Heart Rate Response During Hatha Yoga and the Effects of Hatha Yoga on Health-Related Physical Fitness

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ABSTRACT

The purpose of this study was to investigate the effects of yoga training programs on health-related physical fitness and to measure the heart rate (HR) responses of individuals throughout an actual Hatha yoga class. Two male and six female college students who were enrolled in an intermediate Sivananda yoga class voluntarily participated in this study. Yoga classes lasted 105 minutes and were offered twice a week for eight weeks; participants had to attend at least 50% of the classes. One male and six female participants had their physical fitness tested after the first week of yoga training and again five days after the final yoga class. Aspects of physical fitness tested included: body composition, flexibility, muscular strength, and muscular endurance. Pre and post fitness test results were compared using a paired-samples t-test, with alpha set at 0.05. Only trunk flexibility significantly improved post yoga training (t (6) = -11.12, $p < 0.005$). To measure HR responses to yoga training, HRs of three females and one male were recorded every 30 seconds while participants wore Polar HR monitors during the final yoga class. Mean HRs were highest during sun salutations and lowest during the relaxation pose, savasana. Heart rates for the main Sivananda asanas (excluding locust) ranged from 93 ± 17 beats per minute (BPM) to 106 ± 14 BPM. This study suggests that yoga training approximately once a week can improve hip flexibility but such training is not effective at improving body composition, shoulder flexibility, muscular strength or muscular endurance. This study also shows that HR responses during yoga were highest during warm up exercises and lowest during relaxation exercises; HR responses were moderate during all of the main 12 Sivananda postures.

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INTRODUCTION

Within the last decade the number of individuals participating in yoga has greatly increased. Yoga began in India thousands of years ago, but only recently gained popularity in the United States. This boom in popularity is apparent by the numerous fitness centers, colleges, studios, DVDs, and videos that provide yoga instruction. Yoga instruction can consist of practicing asanas, pranayama, relaxation, and meditation. Researchers have shown that these yoga practices may improve body composition (Bera & Rajapurkar, 1993; Raju, Prasad, Venkata, Murthy, & Reddy, 1997; Ray, Sinha, Tomer, Pathak, Dasgupta, & Selvamurthy, 2001), flexibility (Gharote & Ganguly, 1976; Ray, Mukhopadhyaya et al., 2001; Tran, Holly, Lashbrook, & Amsterdam, 2001), muscular strength (Dash & Telles, 2001; Madanmohan et al., 1992; Tran et al., 2001), and muscular endurance (Ray, Hedge, & Selvamurthy, 1986; Tran et al, 2001).

Within the last 15 years, scientists have begun to assess the intensity of yoga by measuring heart rate (HR) response, rate of oxygen consumption ($\dot{V}O_2$), and metabolic equivalent levels (METs) during yoga training. HR, $\dot{V}O_2$, and METs were measured either while holding specific asanas (Rai & Ram, 1993; Rai, Ram, Kant, Madan, & Sharma, 1994) or during a yoga training session (Clay, Lloyd, Walker, Sharp, & Pankey, 2005; DiCarlo, Sparling, Hinson, Snow, & Rosskopf, 1995). Only two studies have evaluated HR response during a Hatha yoga training session. DiCarlo et al. (1995) measured the HRs of individuals every eight minutes during a Hatha yoga training session with the same asana was being held at each measurement. More recently, Clay et al. (2005) measured HR responses, every minute, while participants followed a 30 minute instructional Hatha yoga video tape. No study has been found that measured HR response throughout the entire duration of a Hatha yoga class.

Purpose of the Study

This study had two purposes. The first purpose was to further investigate the effects of yoga training programs on some main components of health-related physical fitness. These components included: body composition, flexibility, muscular strength, and muscular endurance. The second purpose of this study was to measure the HR responses of individuals throughout an actual Hatha yoga class.

Significance of the Study

This study is important because it will further elucidate the effects of Hatha yoga training programs on body composition, flexibility, muscular strength, and muscular endurance. The majority of studies that have investigated the effect of Hatha yoga on these components of health-related fitness have focused on men. In the few studies that used female participants, participants yoga trained for multiple duration and frequency combinations. The present study had participants training 105 minutes approximately once a week for eight weeks; this combination has not yet been researched. It is unknown if yoga training of this frequency and duration can improve health-related physical fitness.

This study is also important because research that has measured HR responses to Hatha yoga practice is very limited. Of the two studies that have evaluated HR responses during Hatha yoga, one measured HR responses only during a single asana (DiCarlo et al., 1995) and the other measured HR responses while practicing to a yoga video (Clay et al., 2005). No research has been conducted to determine HR responses throughout an actual Hatha yoga class. By using HR responses gathered in this study, the exercise intensity of asanas during a Hatha class can be quantified. As a growing number of individuals participate in yoga classes, it is vital to understand the HR intensity of such classes. The findings of this study will improve the ability to accurately prescribe Hatha yoga classes based on individual exercise goals and limitations.

Hypotheses

For this study it was hypothesized that (a) body composition and (b) flexibility would improve post yoga training. It was also hypothesized that (c) muscular strength and (d) muscular endurance would be greater after yoga training.

Definition of Terms

Age predicted maximal heart rate- A prediction of the highest heart rate one can achieve during maximal exercise. The prediction is made based on the person's age and is calculated using the formula: 220- age of person = age predicted maximal heart rate (BPM).

Anuloma viloma- A type of pranayama in which fingers are used to assist in alternate nostril breathing; inhale through one nostril, retain the breath, and exhale through the other nostril.

Asanas- The postures/poses that are held steadily in yoga practice. Asanas are the main physical component of yoga training.

Auscultatory method- Common method used to measure blood pressure by listening to the sounds of blood flow.

Body mass index (BMI) - A ratio of an individual's body mass to their height squared. Used as a measure of body composition. Expressed in kilograms per meter squared (kg/m^2).

Body composition- The separation of body mass into fat free and fat mass. Often expressed as a percentage of body fat.

Chanting- A practice that can be included in yoga training in which sounds and words are repeated.

Corpse pose- A relaxation pose use in yoga where the individual is resting on his or her back with arms and legs dropped open to the sides of the body comfortably. Also known as savasana.

Flexibility- The range of motion about a joint.

Full yogic breath- A type of pranayama that is practiced during yoga. To complete a full yogic breath the practicing individual slowly inhales by expanding the abdomen then the ribcage, and finally the lungs. This process is reversed for exhalation.

Hatha- A general name for a more modern form of yoga; also known as physical yoga.

Health-related physical fitness- Physical fitness that is needed for a high level of functional capacity for life. Components include: body composition, flexibility, muscular endurance, muscular strength, and cardiorespiratory fitness.

Healthy- Individuals who answered no to all the questions on the Physical Activity Readiness Questionnaire (PAR-Q) or answered yes to no more than one of the questions and were given a physician's "ok" to exercise.

Kapalabhati- A pranayama that can be included in yoga practice. This type of breathing occurs using a series of abdominal contractions accompanied with strong exhalations.

Meditation- A practice in which the mind is calm and focused. This practice can be included in yoga training.

Muscular endurance- The ability of a muscle to repeatedly apply a submaximal force or to sustain a submaximal muscular contraction for a certain period of time.

Muscular strength- The maximal amount of muscular force that can be exerted against a resistance.

Physical Activity Readiness Questionnaire (PAR-Q) - Questionnaire used to screen for individuals who should contact their physician prior to participating in moderate exercise.

Pranayamas- General name for the breathing exercises that are practiced in yoga.

Siddhasana- Popular meditation pose used in yoga where the individual is seated cross-legged with his or her arms rested on the legs.

Sivananda - A type of Hatha yoga that can include asanas, pranayama, relaxation, meditation, as well as chanting. This practice focuses on 12 main asanas which include: headstand, shoulder stand, plough, fish, forward bend, cobra, locust, bow, spinal twist, crow pose, standing forward bend, and triangle.

Sun salutations- A graceful sequence of 12 asanas that are performed in conjunction with breathing and are used to warm up the body for yoga training.

Virabhadrasana- A yoga posture also known as warrior pose. In this pose the individual balances on his or her feet while the legs are spread apart in a lunge position. The torso and hips face forward while the arms are stretched towards the sky.

Virasana- A pose used in yoga where the individual's knees are bent and resting on the floor and the individual is seated between his or her legs. One of the most basic seated yoga postures; also known as hero's pose.

Yoga- An ancient practice that originated in India. This practice integrates mind, body, and spirit to promote health and well-being.

Assumptions

In order for this study to proceed, certain assumptions were made. For this study it was assumed that:

1. Participants maintained the same diet and exercise patterns throughout the duration of the study.
2. Participants reported any changes in diet or exercise patterns that may have affected the outcome of the study.
3. Participants signed up for the correct level of yoga instruction.
4. Participants performed the yoga routines correctly and gave maximal effort during each class.
5. All calibrated equipment worked properly during exercise testing.

Delimitations

In order to evaluate the effects of yoga training on physical fitness, certain limitations were set. These delimitations for this study were that:

1. Participants attended at least eight of the 16 yoga classes that were offered during the spring semester.
2. Participants completed the entire two months of yoga training.
3. Participants refrained from exercising, eating, drinking, or using any substances three hours prior to each exercise testing session.
4. Each participant wore his or her same sneakers and similar exercise apparel during both exercise testing sessions.

Limitations

There were certain limitations in this study. Limitations included:

1. Variation in previous yoga training across participants. Due to the small number of individuals who consistently attended yoga class, it was impossible to limit this study to untrained or trained individuals. Therefore the participants used in this study ranged from those who were previously trained in yoga to those that were new to this practice. This was a limitation because previous yoga training could not be controlled for and this could have influenced heart rate response during yoga training and the effectiveness of yoga training to improve physical fitness.
2. Small sample size. The small number of participants was due to the delimitation that participants had to attend at least eight of the sixteen yoga classes offered. Having a small sample size was a limitation because it reduced the statistical power of this study.
3. Lack of a control group. It was difficult to recruit a group of individuals who had consistent dietary and exercise patterns throughout the spring semester, matched the same demographics as those in this study, and who wanted to participate in

this study. This was a limitation because individuals may have performed better during the post yoga training exercise testing due to learning effects rather than improved physical fitness.

CHAPTER 2

LITERATURE REVIEW

Participation in physical activity can lead to improved physical fitness. Yoga is one physical activity that has recently gained popularity in the United States. In 1997 alone, an estimated 7.4 million Americans had practiced yoga at least once in their lifetime (Saper, Eisenburg, Davis, Culpepper, & Phillips, 2004). The physical fitness benefits of practicing yoga have been evaluated by assessing the effects of yoga training on body composition, flexibility, muscular strength, and muscular endurance. The findings of such studies can be used to help prescribe yoga training to individuals who want to improve one or more of these components of health-related physical fitness. However, to safely and accurately prescribe an exercise, such as yoga, the intensity of the exercise should be known.

This chapter briefly explains some of the components of health-related physical fitness and how these components can be measured. The components of health-related physical fitness assessed in this study included: body composition, flexibility, muscular strength, and muscular endurance. The majority of this chapter summarizes the effects of different yoga training programs on these components. This chapter reviews the few studies that have evaluated HR response during Hatha yoga and finishes by drawing attention to the lack of information about HR response throughout an actual Hatha yoga class.

Body Composition and the Effects of Yoga Training on Body Composition

Body composition is an important component of health-related physical fitness because excess body fat is associated with disease. Various methods are available to assess body composition by measuring the fat free and fat masses of an individual. These methods include: hydrostatic weighing, bioelectrical impedance, dual X-ray absorptiometry (DEXA), and skin fold measurements. Of these methods, skin fold measurements is the least expensive method and is relatively easy to administer. Measurements of skin fold thickness are made at a variety of body sites and these measurements are entered into an equation that predicts body fat percentage. Body fat percent predictions made from skin fold measurements are highly correlated with body fat measurements made during hydrostatic weighing (Nieman, 2003). Additionally, when skin fold measurements are made correctly, the prediction of body fat percentage has an error of only 3.5% (Franklin, 2000). It is for these reasons that the skin fold method is a widely accepted way to assess body composition and estimate the percentage of body fat.

Raju et al. (1997) studied six female physical education teachers, mean age 25.6, who yoga trained intensely for four weeks. Each participant’s body fat was predicted from skin fold measurements made upon arrival at the yoga camp and again after the four weeks of yoga training. Yoga training consisted of practicing twice a day for 90 minutes each time. Although these women were physically fit upon entering the yoga camp, they still had significant improvement in body composition after yoga training; percent body fat was significantly lower post yoga training (Raju et al., 1997). However, women who train less intensely may not experience improvements in body composition. A study of nine female college students who trained for 85 minutes at least twice a week for eight weeks found that yoga training did not significantly improve body composition (Tran et al., 2001). Only these combinations of yoga training durations and frequencies have been used to assess the effects of yoga training on the body composition of females. It is obvious that more research is needed to assess the effectiveness of yoga training to change the body composition of females.

Most researchers who have assessed the effects of yoga training on body composition have used male participants. Ray, Sinha et al. (2001) studied 20 Indian Army men between the ages of 19-23 who yoga trained for six months, 60 minutes a day, six days a week. Skin fold measurements for these men were made at the subscapula and thigh and used in the Sloan method to predict body fat percentages. The changes in body composition of these men were compared to those of 20 men of similar ages in a control group. Men in the control group did not yoga train but were physically active for the same durations and frequencies as the men in the experimental group. In comparing pre and post results, the experimental group had a significant reduction in percentage of body fat and an increase in lean body mass. There were no significant changes in body composition for the control group (Ray, Sinha et al., 2001).

Gharote and Ganguly (1979) measured the body composition of men, the same ages as those used in Ray, Sinha et al. (2001), before and after yoga training. Using the Dumin and Rahaman body fat prediction equation and skin fold measurements at the biceps, subscapula, triceps, and iliac crest the body fat percentages of these men were predicted. Men who yoga trained in addition to their regular workouts at a police training school actually had an increase in predicted percent body fat. Whereas men who just did their regular police training workouts had no change in predicted percent body fat (Gharote & Ganguly, 1979). However, yoga training appears to improve the body composition of younger males. Bera and Rajapurkar (1993) had boys ages 12-15 yoga train for a full year. Their yoga training consisted of practicing three times a week for 45 minutes each time. Twenty boys in the experimental group completed this training. The boys in the experimental group were compared to 20 boys in a control group who did not train but had the same daily routine and diet. Body fat for all boys was predicted using skin fold measurements made at seven sites. In comparing pre and post data, the experimental group had significantly smaller fat folds at six of the seven sites and an overall significant reduction in predicted percent body fat. These results were not observed in the control group, which had no significant change in predicted percent body fat (Bera & Rajapurkar, 1993).

The findings of the effects of yoga training on body composition seem to depend greatly on the demographics of the participants who yoga trained and the frequency and duration of the yoga training program. For example, although Gharote and Ganguly (1979) and Ray, Sinha et al. (2001) studied similar populations, the frequency and duration of the yoga training programs studied were different. This may be one reason for the different findings.

Flexibility and the Effects of Yoga Training on Flexibility

Flexibility is an important component of health-related physical fitness. Since adequate range of motion is vital for everyday tasks, posture, muscle relaxation, and injury prevention (Plowman & Smith, 1997), flexibility exercises should be included in physical training. It is important to remember that flexibility is joint specific and that the flexibility of one joint does not indicate the overall flexibility of an individual. Goniometers, yardsticks, tape measures, and sit-and-reach boxes are common tools to assess flexibility. The sit-and-reach box is an instrument used to measure flexibility of the lower back (trunk flexion) and hamstrings. The shoulder joint’s range of motion is another common measurement of flexibility. Lower back and shoulder flexibility are extremely important for everyday functions. Therefore, it is important to determine if yoga training can be used to improve flexibility of these joints.

According to researchers yoga training may improve the range of motion of a variety of joints (Gharote & Ganguly, 1979; Ray, Mukhopadhyaya et al., 2001; Tran et al., 2001). Tran et al. (2001) looked at the effects of yoga training on nine sedentary females and one sedentary male. These participants were 18 to 27 years old and attended two to four yoga classes a week. Each class lasted 85 minutes and included pranayama, relaxation, and 50 minutes of asanas. Trunk flexion and extension, shoulder elevation, and ankle range of motion were tested prior to yoga training and again eight weeks later. Ankle flexibility, shoulder elevation, trunk flexion, and trunk extension increased by 13%, 155%, 14%, 188% respectively (Tran et al., 2001).

Contrary to these findings, Ray, Mukhopadhyaya et al. (2001) reported that women between 20 and 25 years old who yoga trained for 60 minutes, three times a week, for five months, did not have significantly greater gains in flexibility than women in a control group. For this study, range of motion was assessed pre and post at the following joints: shoulder, trunk, hip, knee, and neck. While the women in this study did not show a significant change in range of motion, men did. The men who practiced in this same yoga training program had increased flexibility at the trunk, neck, hip, and shoulder joints but not at the knee joint (Ray, Mukhopadhyaya et al., 2001).

Gharote and Ganguly (1979) measured flexibility of male individuals pre and post yoga training and also compared mean gains in flexibility of the yoga trainees to the mean gains of flexibility of individuals in a control group. Both groups of individuals, partook in routine workouts at a police training school but only men in the experimental group yoga trained for 45 minutes, six days a week, for a total of nine weeks. These young males (mean age 19.74 years) had significant improvements at all the joints tested; joints included: shoulder, trunk, and ankle. However, when the mean gains in flexibility of the experimental group were compared to that of the physically active control group, there were no significant differences, except for the control group, which had a greater gain in flexibility at the left ankle joint.

It is clear that more research needs to be done to assess the effects of yoga training on flexibility. Ray, Mukhopadhyaya et al. (2001) and Gharote and Ganguly (1979) have shown that practicing yoga three or more times a week may improve flexibility of men. Tran et al. (2001) has shown that yoga training for 85 minutes, at least twice a week, for a total of eight weeks can significantly improve the flexibility of sedentary female college students. It remains unclear if active female college students, who yoga trained for similar durations and frequencies, would experience improvements in flexibility.

Muscular Strength and the Effects of Yoga Training on Muscular Strength

Everyday activities such as lifting a grocery bag or a young child require muscular strength. Lacking enough muscular strength can cause injury and can make daily activities difficult or impossible to do. Consequently, maintaining muscular strength is important. It is therefore noteworthy to know whether yoga training can improve muscular strength.

Muscular strength, the maximal force one can exert against a resistance, can be measured statically or isometrically. Measuring handgrip strength (HGS) using a handgrip dynamometer is a common method to assess muscular strength. This method is commonly used because handgrip dynamometers are both highly portable and easy to use. As the participant squeezes the dynamometer, a needle moves to indicate the amount of force produced.

The effects of yoga training on muscular strength have been evaluated by comparing pre and post yoga training test results. Madanmohan et al. (1992) compared the pre and post yoga training HGS of 27 male medical students. These men were 18 to 21 years old and their yoga training consisted of practicing yoga for 30 minutes six days a week, for a total of three months. In comparing the HGS of the dominant hand before yoga training to the HGS of the dominant hand after yoga training, there was a significant difference. Handgrip strength after yoga training was 21% higher than HGS before yoga training (Madanmohan et al., 1992).

Similar results have been observed with adults, children, and individuals with rheumatoid arthritis. Dash and Telles (2001) designed a complex study to evaluate the effects of yoga training on HGS of males and females. In this study there were three experimental groups; healthy adults, children, and patients with rheumatoid arthritis. All three of the experimental groups consisted of both males and females and each group practiced yoga daily. Yoga training for all groups included asanas, pranayama, meditation, and lectures about yoga philosophy. The healthy adult group (n =37) practiced yoga for 30 days, the child group (n = 86) practiced yoga for ten days, and the rheumatoid arthritis group (n =20) practiced yoga for 14 days. The three experimental groups were also different in that the healthy adult group practiced some additional asanas, the child group practiced memory games, and the rheumatoid arthritis group practiced loosening exercises. Each experimental group was matched to a control group that did not yoga train but was equal in number and demographics. All experimental groups had a significant increase in HGS. This increase in HGS ranged from 11.6% for the females in the healthy adult group to 121.6% for the females in the rheumatoid arthritis group. Although men in the experimental groups did not have improvements in HGS that were as large as the females' improvements, they too had significantly greater HGS post yoga training. There was no significant change in HGS for any of the control groups (Dash & Telles, 2001).

Contrary to these findings, HGS of men in police training school did not improve after yoga training for 45 minutes, six days a week, for nine weeks. These young men had their HGS tested before and after yoga training. These findings were also compared to a control group as previously described. The HGS of the experimental group significantly decreased post yoga training, whereas there was no significant change in HGS for the control group. Although the experimental group had a decrease in HGS post yoga training, when the mean changes in HGS of the control and experimental groups were compared, there was no significant difference between groups (Gharote & Ganguly, 1976). Although HGS is a widely accepted measure of muscular strength, it is not the only way to assess muscular strength. These same men had the number of pull-ups that they could do assessed before and after yoga training. After completing the yoga training, described above, there was no significant change in the number of pull-ups the experimental group could complete. The control group actually had a significant decrement in the number of pull-ups completed. As with HGS, when mean changes in number of pre and post pull-ups were compared between groups, the control and experimental groups were not significantly different (Gharote & Ganguly, 1976).

Rather than using HGS, Tran et al. (2001) tested the muscular strength of elbow extension and flexion and of knee extension and flexion. Participants of this study, one male and nine females, yoga trained for 85 minutes at least twice a week, for a total of eight weeks. In comparing pre and post results, there was a significant increase in isokinetic muscular strength for elbow extension and flexion and for knee extension by 13%, 19%, and 28% respectively. There was no significant change in muscular strength for knee flexion (Tran et al, 2001).

Muscular Endurance and the Effects of Yoga Training on Muscular Endurance

The purpose of muscular endurance tests is to determine the ability of a muscle to repeatedly exert a force or maintain a submaximal force for a prolonged period of time. Muscular endurance is a component of health-related physical fitness because it is necessary for everyday life functions. Jobs, especially factory and manual labor, require tasks to be completed repetitively, such tasks require muscular endurance. Even activities such as yard work or house cleaning require some muscular endurance. Since, muscular endurance is a component of everyday life, it is essential to maintain this muscular fitness. Yoga practice may be one method for improving muscular endurance.

Muscular endurance tests are relatively easy to administer outside of the laboratory because they usually require minimal equipment; often callisthenic activities can be used to measure muscular endurance. One commonly used callisthenic activity is the bent-knee-sit-up test. In this test, the individual’s legs are bent at 90 degrees and the feet are held flatfooted against the floor or mat. Muscular endurance is measured by recording the number of correctly performed sit-ups the individual completes in one minute. Another muscular endurance test is the YMCA bench press test, which requires participants to complete as many bench presses as possible until fatigue. In this test, females use a 35 pound weighted bar and males use an 80 pound weighted bar. All participants move the selected weight at the same cadence (60 beats per minute) set by a metronome. Other variations of the bent-knee-sit-up and bench-press tests can also be used to measure muscular endurance.

Ray et al. (1986) designed a creative experiment to measure muscular endurance. In this experiment participants pulled one end of a spring, while the other end of the spring was attached to a table. The participants arm position and degree of elbow flexion was the same for each trial. The time until the participant could no longer maintain the predetermined degree of flexion was recorded. Electromyographic (EMG) recordings of the biceps brachii and triceps brachii muscles were also recorded during this activity. Twenty male soldiers completed this same experiment before and after yoga training 62 minutes daily for a total of six months. A control group was composed of 20 soldiers who did not yoga train but did physical exercises such as slow running, stretching, pull-ups, and physical games for an hour daily. In comparing the results of the control and experimental groups, the experimental group had a significant increase in holding time, whereas the holding time of the control group did not significantly change. The EMG readings for both the control and experimental groups were significantly lower during post testing than pre testing (Ray et al., 1986).

Tran et al. (2001) tested the muscular endurance of nine females and one male before and after yoga training. Muscular endurance was tested at the knee and elbow joints by recording time until the participant could no longer maintain 70% of their maximal torque. Muscular endurance during knee flexion significantly increased by 57% after yoga training, whereas muscular endurance during knee extension, elbow extension, and elbow flexion did not significantly change.

Heart Rate Response During Yoga Training

Many individuals participate in yoga in hopes of improving their physical fitness. As summarized above, yoga training may improve health-related physical fitness by improving body composition, body flexibility, muscular strength, and muscular endurance. Before exercise specialists and personal trainers begin prescribing yoga to individuals, the heart rate (HR) responses to yoga should be known. This information can be used to quantify the intensity of yoga training, which will help exercise specialists and personal trainers prescribe yoga workouts that fit individual goals and limitations.

Rai and Ram (1993) measured the heart rates of ten male yoga teachers while resting in savasana and while maintaining virasana. Heart rates during the resting posture, corpse pose ranged from 65.19 beats per minute (BPM) to 71.13 BPM. The HRs for virasana were higher ranging from 101.40 BPM to 104.35 BPM. Heart rate responses have also been measured while male yoga teachers maintained siddhasana, a seated asana that is often held during meditation and pranayama. Rai et al. (1994) found that the mean HRs of male yoga teachers during this asana ranged between 73.8 BPM to 82.1 BPM.

The HRs of individuals who are not yoga teachers have also been measured while maintaining specific asanas. DiCarlo et al. (1995) measured the HR responses of four females and six males during Hatha yoga training. These participants ranged from 38 to 47 years old and had been practicing yoga for at least one year. Each participant completed a yoga routine that consisted of a five minute warm up and 12 standing asanas. Although the participants did a variety of asanas, HRs were only measured every eight minutes during the specific asana, virabhadrasana. Heart rates during this asana were measured and recorded a total of four times throughout the entire yoga routine and ranged from 119 ± 18.7 BPM to 144 ± 14.7 BPM (DiCarlo et al., 1995).

In a more inclusive study, HRs were measured every minute throughout an entire 30 minute Hatha yoga routine. This routine consisted of five minutes of warm up, 20 minutes of asanas, and another five minutes of cool down exercises. Each of the 26 women in this study followed the 30 minute Hatha yoga tape as her HR was being measured and recorded with a HR monitor. The mean HR for this routine was 105.28 ± 14.92 BPM (Clay et al., 2005). Although studies have measured HRs during a few specific asanas or while following an instructional yoga videotape, no one has yet to measure HRs for multiple asanas throughout an actual Hatha yoga class.

Conclusion

The effectiveness of yoga training to improve health-related fitness greatly depends on the population who undergoes the yoga training and the frequency and duration of the yoga training. Gaps in the current yoga literature remain because the effectiveness of yoga training programs of other frequencies and durations on health-related physical fitness are not yet known. It is also unclear if the yoga training programs that have been shown effective for sedentary college students will be effective for active college students. Although, this study cannot completely fill these knowledge gaps it can increase our understanding of the effects of yoga training on some aspects of health-related physical fitness.

As yoga is becoming more popular and as some yoga training programs have been shown to improve health-related fitness, more individuals may want to select yoga as their desired physical activity. It is therefore also important to understand HR responses to yogic exercises. Knowing HR responses to yogic exercises can be used to quantify the exercise intensity of yoga training programs. This information is necessary for appropriate yoga exercise prescription based on individual exercise goals and limitations.

CHAPTER 3

RESEARCH METHOD

The purpose of this study was to investigate the effects of yoga training programs on health-related physical fitness (body composition, flexibility, muscular strength, and muscular endurance) and to measure the heart rate (HR) responses of individuals throughout an actual Hatha yoga class. To determine if yoga training affects health-related physical fitness, each participant's physical fitness was assessed before and after yoga training. To assess HR responses to yoga, HR data was collected from participants while practicing yoga during the final yoga class. This chapter describes the participants that partook in this study and the yoga training that these individuals underwent. This chapter also fully illustrates how four components of health-related physical fitness were assessed and how the pre and post assessments of these components (body composition, flexibility, muscular strength, and muscular endurance) were statistically compared. Finally, this chapter explains how HR response was measured and recorded throughout an actual Hatha yoga class.

Participants

Participants for this study included two male and six female college students who were enrolled in an eight-week intermediate level yoga class during the spring of 2006. These participants had been practicing yoga for two years or less. For some of the participants, this was their first time ever practicing yoga. The participants' ages ranged from 18 to 30 years old. At the first two yoga classes, this study was described and individuals who were interested in participating were given an interest packet which included the Interest Letter (see Appendix A), Informed Consent (see Appendix B), Physical Activity Readiness Questionnaire (PAR-Q) (Canadian Society for Exercise Physiology), Medical/Health Status Questionnaire (BSDI), and General Information Sheet (see Appendix C). Students were to read over the forms and return them at the first exercise testing session, which they signed up for at the second yoga class. Of the fifteen students that signed up to participate, only eight attended at least 50% of the classes. Of those eight, pre and post data were collected on only seven participants, one male and six females (Table 1) and these pre and post measurements were used for statistical analysis. Heart rate data were collected from three of the women whose pre and post data were used for analysis and from one male who did not have his fitness tested both pre and post yoga training (Table 2).

Table 1. Physical Characteristics of Participants Used for Pre and Post Testing.

Parameter	Mean	Range
Age (yrs)	20.86 ± 4.22	18 – 30
Height (cm)	166.19 ± 8.60	156.85 – 183.52
Body weight (kg)		
Pre training	61.12 ± 14.13	46.7 – 91.0
Post training	61.25 ± 14.09	47.6 – 91.4

Note. Values represent means ± 1 SD. n = 7 (6 females, 1 male), df = 6.

Table 2. Physical Characteristics of Participants Used for HR Response.

Parameter	Mean	Range
Age (yrs)	20.00 ± 1.15	19 – 21
Height (cm)	168.27 ± 13.68	156.9 – 187.3
Bodyweight (kg)	62.35 ± 16.05	47.6 – 85.2

Note. Values represent means ± 1 SD. n = 4 (3 females, 1 male), df = 3.

Treatment

The intermediate level yoga training class was offered by The Department of Recreation at SUNY Cortland. Classes were advertised around campus and on the campus website and were open to students, faculty/staff, and community members. Interested individuals signed up through the Recreation Department and paid a small fee; the fee for students was 30 dollars, between 50-60 dollars for faculty/staff, and 90 dollars for community members. Classes began during the second week of February in 2006 and ended the second week of April in 2006. Classes met from 7:00 to 8:45 pm every Tuesday and Thursday, except for the third week in February and the second week in March when the class did not meet. All of the yoga classes were of the Sivananda yoga tradition and were taught by the same experienced instructor who was certified in this tradition. This instructor had practiced yoga for 22 years and instructed for 16 years. Yoga classes included relaxation, meditation, pranayama, and the 12 main Sivananda asanas (see Appendix D). Not all 12 asanas were practiced at the beginning of the yoga training, as they can be difficult to perform, but all were included in the later yoga classes. The pranayama that was practiced during class included full yogic breath, kapalabhati, and anuloma viloma. Individuals in the class were instructed to push themselves but to go at their own pace. Participants' attendance for each class was recorded by having the participants sign-in at each class.

Evaluation

Fitness assessments were made in the third week of February during a week when the yoga class did not meet, and again in April five days after the final yoga class. Each participant came into the SUNY Cortland Human Performance Laboratory with the completed Informed Consent (see Appendix B), which described the purpose of the study and any potential risks and benefits of participation, the Physical Activity Readiness Questionnaire (PAR-Q) (Canadian Society for Exercise Physiology) and the Medical/Health Status Questionnaire (BSDI). Participants also completed the General Information Sheet (see Appendix C) which collected information on basic demographics such as age and gender, previous yoga training, and the participant's reasons for enrolling in the yoga class. Individuals who answered no to all the questions on the PAR-Q or answered no to all but one question on the PAR-Q and had a physician's permission to exercise were able to participate in exercise testing. During the post yoga testing, participants competed the Follow-Up General Information Sheet (see Appendix E). This questionnaire asked whether the participants enjoyed the yoga class, if they felt they had benefited from yoga training, and if they felt their physical fitness had changed after yoga training.

After checking that the paperwork was completed, participants who were deemed able to exercise, were fitted with a S-610 or S-610i Polar heart rate (HR) monitor and transmitter. The transmitter's electrodes were moistened with electrode gel and then the transmitter was positioned on the participant's chest following the instructions detailed in the Polar S-610 or S-610i owner's manual. The strap was then fixed to ensure the transmitter would remain in place. The HR monitor was placed on the participant's wrist. The participant then proceeded from one exercise testing station to the next. Heart rate monitors and transmitters were coded so that participants would wear the same equipment at both exercise testing sessions.

Exercise Testing Stations

Exercise testing stations included: height and weight, resting HR and blood pressure (BP), body composition, flexibility, muscular strength, and muscular endurance. Originally an additional exercise testing station, the YMCA Bike Test, followed the other stations but was removed due to complication of administration. The same technician was at each station and that technician was properly trained to administer the exercise test(s) at that station. Participants proceeded through the stations during post testing in the same order as they did during pre testing. Pre and post data were recorded using a separate Data Collection Sheet (see Appendix F).

Height and weight. Height and weight were measured using a Detecto beam scale and stadiometer. To ensure the validity of the beam scale, it was calibrated that day at zero and with known weights of 50, 100, and 150 pounds. This calibration was done by positioning the beam weights to zero and adjusting the tear screw until the pointer was resting in midair in the pointer window. This same method was used when known weights were placed on the beam scale.

To ensure reliably of measurements, height and weight measurements were made the same way each time by the same trained technician. At each testing session, height was measured to the nearest tenth of an inch after the barefooted participant faced away from the balance beam and stood as straight as possible. Weight was measured to the nearest tenth of a pound while the participant was in this position. Participants wore similar exercise apparel for each testing session.

Resting heart rate and blood pressure. Resting HRs were measured using a S-610 or S-610i Polar HR monitor and transmitter. To ensure reliable measurements, the transmitters were checked for proper fit prior to testing and electrode gel was used. Participants selected which wrist to wear the HR monitor on. Resting HR was not recorded until the participant had rested in a chair for at least five minutes. Two resting HRs were recorded and the average HR was used for statistical analysis. Using an Atlas mercury sphygmomanometer and stethoscope, the auscultory method was used to measure resting BP at this same station. To ensure reliable measurements, the same experienced technician measured BP each time, an appropriate sized cuff was fitted to the participant's arm, and the participant's arm was rested at heart level for five minutes prior to measurement. Two minutes after completion of the first BP measurement, BP was measured again. If these measurements differed by five mmHg or more, additional measurements were made. Blood pressure measurements were averaged and rounded to the nearest whole even number. The rounded average systolic blood pressure and rounded average diastolic blood pressure were used for pre and post comparisons.

Body composition. Body composition was determined by using Lang skin fold calipers to measure skin folds at four body sites. The skin fold sites were triceps, suprailiac, abdomen, and thigh. All skin folds were measured to the nearest millimeter and measurements were made in the same order for a total of three times at each body site. These skin fold measurements were made according to Nieman (2003). The mean value for each site was entered into the Jackson-Pollack four-site equation for males [0.29288 (sum of four skin folds) – 0.0005 (sum of four skin folds)^2 + 0.15845 (age) – 5.76377] or for females [0.29669 (sum of four skin folds) – 0.00043 (sum of four skin folds)^2 + 0.02963 (age) -1.4072], to predict body fat percentage (Jackson & Pollock, 1985). The Jackson-Pollock prediction equations were used because they could be generalized for all of the participants, regardless of differences in age. The predicted body fat percentages were rounded to nearest tenth of a percentage and these values were used for pre and post test comparisons.

Flexibility. Hamstring-trunk flexibility was measured using a sit-and-reach box. After some warm-up stretching, the participant was seated on the floor with legs extended and against the floor while the participant's shoeless feet rested flat against the box. Each participant was instructed to place one hand over top of the other, with their arms completely extended. The participant then flexed at the trunk and extended forward holding the stretch for one to two seconds. The distance the individual was able to reach with their hands while bending forward was measured to the nearest tenth of a centimeter. The best value of three trials was used for pre and post comparisons.

Shoulder flexibility was also assessed at the flexibility station. In this test, the participant placed both arms behind the back; one arm was positioned over the shoulder and the other arm came up from the lower back in attempts for the fingers meet. The distance of finger overlap was measured to the nearest tenth of an inch. The distance measured between fingers was recorded as a negative value if the fingers did not meet. Three trials were done for both shoulders. The average of the best score for the right and left side were used for pre and post comparisons.

Muscular strength. Muscular strength was assessed using a hand dynamometer after the dynamometer was adjusted for the participant's hand size. Prior to measurement each participant was first shown the proper way to squeeze the hand dynamometer and the dynamometer was zeroed. While holding the dynamometer at the participant's side, the participant began to squeeze the hand dynamometer and continued squeezing until he or she could not squeeze any harder. The ending position was with the shoulders flexed and entire arm parallel to the floor. Each hand was tested three times and measurements were made to the nearest tenth of a kilogram. The sum of the average force of the best two trials for each hand was used for statistical analysis.

Muscular endurance. Muscular endurance was assessed with the bent-knee-sit-up and bench-press tests. During the bent-knee-sit-up test the participant assumed the sit-up position: knees at a 90-degree angle, feet flat on the mat, and arms across the chest. During testing, one technician held the participant's feet flat against the mat while another technician counted the number of sit-ups completed. The participant started with his or her back completely touching the mat, the participant then came up until his or her arms contacted their knees, the sit-up was completed when the individual's back again made full contact with the mat. The participant's arms had to remain against his or her chest throughout the entire exercise. The number of correctly preformed sit-ups completed in one minute was recorded and used for statistical analysis.

During the bench-press test the participant lay on the bench with his or her feet on the floor. A metronome was set for 60 beats per minute (30 lifts per minute) and at each beat of the metronome the participant had to be either in the down (elbow flexion) or up position (elbow extension). The female participants lifted 35 pounds and the male participants lifted 80 pounds. The number of times the individual was able to lift the weight, until he or she could no longer maintain the cadence or proper form, was recorded and used for statistical analysis.

Statistical Analysis

Statistical analysis was conducted for each dependant variable using SPSS version 11.0. For each fitness test the mean initial scores were compared to the mean post yoga training scores using a paired-samples t-test. Significance was accepted at the 0.05 level.

Heart Rate Response During Yoga

Using S-610 Polar heart rate (HR) monitors HRs of participants were recorded during two yoga classes that occurred at the end of the eight week yoga training program. These classes were selected to ensure that they included the main 12 Sivananda asanas and were typical of a Hatha yoga routine. Prior to the start of these yoga classes, the participants applied electrode gel to the electrodes of their fitted transmitters. During the first of the final two yoga classes, HR was collected by having the participant's HR monitor placed near his or her body but off of the yoga mat. The data recorded during that yoga class was later downloaded from the HR monitor to a laptop. Due to unknown technical difficulties, HR data did not transmit or was not recorded by the HR monitors. Therefore, data was collected using a different method in the next yoga class. During the following and final yoga class, each participant who was wearing a transmitter had a research technician positioned nearby to hold the HR monitor and record the participant's HRs. Technicians recorded HRs every 30 seconds and all technicians began recording at the same time. During both methods, the time that each activity (asana, meditation, relaxation, and pranayama) began and ended was recorded. By matching HRs and asanas by time, HR responses to the main Sivananda asanas were determined.

CHAPTER 4

RESULTS and DISCUSSION

The purpose of this study was to investigate the effect of yoga training programs on health-related physical fitness (body composition, flexibility, muscular strength, and muscular endurance) and to measure heart rate (HR) responses of individuals throughout an actual Hatha yoga class.

Effects of Yoga Training on Health-Related Physical Fitness

This first purpose of this study was to determine the effects of yoga training on four main components of health-related physical fitness which included: body composition, flexibility, muscular endurance, and muscular strength. It was hypothesized that all of these components would improve post yoga training. These hypotheses were evaluated by comparing pre and post fitness data using a paired samples t-test to test for statistical significance with alpha set at 0.05.

Participants' fitness improved on four of the six fitness tests. These tests included: hamstring-trunk flexibility, shoulder flexibility, bench-press and sit-up. Fitness worsened on the remaining two fitness tests, body fat percentage and handgrip strength. However the only statistically significant change was an increase in hamstring-trunk flexibility. Post hamstring-trunk flexibility (40.96 ± 5.26 cm) was significantly greater than pre hamstring-trunk flexibility (33.00 ± 6.22 cm), $t(6) = -11.118$, $p < 0.005$ (two-tailed). There were no significant changes in shoulder flexibility, handgrip strength, percent body fat, number of bench-presses completed or number of sit-ups completed. Additionally, mean weight, resting HR and resting BP before yoga training were not significantly different than mean weight, resting HR and resting BP after completion of the yoga training program (Table 3).

Table 3. Comparison of Weight, HR, BP, and Fitness Pre and Post Yoga Training.

Parameter	Pre	Post	Sig.
Weight (lbs)	134.76 ± 31.15	135.04 ± 31.05	.879
Heart Rate (BPM)	72.86 ± 9.78	73.71 ± 4.68	.868
Blood Pressure (mmHg)			
Systolic	123.14 ± 5.76	122.57 ± 2.23	.808
Diastolic	72.00 ± 6.22	74.86 ± 4.74	.245
Body fat (%)	21.69 ± 4.67	22.37 ± 5.22	.574
Hamstring-Trunk Flexibility (cm)	33.00 ± 6.22	40.96 ± 5.26	.000*
Average Shoulder Flexibility (in)	1.25 ± 2.26	1.64 ± 2.59	.341
Handgrip Strength (kg)	58.57 ± 25.98	55.29 ± 15.79	.478
Bench-presses (# completed)	20.43 ± 13.77	20.71 ± 14.91	.760
Sit-ups (# completed)	37.14 ± 9.96	39.57 ± 10.68	.132

Note. HR = heart rate, BPM = beats per minute, BP = blood pressure. Heart rate and BP were measured at rest. Values represent means ± 1 SD. n = 7 (6 females, 1 male), df = 6. $p < 0.05$. * indicates significance at the 0.05 level.

The fitness results of this study suggest that yoga training approximately once a week for at least 105 minutes can improve hamstring-flexibility. However, this level of training may not be effective at improving weight, resting HR, resting BP, shoulder flexibility, body composition, muscular strength, or muscular endurance. Within yoga there are multiple styles and even within the same style yoga training can differ in duration and frequency of sessions, asanas practiced, and whether or not pranayama, chanting, and meditation are included. The variety of yoga training programs used by other researchers makes it difficult to compare the findings of this study to that of previous studies. For example a yoga class may consist of individuals laying in savasana for a majority of the class, and yet in another class individuals may have to quickly jump from one asana to the next. However, both of these classes would be categorized as yoga classes.

Of the published yoga studies, the methodology of this study is most similar to that by Tran et al. (2001). Tran et al. (2001) measured the body composition, flexibility, muscular strength, and muscular endurance of nine females and one male both before and after yoga training. Although this study and that by Tran et al. (2001) measured the same components of health-related physical fitness, different valid fitness tests were used for all components except trunk flexion. In both this research and that of Tran et al. (2001) the majority of participants were females and there were less than 11 participants. Additionally, participants studied by Tran et al. (2001) were between the ages of 18 and 27 which are similar to the ages of those used in this study (18-30). Participants studied by Tran et al. (2001) yoga trained twice as often (approximately two times per week) and for a longer duration (90 minutes each class) than those in this study, who trained approximately once a week for 105 minutes each time. Yoga training used in this study lasted for 16 weeks as compared to the eight weeks used in Tran et al. (2001). Both yoga trainings were comprised mostly of asana practice and included some pranayama and relaxation.

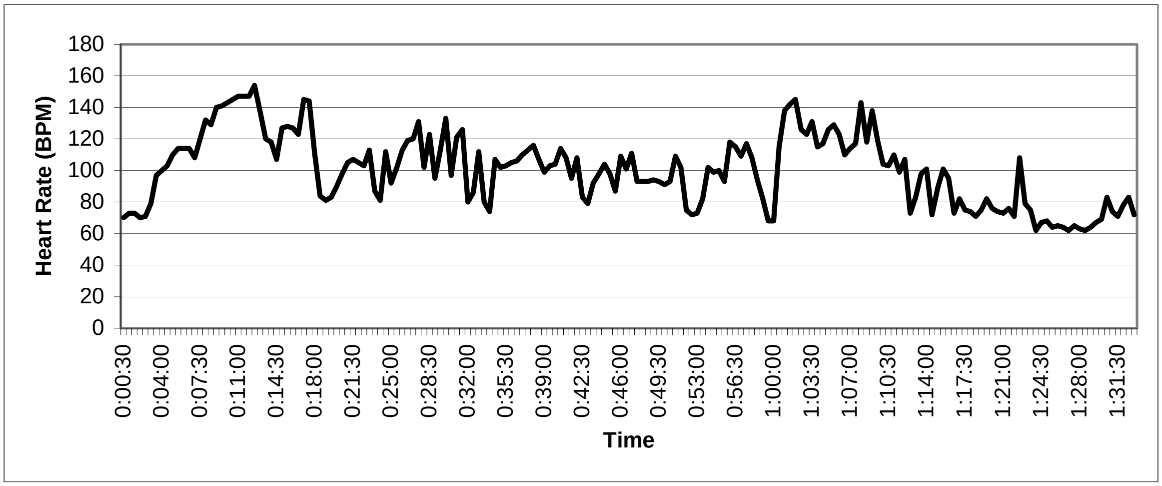
This study supports the findings of Tran et al. (2001) which showed that yoga training could increase trunk flexion. Although participants in this study trained less, they had a greater increase in trunk flexibility; participants studied by Tran et al. (2001) increased trunk flexibility by 4.10 cm compared to an increase of 7.96 cm by participants in this study. Contrary to the findings in this study, Tran et al. (2001) found significant improvements in shoulder flexibility, muscular strength and muscular endurance. The differences in these findings may be due to participants' initial level of physical activity. All of the participants in Tran et al. (2001) were classified as sedentary whereas the majority of the participants in this study were physically active three to five times a week.

In the present study, muscular strength was measured by using a hand dynamometer and it was found that handgrip strength (HGS) did not improve after yoga training. However, when Madanmohan et al. (1992) used the same test to measure HGS of college-aged men after yoga training, there was a significant increase in HGS. This improvement in HGS may be due to higher frequency at which the participants yoga trained; 30 minutes daily for a total of 12 weeks. Neither Tran et al. (2001) nor this study found significant changes in body composition post yoga training. However, changes in body composition can occur from yoga training more intensely. For example, women who yoga trained for 90 minutes twice a day, everyday, for a total of four weeks decreased their percent body fat from 15.38 ± 2.35% to 12.57 ± 3.76% (Raju et al., 1997). It appears that yoga training for 105 minutes approximately once a week for 16 weeks will increase trunk-hamstring flexibility but this training will not improve body composition, shoulder flexibility, muscular strength, muscular endurance. Other research suggests that more frequent yoga training can improve these components of health-related physical fitness.

Heart Rate Response Throughout an Entire Hatha Yoga Class

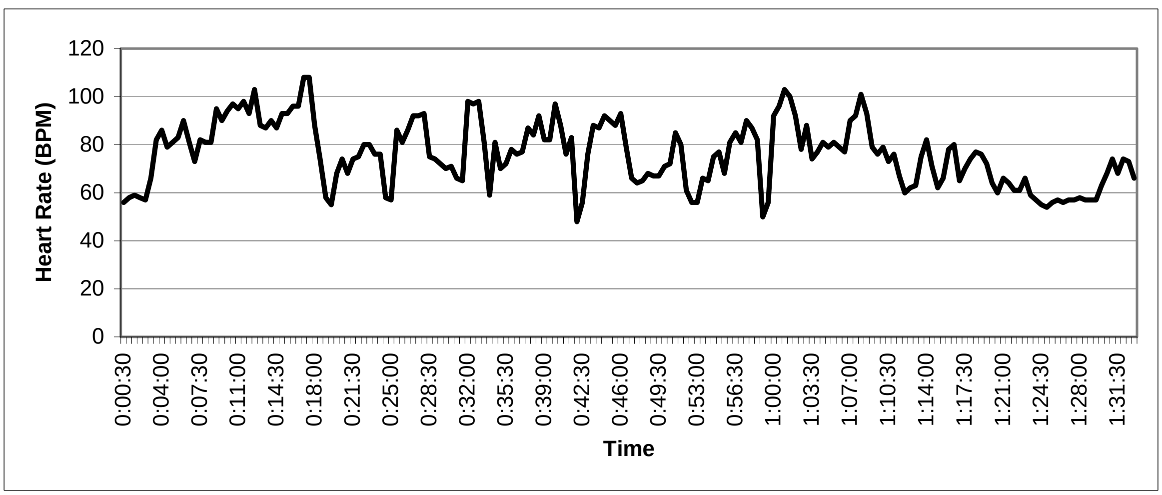
The second purpose of this study was to measure heart rates (HR) of participants while performing the main 12 Sivananda asanas during an actual yoga class. Heart rate data were collected from four participants (3 female, 1 male) at the last yoga class of the semester. Figure 1 and Figure 2 show the HR responses of a female and male participant, respectively, throughout the entire yoga class.

Figure 1. HR Response of a Female Participant Throughout a Hatha Yoga Class.



Note. BPM = beats per minute. Heart rates were collected every 30 seconds throughout the entire final yoga class. Data from participant #6.

Figure 2. HR Response of a Male Participant Throughout a Hatha Yoga Class.



Note. BPM = beats per minute. Heart rates were collected every 30 seconds throughout the entire final yoga class. Data from participant #15.

Heart rate data were collected on 11 of the 12 main Sivananda asanas (Table 4.). Heart rate data from the locust pose was not collected because it was not held long enough. Mean HR during yoga practice was highest (116 ± 23 BPM) while participants performed sun salutations and mean HR during yoga practice was lowest (73 ± 16 BPM) while participants rested in corpse pose. These means were consistent with the yoga HRs for each individual; individual yoga HRs where highest during sun salutations and lowest during corpse pose. Of the 11 main asanas, mean HR was highest during the bow pose (106 ± 14 BPM) and mean HR was lowest during the cobra pose (93 ± 17 BPM).

Table 4. Resting Heart Rates (BPM) and Heart Rates (BPM) during Yogic Exercises.

Exercise	Sub 6	Sub 15	Sub 5	Sub 10	Mean
Resting HR	80	67	64	88	75 ± 11
Corpse	71	58	67	96	73 ± 16
Sun Salutations	133*	87*	107*	135*	116 ± 23
Leg Raises	101	75	83	112	93 ± 17
Headstand[1]	118	82	77	110	97 ± 20
Shoulder Stand[2]	105	76	85	108	94 ± 16
Plough[3]	112	87*	92	125	104 ± 18
Bridge	103	85	100	125	103 ± 17
Fish[4]	106	87	80	119	98 ± 18
Forward bend[5]	95	74	84	121	94 ± 20
Cobra[6]	94	71	94	112	93 ± 17
Bow[8]	113	86	107*	116	106 ± 14
Spinal Twist[9]	131	85	88	109	103 ± 21
Crow[10]	127	80	97	116	105 ± 21
Forward bend[11]	131	79	92	100	101 ± 22
Triangle[12]	119	80	87	122	102 ± 22
Pranayama	82	71	73	107	83 ± 17
Meditation	73	59	67	96	74 ± 16

Note. BPM = Beats per minute. Heart rates (HR) for each participant (Sub) represent their average HR at rest and while performing that specific yogic exercise. The average HR for all participants, during each exercise, is represented as the mean ± 1 SD. n = 4 (3 females, 1 male), df = 3. * represents highest HR each individual attained during yoga training. Superscripts denote the major 12 asanas; subscript 7 is missing, as the locust pose was not held long enough for HR data to be collected.

Lowest HR was achieved during the resting posture, corpse pose; this finding is consistent with previous literature. Rai and Ram (1993) found that male yoga teachers resting in corpse pose had mean HRs that ranged between 65.19 ± 6.26 and 71.13 ± 6.88 BPM. The mean HR of the participants in corpse pose in this study was 73 ± 16 BPM which is within one standard deviation of the HR findings by Rai and Ram (1993). The participants' greatest mean HR was achieved during the sun salutations; during sun salutations individual HRs for the participants ranged from 87 to 135 BPM, with a mean HR of 116 ± 23 BPM. These results agree with those by Clay et al. (2005) which measured the HRs of women every minute during a 30-minute yoga training session. Although an exact HR was not given for the sun salutations, the authors did specify that mean HR was greatest while the participants performed sun salutations (Clay et al., 2005).

Although other studies measured HR during virabhadrasana (DiCarlo et al., 1995) and siddhasana (Rai et al., 1994) this is the first study to measure HR responses to 11 of the 12 main Shivananda asanas. Heart rate data for asana number seven, the locust pose is missing because the pose was not held long enough for HR data to be collected. Mean HRs for these 11 Sivananda asanas ranged from 93 ± 17 BPM for shoulder stand to 106 ± 14 BPM for the bow posture. These values fall within one standard deviation of the mean HR found by Clay et al. (2005) for Hatha yoga; average HR for a Hatha yoga class in Clay et al. (2005) was 105 ± 14.92 BPM.

When each participant's HR, during each yogic exercise, is compared to his or her age predicted maximal HR, the relative intensity of each yogic exercise can be quantified. In this study, yoga HRs were the highest for all participants during the sun salutations; HRs of participants during the sun salutations were 133, 87, 107, and 135 BPM. The corresponding relative intensities for these HRs were 66%, 44%, 53%, and 68% of age predicted maximal HR. The results of this study are slightly lower than those found by Clay et al. (2005); which found the intensity of sun salutations to 67.0 ± 10% of maximal HR. Only two of the intensity values in this study, 66% and 68%, fall within the

American College of Sports Medicine's (ACSM) intensity recommendations of 55/65% – 90% of maximal HR for developing and maintaining fitness (American College of Sports Medicine, 1998). With the exception of sun salutations for two participants, all yogic exercises were below the American College of Sports Medicine's intensity recommendations for developing and maintaining physical fitness. The participants' high level of initial physical fitness and the relatively low intensity of yoga training used in this study may be reasons for the failure of improvement in body composition, muscular endurance, and muscle strength via yoga training.

These results show that HR responses to Hatha yoga depend on the yogic exercises included. This study agrees with previous research that shows corpse pose to be the least cardiovascular taxing yogic exercise and sun salutations to be the most. However when 11 of the 12 main Sivananda asanas were performed in the traditional Sivananda sequence the range of HRs is relatively small; HR didn't change drastically from one posture to the next. Since no other research was found that measured HRs to individual asanas done continuously in a specific order, it's difficult to compare these findings to others in the Sivananda tradition or to other Hatha yoga styles. Heart rate responses from this study were comparable to those found in other yoga studies.

Perceived Benefits from Yoga Class

All of the participants in this study were asked on the General Information Sheet (see Appendix C) why they were enrolling in the yoga class. These responses were sorted into various mental and physical health parameters. After completion of the yoga class and at the final exercise testing session the same participants were asked on the Follow-Up General Information Sheet (see Appendix E) if they thought the class was beneficial or detrimental and if so, how. These responses were sorted into the same mental and physical health parameters as those from the initial data collection (Table 5). All but one participant completed both the initial and the follow-up surveys; one participant only completed the initial survey. All of the participants enjoyed the yoga class and thought their physical fitness had improved after taking the class. All of the participants said they felt the overall class was beneficial and none of the participants listed the class as being detrimental. However one participant cited “maybe time wise” under the question of how the class was detrimental.

Table 5. Percentage of Reported Reasons for and Benefits of Enrolling in Yoga.

Parameter	Enrollment (%)	Benefited (%)
Mental Health		
General	33	13
Education	22	0
Relaxation/ Stress relief	33	38
Spiritual/Mediation/Balance	33	63
Physical Health		
General	33	13
Strength	33	38
Flexibility	88	88
Toning	11	0
Endurance	11	0
Alternative workout	11	0

Note. Values represent the percentage of the participants who cited that parameter (out of the number of participants who completed the survey); percentages are rounded to the nearest whole number. Participants were allowed multiple responses. n = 9 for enrollment and n = 8 for benefited.

Eleven percent of the participants cited enrolling in yoga as an alternative workout, or for toning, or endurance however none of the participants thought yoga benefited these enrollment reasons. However, an equal percentage of individuals who enrolled in yoga to improve flexibility cited yoga as improving their flexibility. Although only 33% of the participants cited yoga enrollment for relaxation/stress relief, spiritual/meditation/balance, and physical strength a higher percentage of participants thought that yoga had benefited them in these areas.

In reviewing the literature for this topic, it was interesting that none of the studies that compared fitness pre and post yoga training, evaluated the reasons for yoga participation. This may be because some individuals began practicing yoga to be in those specific studies. However, a majority of these studies used participants who had already been practicing yoga or participants who had enrolled to practice yoga regardless of the studies.

In this study, participants were asked to write the reasons why they enrolled in the yoga training program. At the end of the yoga training program participants were asked to write any benefits or detriments they experienced by practicing yoga. The largest percentage of participants (88%) cited enrolling in yoga to improve flexibility. The same percentage of participants cited that their flexibility benefited from the yoga training program. This is interesting because hamstring-trunk flexibility was the only component of health-related physical fitness that significantly improved during yoga training. Likewise, none of the participants listed improved endurance as a benefit of yoga, which is supported by the findings on the bent-knee-sit-up and bench-press tests. The results from both of these tests for muscular endurance show that there was no significant change in muscular endurance post yoga training. However, thirty-eight percent of participants thought that yoga improved their physical strength (33% enrolled to improve physical strength) even though there was no significant difference in physical strength before and after yoga training. In addition to flexibility, a majority (63%) of the participants cited that yoga training was beneficial for spiritual health/meditation/balance.

Likewise, 38% of participants thought yoga training was beneficial for relaxation/stress relief.

All of the participants stated that they enjoyed the yoga class and thought their physical fitness had improved via yoga training. It should be noted that the style and type of yoga training would impact cited reasons for both enrollment and benefits of enrollment. For example, individuals may cite spiritual/mental/balance benefits more often in a yoga class that focuses on pranayama and meditation, whereas individuals in more physical styles of Hatha yoga, such as ashtanga, may cite physical reasons for enrollment or physical benefits more often.

CHAPTER 5

SUMMARY, CONCLUSIONS, IMPLICATIONS, and RECOMMENDATIONS

Summary

The purpose of this study was to investigate the effects of yoga training programs on health-related physical fitness (body composition, flexibility, muscular strength, and muscular endurance) and to measure the heart rate (HR) responses of individuals throughout an actual Hatha yoga class. To determine if yoga training at least once a week for 105 minutes, for a total of 16 weeks would result in improved health-related physical fitness, one male and six female college students completed fitness tests after the first week of yoga training and again five days after the final yoga class. It was hypothesized that all these components of health-related physical fitness would improve after yoga training. Statistical analysis showed that there was no significant improvement in body composition, shoulder flexibility, muscular endurance, or muscular strength. However, there was a significant improvement in hamstring-trunk flexibility. To evaluate HR response during the 12 main Sivananda yoga postures one male and three female college students wore HR monitors during the final yoga class. Heart rates were collected for all asanas except locust pose, which was not held long enough to collect HR data. Heart rates were highest for all participants during the warm-up sun salutations exercises and lowest during the relaxation corpse posture. The HR range for the 11 main Sivananda asanas was from 93 ± 17 BPM to 106 ± 14 BPM.

Conclusions

The results of this study show that yoga training 105 minutes approximately once a week for 16 weeks is effective at improving hamstring-trunk flexibility. However, this training is not effective at improving body composition, shoulder flexibility, muscular strength, or muscular endurance. Other research suggests that more frequent yoga training (at least twice a week) can improve these other components of health-related physical fitness. Heart rates were highest and lowest in yoga training during warm-up (sun salutations) and relaxation (corpse pose) exercises respectively. Throughout the main Sivananda asanas HRs varied only slightly as all HRs were within 13 BPM of each other. Participants enrolled in the yoga training for a variety of mental and physical health reasons. Participants cited “to improve flexibility” more than any other reason for enrollment in the yoga class. Likewise, participants cited “improved flexibility” more than any other benefit of yoga training. Other cited benefits of yoga training included physical strength, relaxation/stress relief, and spiritual/meditation/balance. All participants enjoyed the yoga training program and thought their physical fitness had improved after yoga training.

Implications

This study has great implications for individuals who want to improve their physical fitness via yoga and for exercise professionals. This study shows that yoga training approximately once a week for 105 minutes is not effective at improving a majority of physical fitness components. Likewise, the HR data in this study shows that the intensity of most of the exercises in this Hatha yoga training were below ACSM’s recommendations for developing and maintaining physical fitness. Therefore individuals, especially those who are relatively physically active, who want to improve their physical fitness via yoga may need to yoga train more frequently, for longer durations, and at higher intensities. However shorter, less frequent yoga training of lower intensities may still improve flexibility and hence complements other forms of physical training.

Due to the inverted asanas and length of holding static postures, cardiac responses during yoga may be higher than during other low impact activities. Therefore knowing the HR responses throughout an entire yoga routine and to specific asanas is essential for correct yoga exercise prescription. Knowing the HR responses of healthy individuals to yoga is not only helpful to quantify intensity of yoga training but is also helpful to those with heart problems. Using this information, individuals with heart concerns can assess if certain postures may be too taxing for their cardiac abilities. Likewise, yoga training may be ideal for individuals who must avoid high impact activities but need to exercise their heart.

Recommendations

Future research could expand on this study by making slight improvements in its methodology. Setting limitations such as attending at least one yoga class per week rather than attending 50% of the yoga classes offered may influence the post test results and therefore the effectiveness of yoga training to effect physical fitness. Utilizing a control group of individuals not enrolled in a training program and with similar demographics as those who yoga trained could ensure that post fitness test results are due to yoga training and not learning affects. Additionally taking HR readings of more participants and at multiple yoga classes throughout training would be helpful to see if HR responses change throughout yoga training programs. Providing some type of attendance motivation to individuals who enroll in yoga would increase the number of participants who meet the attendance requirements. This would increase the sample size and improve statistical power of this study. Also, sequential studies that utilize college students as participants may want to do research in the fall semester to avoid changes that may occur over spring break. Future researchers may consider doing similar studies at yoga teacher training schools. Such schools would be ideal because yoga trainees often live and eat at the school and 100% attendance is required at all yoga functions. Even though advancements and alterations can be made to this study, it remains a great contribution to the research on Hatha yoga. As more studies quantify the intensities of specific yoga training programs, exercise specialists will be able to better prescribe yogic exercises based on individual goals and limitations.

REFERENCES

American College of Sports Medicine. (1998). Position Stand: The recommended quantity and quality of exercise for developing and maintaining cardiorespiratory and muscular fitness, and flexibility in healthy adults. *Medicine & Science in Sports & Exercise, 30*(6), 975- 991.

Bera, T.K., & Rajapurkar, M.V. (1993). Body composition, cardiovascular endurance, and aerobic power of yogic practitioner. *Indian Journal of Physiology and Pharmacology, 37* (3), 225-228.

BSDI. Fitness Publisher (Version 9) [Computer software]. Health / Medical Status Questionnaire. http://www.bsdifitness.com.

Canadian Society for Exercise Physiology. (1994). PAR – Q and You. Ottawa, Ontario, Canada; Canadian Society for Exercise Physiology.

Clay, C.C., Lloyd, L.K., Walker, J.L., Sharp, K.R., & Pankey, R.B. (2005). The metabolic cost of Hatha yoga. *Journal of Strength and Conditioning Research, 19*(3), 604-610.

Dash, M., & Telles, S. (2001). Improvement in hand grip strength in normal volunteers and rheumatoid arthritis patients following yoga training. *Indian Journal of Physiology and Pharmacology, 45*(3), 355-360.

DiCarlo, L.J., Sparling, P.B., Hinson, B.T., Snow, T.K., & Rosskopf, L.B. (1995). Cardiovascular, metabolic and perceptual responses to Hatha yoga standing poses. *Journal of Medicine, Exercise, Nutrition, and Health, 4*, 107-112.

Franklin, B.A. (Ed.). (2000). *ACSM's Guidelines for Exercise Testing and Prescription* (6th ed.). New York: American College of Sports Medicine.

Gharote, M.L., & Ganguly, S.K. (1979). Effects of a nine-week yogic training programme on some aspects of physical fitness of physically conditioned young males. *Indian Journal of Medical Sciences, 33*(10), 258-263.

Jackson, A.S., & Pollock, M.L. (1985). Practical assessment of body composition. *The Physician and Sportsmedicine, 13*, 76 –90.

Kirk, M., Boon, B., & DiTuro, D. (2006). *Hatha yoga illustrated*. Hong Kong: Human Kinetics.

Madanmohan, Thombre, D.P., Balakumar, B., Nambinarayanan, T.K., Krishnamurthy, S.T.N., & Chandrabose, A. (1992). Effect of yoga training on reaction time, respiratory endurance, and muscle strength. *Indian Journal of Physiology and Pharmacology, 36*(4), 229-233.

McArdle, W.D., Katch, F.I., & Katch, V.L. (2000). Fundamentals of human energy transfer. In E. Johnson (Ed.), *Essentials of exercise physiology* (2^{nd} ed., pp 107-108). Philadelphia: Lippincott Williams & Wilkins.

Nieman, D.C. (2003). Cardiorespiratory fitness. In J. Karpaczv (Ed.), *Exercise testing and prescription* (5th ed.). Boston: McGraw Hill.

Plowman, S.A., & Smith, D.L. (1997). Metabolic training principles and adaptations. In S. Spivey, & L. Davidson (Eds.), *Exercise physiology for health, fitness, and performance*. Boston: Allyn and Bacon.

Rai, L., & Ram, K. (1993). Energy expenditure and ventilatory responses during Virasana- A yogic standing posture. *Indian Journal of Physiology and Pharmacology, 37*(1), 45-50.

Rai, L., Ram, K., Kant, U., Madan, S.K., & Sharma, S. K. (1994). Energy expenditure and ventilatory responses during Siddhasana- A yogic seated posture. *Indian Journal of Physiology and Pharmacology, 38*(1), 29-33.

Raju, P.S., Prasad, K.V.V., Venkata, R.Y., Murthy, K.J.R., & Reddy, M.V. (1997). Influence of intensive yoga training on physiological changes in 6 adult women: A case report. *The Journal of Alternative and Complementary Medicine, 3*(3), 291-295.

Ray, U.S., Hedge, K.S., & Selvamurthy, W. (1986). Improvement in muscular efficiency as related to a standard task after yogic exercises in middle aged men. *Indian Journal of Medical Research, 83*, 343-348.

Ray, U.S., Mukhopadhyaya, S., Purkayastha, S.S., Asnani, V., Tomer, O.S., Prashad, R., et al. (2001). Effect of yogic exercises on physical and mental health of young fellowship course trainees. *Indian Journal of Physiology and Pharmacology, 45*(1), 37-53.

Ray, U.S., Sinha, B., Tomer, O.S., Pathak, A., Dasgupta, T., & Selvamurthy, W. (2001). Aerobic capacity & perceived exertion after practice of Hatha yogic exercises. *Indian Journal of Medical Research, 114*, 215-221.

Saper, R.B, Eisenburg, D.M., Davis, R.B., Culpepper, L., & Phillips, R.S. (2004). Prevalence and patterns of adult yoga use in the United States: Results of a national survey. *Journal of Alternative Therapies in Health and Medicine, 10*(2), 44-49.

Tran, M.D., Holly, R.G., Lashbrook, J., & Amsterdam, E.A. (2001). Effects of Hatha yoga practice on the health-related aspects of physical fitness. *Journal of Preventive Cardiology, 4*(4), 165-170.

APPENDICES

Appendix A- Interest Letter

So you're interested?

What is this? This is a thesis project that is looking at the effects of yoga training on fitness and heart rate.

Why participate? If you have ever wondered about your current level of physical fitness, you should consider being a participant for this study. As a participant you will receive a free complete fitness assessment that provides feedback on your flexibility, aerobic fitness, body composition, muscular strength and endurance.

Who can participate? Anyone that is enrolled in the intermediate yoga class at SUNY Cortland can participate. Since this study is looking at the effects of yoga training on fitness, it is important that other exercise habits and diet stay relatively constant. Participants are encouraged to keep both diet and exercise patterns constant throughout the study as well attend the majority of yoga classes.

So now what? If you are interested in participating, you need to:

1. Sign up for exercise testing *
2. Complete the PAR-Q and Medical/Health Status Questionnaire. These questionnaires are used to ensure you can complete moderate exercise tests without medical complications.
3. Complete the Informed Consent and General Information Sheet.
4. Bring the completed PAR-Q, Medical/Health Status Questionnaire, Informed Consent, and General Information Sheet with you to your exercise testing session.

* Exercise testing will take approximately 40 minutes and will occur on Tuesday, February 21st from 4:30-6:30. Please try to sign up for a slot on that day. A second exercise testing MAY take place on Thursday, February 23rd from 4:30-6:30.

Contact information: Lissa Delaney Walls
607-753-2966
lissawalls@yahoo.com

Appendix B- Informed Consent

Adult Consent Form
State University of New York at Cortland

The research you have been asked to participate in is being conducted by Lissa Delaney Walls of the Exercise Science Department at SUNY Cortland, as part of a graduate thesis. In order to be a participant in the study described below, this informed consent form must be completed.

Purpose and Procedures of This Research Study

The purpose of this study is to determine the effects of yoga training on heart rate and physical fitness. You will come to the exercise physiology laboratory twice to have your physical fitness tested. Items tested will include body composition, cardiorespiratory fitness, muscular strength, muscular endurance, and flexibility. Body composition will be determined by measuring body fat, cardiorespiratory fitness will be assessed during a submaximal bike test, muscular endurance will be assessed by the number of sit-ups and bench-presses one can complete, muscular strength will be determined with a hand grip test. Finally, flexibility will be measured using standard over the shoulder and sit-and-reach flexibility tests. To measure heart rate response during yoga, you will wear a heart rate strap around your sternum during at least two of the yoga classes. Height, weight, and blood pressure will also be measured.

Before you agree to participate you should know that:

A. <u>Freedom to withdrawal</u>
You are free to withdraw your consent and discontinue this study at anytime. Withdrawal will not result in penalty of any kind.

B. <u>Protection of Participants' Responses</u>
To protect confidentially, numbers will be used to identify all data collected from exercise testing and only the primary researcher will see your name and contact information. All data collected and information containing the names of participants will be filed and then locked up in the Exercise Science Department at SUNY Cortland for three years, after this time, all records will be destroyed.

C. <u>Length of Participation</u>
Each exercise testing session should take one hour; the first testing session will be in late February and the second testing session will occur in late April. Participants will have to arrive to class ten minutes early to put on a heart rate monitor, at least twice.

D. <u>Full Disclosure</u>

It may be necessary to keep some information regarding the experiment withheld from participants. No fitness assessment information will be given to the participant until two weeks after the post yoga exercise testing.

E. Risks Expected

Although you should not experience any pain or discomforts from participating in this study, risks and discomforts are possible. Possible risks may include injury and abnormal heart rate and/or blood pressure. Possible discomforts may also include heavy breathing and soreness.

F. Benefits Expected

Participation in this study is beneficial to you because you will receive a free complete fitness assessment. This study will also be beneficial to society, as it will lead to a better understanding of yoga training.

G. Contact Information

If you have any questions concerning this research study or your participation in it, before or after consent, you can contact Lissa Delaney ph: 607-753-2966 or the research advisor, Dr. McGinnis Ph: 607-753-4909. If you have any questions about research or the rights of research participants you can contact Amy Henderson-Harr, IRB Designee, Office of Sponsored programs, SUNY Cortland ph: 607-753-2511.

I________________________ (print name) have read the description of the project, for which consent is requested, understand my rights, and I hereby consent to participate in this study.

Signed________________________________ Date_____________

Appendix C- General Information Sheet

To the participant:

Please fill in all information as accurately as possible. All information will be kept confidential. Contact information may only be used by the researcher and only for this project. If you have any questions, about anything related to this study, please contact the researcher.

Name___________________________________ Date______________________

Age________ Contact information (phone number/ email)_________________________

Enrolled in class as a:
(check one) ☐Student ☐ Faculty/Staff ☐ Community Member

Previous yoga training (check one) ☐ Yes ☐ No

If yes, how long have you been practicing yoga? ________________________________

What are your main reasons for enrolling in this yoga class?
____
____
____
____
____
____
____

Appendix D- 12 Basic Sivananda Asanas

The common and yoga name and descriptions of each of the 12 main Sivananda asanas are given below. To the right is a picture corresponding to each asana. Asanas are in order of performance.

1. Headstand – Sirshasana: An inverted posture which is performed to improve circulation, prevent back problems, and improve concentration and memory.

2. Shoulder stand – Sarvangasana: Invigorates and rejuvenates the body while stimulating the thyroid and parathyroid glands. This posture helps the spine become strong and elastic.

3. Plough – Halasana: Brings flexibility to the neck and spine while nourishing spinal nerves. Strengthens back, shoulder, and arm muscles.

4. Fish – Matsyasana: Removes stiffness from the neck, shoulder, and back muscles. It opens up the chest increasing lung capacity and correcting round shoulders.

5. Forward Bend – Paschimothanasana: Relieves spine from compression and stretches hamstrings. Stimulates and massages the abdominal area and improves digestion.

6. Cobra – Bhujangasana: Position gives the spine a powerful backward stretch while strengthening the surrounding muscles.

7. Locust – Salabhasana: This position strengthens the lower back and leg muscles and massages all the internal organs.

8. Bow – Dhanurasana: Position strengthens back muscles and elasticity of the spine, resulting in improved posture. Pose massages and invigorates internal organs resulting in improved digestion.

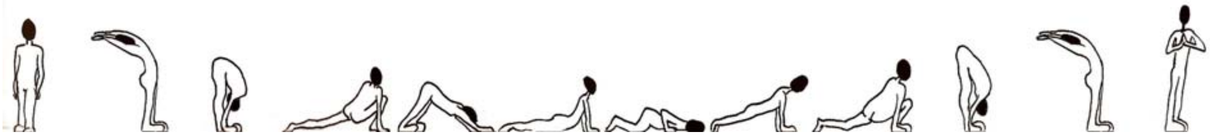
9. Spinal Twist - Ardha Matsyendrasana: Improves spine flexibility by rotating vertebrae in both directions.

10. Crow - Kakasana Strengthens the arms, wrists and shoulders. This pose helps to train the mind to focus.

11. Standing Forward Bend - Pada Hasthasana Pose lengthens the back and provides blood flow to the brain. Stretches hamstrings and back muscles.

12. Triangle -Trikonasana Pose gives a lateral stretch to the spine and promotes hip and leg flexibility.

Sun Salutations are not one of the 12 main Sivananda asanas. Rather they are a series of fluid body positions that are done prior to the main 12 yogic asanas to warm up and prepare the body for exercise.



Appendix E- Follow-up General Information Sheet

To the participant:

Please fill in all information as accurately as possible. All information will be kept confidential. Contact information may only be used by the researcher and only for this project. If you have any questions, about anything related to this study, please contact the researcher.

Name___________________________________ Date______________________

Age________ Contact information (phone number/ email) ________________________

Enrolled in class as a:
(check one) □Student □ Faculty/Staff □ Community Member

Previous yoga training (check one) □ Yes □ No

If yes, how long have you been practicing yoga? _______________________________

Did you enjoy this yoga class? (Check one) □ Yes □ No

Do you feel you have benefited from this yoga class in any way?
(Check one) □ Yes □ No

If yes, how was it beneficial?
____
____
____
____

Do you feel this class has been detrimental to you in an anyway?
(Check one) □ Yes □ No

If yes, how was it detrimental?
____
____
____
____

After taking this yoga class do you feel your level of physical fitness has changed? (Check one)

□ No change □ It improved □ It decreased

Appendix F- Data Collection Sheet

Participant's Number_______ Age____yrs Gender (M/F)___

Date_____________ Time________ AM/PM

Lab: Temp____Degrees C RH%_______ P_b ____ mmHg Tech ID_____

HR monitor #_____ Strap size XS/S/M/L Transmitter #______

BACKGROUND CHECK Tech ID_____________

Can this individual participate in moderate exercise testing without high risk? YES/ NO?

RESTING HR AND BP Tech ID___
Arm left/right Cuff #___ Stethoscope #____

BP_1_______mmHg BP_2__________mmHg $BP_{3(\text{if needed})}$_______mmHg

HR_1________BPM HR_2__________BPM $HR_{3(\text{if needed})}$_______BPM

HEIGHT AND WEIGHT Tech ID___________

Height_____.__in Weight____.__lbs Calculated BMI_____

BODY COMPOSITION Tech ID___________ Caliper #____

Skin fold site	Trial 1 (mm)	Trial 2 (mm)	Trial 3 (mm)	Mean (mm)
Abdomen				
Triceps				
Suprailiac				
Thigh				

FLEXIBILITY Tech ID_____________

Test	Trial 1	Trial 2	Trial 3	Best
Sit and Reach (cm)				

Shoulder (in) (R/L)				

MUSCULAR STRENGTH Tech ID___________

Hand Dynamometer: Dominate hand (L/R)___

Hand	Trial 1 (kg)	Trial 2 (kg)	Trial 3 (kg)	Ave of best 2 (kg)
Left				
Right				

MUSCULAR ENDURANCE Tech ID____________

Bench-press: Metronome_____bpm Weight____lbs Number completed______

Sit-up: Number completed______

Appendix G- Raw Pre and Post Test Data

Table 6. Raw Pre and Post Yoga Training Test Data

Participant Number	2	3	4	5	6	7	10
Attendance (%)	56.3	87.5	68.8	81.2	100	87.5	56.3
HR (BPM)							
Pre	60	68	78	64	80	72	88
Post	82	76	72	70	76	72	68
BP (mmHg)							
Pre	128/80	126/72	126/64	128/72	122/78	112/74	120/64
Post	124/76	124/82	122/70	124/74	118/72	124/80	122/70
Weight (lbs)							
Pre	200.5	138.0	119.0	126.5	134.3	122.0	103.0
Post	201.5	134.3	116.0	127.0	130.0	131.5	105.0
Body Fat (%)							
Pre	12.9	22.2	19.6	28.0	24.2	23.3	21.6
Post	13.0	20.8	20.0	25.0	24.0	29.8	24.0
Ham-trunk Flex (cm)							
Pre	34.0	32.0	24.0	45.0	33.0	32.0	31.0
Post	41.8	41.0	35.5	52.0	38.5	39.0	39.0
Shoulder Flex (in)							
Pre	-2.65	0	1.35	2.4	4.0	0.2	3.20
Post	-3.75	1.1	2.75	2.4	4.5	1.9	2.60
HGS (kg)							
Pre	116.0	57.5	49.0	49.0	52.0	38.0	48.5
Post	88	63.5	48.0	47.5	47.5	43.0	49.5
Bench-presses (#)							
Pre	46	21	21	24	17	14	0
Post	50	22	18	22	17	16	0
Sit-ups (#)							
Pre	48	21	44	35	47	36	29
Post	51	27	44	32	55	37	31

Note. Raw pre and post data for one male (sub 2) and six females participants. Attendance % represents the number of yoga classes the participant attended divided by 16 (the number of classes offered). HR = heart rate, BP = blood pressure, Ham-trunk = hamstring-trunk, Flex = flexibility, HGS = hand grip strength. Pre measurements were made after one week of yoga training. Post measurements were made five days after the final yoga class.