copy of this form (with John Mahoney’s signature in place) to your graduate committee.

Do you want a photo copy of this form emailed to you? Yes Please
If yes, provide email address:sflores16@mail.csuchico.edu