A COMPARISON OF THE EFFECTS OF HATHA YOGA AND AEROBIC DANCE ON HEALTH-RELATED PHYSICAL FITNESS IN YOUNG ADULT FEMALES

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CHAPTER 1

INTRODUCTION TO THE STUDY

Leading organizations, such as the American College of Sports Medicine (ACSM), have established specific guidelines based on the safest and most effective training stimuli for enhancing the components of health-related physical fitness (HRPF), i.e., cardiorespiratory fitness, body composition, muscular strength, muscular endurance, and flexibility (1). For example, in order to maintain optimal levels of cardiorespiratory fitness and body composition, the ACSM recommends that an individual perform 20 to 60 minutes of continuous or intermittent aerobic exercise at 50 to 85% of maximum oxygen uptake reserve (VO_2R) 3 to 5 days per week (1). In addition, in order to maintain optimal levels of muscular strength and endurance, a minimum of one set (i.e., 8 to 12 repetitions to volitional fatigue per set) of 8 to 10 exercises targeting the major muscle groups should be performed 2 to 3 days per week (1). Finally, to optimize HRPF, flexibility conditioning of the major muscle groups should also be performed 2 to 3 days per week (1). Typically, these guidelines can be met through a combination of conventional forms of physical activity, such as walking-hiking, running-jogging, cycling-bicycling, group exercise (e.g. aerobic dance, step, and kickboxing), and weight lifting-resistance exercise (1,2). Surprisingly, less than 15% of adults participate in physical activities with sufficient intensity and regularity to meet minimum ACSM recommendations (1). Identifying additional conventional as well as unconventional modes of appropriate physical activity (i.e., activity that provides the proper training stimulus required to promote HRPF) may increase the percent of those who meet recommended physical activity guidelines.

In recent years, the popularity of unconventional modes of physical activity, such as hatha yoga, has increased in the United States. Since 1994, there has been a three-fold increase in hatha yoga participants (3,4), in part, due to its gentle style and purported stress-relieving (3) and physical fitness (5,6) benefits. Although hatha yoga has just recently become a widely practiced form of physical activity in the United States (3,4), the tradition of yoga originated at least 5000 years ago in India (6,7). According to traditional eastern yoga, the incorporation of a specific system of yoga techniques will liberate one from all human imperfections and suffering, which derive from ill-fated attempts to achieve happiness from external sources (e.g., power and wealth) (5,8,9). Literature on traditional eastern hatha yoga has not clearly operationally defined the subjective, experiential nature of yoga, but suggests that traditional eastern yoga is a discipline that can be practiced regularly to help one realize one's already existing internal potential for perfection and happiness (5,8,9).

According to Indian sources, achieving a state of perfection and happiness can result from following one or more "paths" (i.e., techniques) of yoga (5,8,9). For example, traditional eastern hatha yoga is one path of yoga that is comprised of the following four practices: (a) Yama (the practice of non-violence, truthfulness, non-stealing and continence); (b) Niyama (observances of cleanliness, contentment, practices which bring about perfection of body and senses, etc.); (c) Asanas (postures); and (d) Pranayamas (breathing exercises) (9). Among all of the different paths of yoga, hatha yoga has become the most commonly practiced path of yoga in the United States due to its focus on physical preparation and enhancement (5).

Since the late 1960's, all paths of yoga, including hatha yoga, have undergone various adaptations in the United States (6,7). Specifically, western hatha yoga (i.e., hatha yoga as practiced in the United States) has become a method for physical fitness and health maintenance (6) rather than a method for perfection and happiness (5,8-10). In contrast to traditional eastern hatha yoga, which incorporates the four practices of asanas, pranayamas, niyamas, and yamas into one's daily routine, western hatha yoga typically incorporates only a variety of asanas and pranayamas into a brief routine (i.e., usually lasting no longer than 90 minutes) that is practiced periodically throughout the week primarily for purposes of health and fitness (5,6,9).

Most of the research on the effect of regular hatha yoga practice on HRPF has been performed in India (11-17). Regular traditional eastern hatha yoga practice has been shown to reduce percent body fat and/or body weight (11,12) and improve cardiorespiratory fitness (11,13,14), muscular strength (15,16), and flexibility (17). However, due to the differences in focus, format, and purpose between eastern and western hatha yoga, results of these eastern studies should be used cautiously when discerning the effects of western hatha yoga on HRPF.

The only study to examine the effects of regular western hatha yoga training on HRPF demonstrated that 8 weeks of western hatha yoga training increased muscular strength, muscular endurance, flexibility, and aerobic fitness in 10 males and females, 18-27 years of age (18). Specifically, Tran et al. (18) found that 10 minutes of pranayamas, 15 minutes of warm-up poses, 50 minutes of asanas, and 10 minutes of relaxation performed 2 to 4 days a week for 8 weeks resulted in a significant increase in isokinetic muscular strength for elbow extension, elbow flexion, knee extension by 31%, 19%, and 21%, respectively. Isometric muscular endurance for knee flexion significantly increased by 57%. Ankle flexibility, shoulder elevation, trunk extension, and trunk flexion increased significantly by 13, 155, 188, and 14%, respectively. Lastly, maximal oxygen consumption (VO_2max) significantly increased by 6%. However, no significant changes in body composition were found. Although results of this study suggests that regular hatha yoga training enhances cardiorespiratory endurance, muscular fitness, and flexibility, the following limitations should be recognized: (a) a small sample (n=10), and (b) lack of both a control group and comparable exercise group. Therefore, research is warranted comparing the physiological effects of regular hatha yoga to more conventional modes of physical activity that provide proper training stimulus for the promotion of HRPF.

Aerobic dance is a well-accepted form of aerobic exercise that has been shown to enhance cardiorespiratory fitness (19-24), body composition (24), and muscular endurance (25). Briefly, aerobic dance involves continuous, coordinated, and choreograph dance and calisthenic movements performed to music (2,26). However, due to its often-times complex choreographaphy, loud music, young female audience, and intense style, it may have limited appeal to some participants. Therefore, there is a need to identify other modes of physical activity that appeal to such individuals as well as enhance HRPF. Because western hatha yoga is gentler on the joints (3), targets both stress reduction (3) and enhancement of physical fitness (5,6), and does not involve loud music or difficult choreography, it maybe, for some, a more appealing alternative to aerobic dance. There is a need for research that investigates the training stimulus of western hatha yoga, and its impact on the HRPF. The purposes of this study are to document the changes in HRPF that result from 8 weeks of western hatha yoga training and to compare these results with those of a comparable aerobic dance program in college-aged females, as well as a non-exercise control group.

CHAPTER 2

MATERIALS AND METHODS

Subjects

Experimental subjects were recruited from students enrolled in yoga (N = 20 females) and aerobic dance classes (N = 34 females) at a university. The subjects in the control group were recruited from lecture, billiards, and bowling classes (N = 15 females) at a university. The controls were asked to maintain their current level of fitness throughout the duration of the study. Written consent was obtained from all subjects after a detailed description of all testing procedures was provided. This investigation was submitted to and approved by the university's Institutional Review Board.

Instruments

A calibrated physician's scale (Detecto Scale Co., Jericho, NY) was used to obtain height and weight, and Lange calipers (Cambridge, MD) were used to measure skinfold thickness. Maximal exercise tests were performed on a Trackmaster treadmill (FullVision, Newton, KS). During the maximal exercise tests, subject's heart rate (HR) was measured by a Polar Vantage XL telemetric HR monitor (Stanford,CT). Expired air was analyzed throughout the tests with a PARVO Medics metabolic analyzer (Salt Lake City, UT). Minute ventilation (V_E), oxygen consumption (VO_2), carbon dioxide production (VCO_2), and respiratory exchange ratio (RER) was determined from 60-s averages. Calibration was performed before each test day using a certified gas mixture (O_2 = 16% and CO_2 = 4%, Scott Medical Products, Plumsteadville, PA). Upper body muscular strength was assessed using a Samson bench press and lower body muscular strength was assessed using a Samson power rack. Finally, flexibility was assessed using the Acuflex I sit and reach flexibility tester (Rockton, IL).

Testing Procedures

All subjects visited the laboratory on two separate occasions within 1 to 3 weeks prior to the 8-week training period. Subjects were instructed to: (a) drink plenty of fluids over the 24-hr period preceding the test; (b) avoid food, alcohol, nicotine, and caffeine for at least 4 hours before testing; (c) avoid strenuous physical activity the day of the test; and (d) get 6 to 8 hours of sleep the night before the test (27).

The first visit to the laboratory included completion of an informed consent and a comprehensive health appraisal questionnaire as well as measurement of: (a) height and weight (in exercise clothes, without shoes); (b) skinfold thicknesses; and (c) VO_2max. The tricep, suprailiac, and thigh skinfold thickness were measured and % body fat was estimated from sum-of-skinfolds using equations by Jackson et al. (28). The skinfold measurements were obtained by one experienced test administrator, who was previously trained according to the ACSM standards for body composition assessment (27).

Subject's VO_2max was measured using the Bruce treadmill protocol (27). Subject's peak VO_2 attained was considered VO_2max if three of the following criteria were met: (a) leveling off of VO_2 despite an increase in workload; (b) achievement of age-predicted maximal heart rate (HR) (220-age); (c) an RER greater than 1.15; and (d) failure to maintain pace despite strong verbal encouragement. Measurements for VO_2, VCO_2, VE, and RER were determined from 60-s averages. HR was recorded at the end of each minute.

Within 2 to 7 days of the first visit, subjects returned to the lab for muscular strength, muscular endurance, and flexibility testing. Estimated 1-RM from bench press and squat were used to assess upper body muscular strength (UBMS) and lower body muscular strength (LBMS), respectively. Procedures were followed according to National Strength and Conditioning's recommendations for estimating 1-RM from multiple repetitions (29).

Muscular endurance was assessed using the YMCA partial curl-up test and a push-up test. Flexibility was assessed using the sit and reach test. For all 3 tests, test administrators followed assessment procedures outlined by ACSM precisely (27).

Training Program

Hatha Yoga Training Session. The hatha yoga group participated in 50 minutes of hatha yoga 2 days per week for 8 weeks. The routines performed consisted of asanas and pranaymas primarily from books by Birkel and Feuerstein and Payne (6,7). The format of the class consisted of 5-10 minutes of pranayamas with preparation poses, 30 minutes of asanas, and 5-10 minutes of relaxation/meditation.

Aerobic Dance Training Session. The aerobic dance group participated in 50 minutes of aerobic dance 2 days per week for 8 weeks. Each class consisted of a 10-minute warm-up, a 25 to 35-minute aerobic dance with resistance training, and a 5-minute cool down with flexibility training. During the aerobic dance portion of the class, the participants were asked to maintain an exercise intensity of 50-85% of maximal heart rate reserve (HRR). At the beginning of the study, the subjects were instructed on how to palpate for HR and maintain their target HR during exercise.

Data Analysis

Independent variables were the groups: (a) aerobic dance, (b) hatha yoga, and (c) control, as well as the pre- and post-test trials. The dependent variables were body composition, cardiovascular endurance, muscular strength and endurance, and flexibility.

Descriptive statistics (mean and standard deviations) were calculated for each dependent variable. A multivariate analysis of variance (MANOVA) was used to compare the effects of aerobic dance, hatha yoga, and the control groups on each dependent variable. A repeated measures analysis of variance (ANOVA) was used to determine if there were differences between the groups' pre- and post-test scores. Statistical significance was set at the 0.05 level.

CHAPTER 3

RESULTS

Of the initial 69 female volunteers, 16 discontinued participation in the study for personal reasons or were asked to discontinue the study because of additional physical activity beyond the parameters of this study. After data screening, the final sample included 53 females (18 in the yoga group, 26 in the aerobic dance group, and 9 in the control group).

No significant differences in pre-test scores for weight, SSF, % body fat, VO_2max, curl-ups, sit-and-reach (SNR), and 1-RM squat were observed among the groups at $p > .05$. MANOVA revealed that the hatha yoga group was significantly weaker in upper body muscular strength (UBMS) than the other two groups (Wilk's Lambda = 0.44, $F_{22,106} = 2.42$, $p < .05$), including both 1-RM bench press (lb, $F_{2,63} = 4.94$, $p < .05$) and push-ups (repetitions, $F_{2,63} = 11.64$, $p < .05$). Since no significant group difference in improvement were observed for either bench press ($F_{2,19} = 0.18$, $p > .05$) or push-ups ($F_{2,49} = 0.66$, $p > .05$), the hatha yoga group was significantly weaker in upper body muscular strength and endurance before and after the training period.

Table 1 reports the physiological responses (mean $\pm$ SD) for the pre- and post-tests for each dependent variable in the three groups. No significant

.05). Significant improvement in 1-RM squat and flexibility (sit and reach) were observed between the pre- and post-tests among all groups; however for 1-RM squat, all three groups had similar improvements. For the 1-RM squat, the hatha yoga group, aerobics group, and control group improved by an average of 3.4 kg, 5.7 kg, and 4.9 kg, respectively. For the SNR, the hatha yoga group, aerobics group, and control group improved by an average of 3.0 cm, 1.0 cm, and 1.1 cm, respectively. SNR was the only variable for which a significant group difference in improvement was observed ($F_{2,50} = 4.9$, $p < .05$). Post-Hoc tests revealed significantly greater improvement in SNR in the hatha yoga group than both the aerobic dance group ($F_{1,42} = 7.8$, $p < .05$) and the control group ($F_{1,25} = 6.1$, $p < .05$).

Table 1. *Pre and Post Test (mean ± SD) and Absolute Change in the Hatha Yoga, Aerobic Dance, and Control Groups.*

Variables	Hatha Yoga		Absolute	Aerobic Dance		Absolute	Control		Absolute
	PRE	POST	Change	PRE	POST	Change	PRE	POST	Change
Weight (kg)	63.6 ± 14.0	63.7 ± 13.6	0.1	60.3 ± 6.7	60.7 ± 7.1	0.4	65.6 ± 26.7	65.3 ± 27.1	0.3
SSF (mm)	69.5 ± 30.1	67.7 ± 24.6	-1.8	60.1 ± 11.7	59.7 ± 13.0	-0.4	59.8 ± 30.1	60.5 ± 32.8	0.7
% Body Fat	25.8 ± 8.4	25.5 ± 7.0	-0.3	23.5 ± 3.7	23.4 ± 4.2	-0.1	22.8 ± 8.3	22.9 ± 9.0	-0.1
VO_2max (ml kg^{-1} min^{-1})	30.7 ± 5.9	31.6 ± 6.3	0.9	32.7 ± 5.6	33.8 ± 4.5	1.1	37.3 ± 7.0	36.7 ± 6.0	-0.6
1RM-Bench Press (kg)	27.0 ± 3.8*	28.2 ± 4.3	1.2	34.5 ± 5.5	35.2 ± 5.9	0.7	35.5 ± 3.8	36.8 ± 4.4	1.3
Curl-Ups	16.1 ± 11.9	22.7 ± 17.9	6.6	28.4 ± 21.4	30.8 ± 19.0	2.4	21.9 ± 17.5	23.2 ± 19.6	1.3
Push-Ups	5.6 ± 7.3*	8.1 ± 9.5	2.5	10.4 ± 7.6	11.2 ± 6.4	0.8	15.8 ± 7.6	16.3 ± 6.0	0.5
SNR (cm)†, ‡	31.5 ± 7.4	34.5 ± 6.4	3.0	31.0 ± 6.4	32.0 ± 6.6	1.0	34.0 ± 4.6	35.1 ± 4.8	1.1
1-RM Squat (kg)†	52.1 ± 2.9	55.5 ± 12.0	3.4	50.1 ± 13.4	55.8 ± 13.1	5.7	72.4 ± 37.5	77.3 ± 36.6	4.9

Note: SSF = Sum of Skinfolds; 1-RM Bench Press = 1-Repetition Maximum Bench Press; SNR = Sit and Reach; 1-RM Squat = 1-Repetition Maximum Squat

*Pre-test scores for 1-RM bench press and push-ups were significantly lower in the hatha yoga group than the other two groups $p < .05$. †Significant differences in improvement in 1-RM squat and SNR were observed among the groups at $p < .05$. ‡A greater improvement in SNR was observed in the hatha yoga group than the other two groups at $p < .05$.

CHAPTER 4

DISCUSSION

Hatha yoga, as practiced in the West, is performed to enhance health, fitness, and wellness (3,5,6). Although there is limited research to determine if western-style hatha yoga actually benefits health-related physical fitness (HRPF) (18), it has become a popular form of physical activity in the United States (3,4). This study documented the changes in HRPF that resulted from 8 weeks of western hatha yoga training and compared those results with those of an equivalent aerobic dance program in college-aged females. This study showed that neither hatha yoga nor aerobic dance performed for 50 minutes 2 days per week for 8 weeks improved cardiorespiratory fitness, body composition, and upper body muscular strength and endurance. Because similar differences in pre and post 1-RM squat scores were observed among the hatha yoga group, aerobic dance group, and control group, the increase in lower body muscular strength (1-RM squat) should be attributed to a learning effect. Therefore, neither training programs employed in this study resulted in lower body muscular strength improvements. Finally, differences in pre and post sit-and-reach (SNR) scores were observed among all three groups. However, when compared to both the aerobic dance and control groups, the hatha yoga group demonstrated significantly greater improvements in SNR scores than the other two groups.

Body Composition. In this study, reductions in mean percent body fat were not observed among 53 females participating in 50 minutes of hatha yoga 2 days per week for 8 weeks (25.8 vs 25.5%). While the duration and frequency of training sessions met or exceeded minimum physical activity guidelines (1), the volume of training appears to be insufficient in improving body composition. Results of this study support findings of a similar study on the impact of western hatha yoga on body composition (18). In the study by Tran et al. (18), no significant changes in body composition were observed in 10 subjects performing 85 minutes of hatha yoga 2 to 4 days per week for 8 weeks (28.5 vs 28.3%).

In contrast, the findings of the present study do not support two previous studies on the impact of regular eastern-style hatha yoga on body composition (11,17). For example, Gharote and Ganguly (17) observed significant differences in mean changes in percent body fat between a hatha yoga group and a comparable control group. In that study, 45 minutes of hatha yoga performed 6 days per week for 9 weeks resulted in a significant increase in estimated percent body fat (12.16 vs 12.71%).

In a more recent study, Raju et al. (11) observed a reduction in percent body fat in 6 female physical education teachers attending an India government-sponsored yoga training program. Following 4 weeks of participation in two 90-minute hatha yoga sessions per day, average total body weight did not change (53.0 vs 53.0 kg), but average lean body mass (LBM) increased by 1% (46.0 vs

46.3 kg), percent body fat decreased by 18% (15.4 vs 12.6%), and fat mass decreased by 4% (7.0 vs 6.7 kg). Although no control group was employed, results of this case report suggest that extensive training may improve body composition.

Based on results from the current study and from previous research (11, 17, 18), a large volume of training is required to produce an adequate training stimulus for reducing percent body fat. Although a minimum threshold stimulus cannot be ascertained from neither this study or previous research, based on the study by Raju et al. (11), a decrease in body size and/or composition may be seen when a minimum of 180 minutes of hatha yoga is performed daily for a minimum of 4 weeks. While a training volume of such magnitude does indeed decrease body size and/or composition, such a large duration and frequency may be impractical for many in the U.S.

Cardiorespiratory Endurance. In the present study, improvements in VO_2max were not observed in the hatha yoga group (30.7 vs 31.6 ml kg^{-1} min^{-1}). These results support an older study by Gharote and Ganguly (17). In that study, regular hatha yoga training resulted in no changes in performance on the Harvard Step test (92.42 vs 101.92).

In studies that did not utilize a control group, however, improvements in aerobic fitness following hatha yoga training are consistently seen. For instance, Tran et al. (18) observed that regular hatha yoga training significantly increased VO_2max by 6% (32.3 vs 34.2 ml kg^{-1} min^{-1}). With regard to eastern studies, 60 minutes of hatha yoga performed 6 days per week for 3 weeks resulted in significant improvements among 17 males on the Harvard Step test (17.0 to 69.2) (13). In addition, Balasubramanian and Pansare (14) observed that 60 minutes performed daily for 6 weeks resulted in significant improvements in aerobic fitness among 17 male and female students aged 16 to 18 years. Specifically, estimated VO_2max based on results from the Astrand Rhyming Bench Step Test increased on average by 15% (2.0 vs 2.3 $LO_2 min^{-1}$). Finally, improvements in cardiovascular efficiency at submaximal work rates have also been observed. In the study by Raju et al. (11), regular hatha yoga training resulted in a 6% decrease in Absolute VO_2 (1.7 to 1.6 LO2 min^{-1}), a 13% decrease in Absolute VO_2 per Watt (10.9 to 9.5 $mlO_2 W^{-1}$), a 6% decrease in HR (152.7 to 143.3 bpm), and an 8% decrease in VE (49.1 to 45.0 $L min^{-1}$) while cycling at 154 $W min^{-1}$.

Results from the present study indicate that performing hatha yoga for 50 minutes 2 days per week for 8 weeks provides an inadequate training stimulus for improving cardiorespiratory endurance. From review of the literature, however, hatha yoga training programs of greater training volume (e.g., for 85 minutes at least 2 days per week or 60 minutes most days of the week) may increase cardiorespiratory endurance.

Muscular Fitness. In the present study, significant improvements in 1-RM squat (52.1 vs 55.5 kg), but not in 1-RM bench press (27.0 vs 28.2 kg), push-ups (5.6 vs 8.1), or curl-ups (16.1 vs 22.7), were observed in the hatha yoga group. Because significant improvements in 1-RM squat were also observed in both the aerobic dance and control groups, the observed improvements were probably due to a learning effect among all students. Results of this study support an older study by Gharate and Ganguly (17). In that study, no changes in mean HGS scores (65.9 vs 61.3 kg) or in mean number of pull-ups performed successfully (7.34 vs 7.46) following 9 weeks of regular hatha yoga training were observed. In contrast to results of the present study, Dash and Telles (16) documented improvements in HGS among 37 'normal (healthy)' adults, 86 children, and 20 patients with rheumatoid arthritis, who participated in regular hatha yoga training for 1 month, for 10 days, and for 14 days, respectively.

In studies that did not utilize a control group, changes in muscular fitness following hatha yoga training have been observed (15, 18). Tran et al. (18) demonstrated that isokinetic muscular strength increased by 31, 19, and 28%, for elbow extension, elbow flexion, and knee extension, respectively, and isometric muscular endurance (i.e., the length of time a contraction was held at 70 to 80% peak torque) increased by 57% for elbow extension. In addition, 30 minutes of hatha yoga 6 days per week for 12 weeks resulted in a 21% increase in isometric HGS among 37 males age 18 to 27 years (13.8 vs 16.7 kg) (15).

Results from the present study indicate that performing hatha yoga for 50 minutes 2 days per week for 8 weeks provides an inadequate training stimulus for improving muscular fitness. From review of the literature, however, hatha yoga training programs of greater training volume (e.g., for 85 minutes at least 2 days per week or 30 minutes most days of the week) may increase muscular fitness.

Flexibility. In the present study, SNR scores significantly increased by 6% in the hatha yoga groups (31.5 vs 34.5 cm). This increase was significantly greater than the improvements seen in both the aerobic dance and control groups. The results of this study confirm previous findings (17,18). For example, in the study by Tran et al. (18), ankle flexibility, shoulder elevation, trunk extension, and trunk flexion increased by 13, 155, 188, and 14%, respectively. Furthermore, Gharote and Ganguly (17) observed mean significant differences in extension flexibility and left ankle flexibility, between a hatha yoga group and a comparable control group, but not in dynamic flexibility, forward flexion, right ankle flexibility, and shoulder flexion. Specifcally, for the hatha yoga group, left ankle flexibility increased by 29% (36.4 vs. 47.1 degrees).

When compared to previous research (17,18), however, the magnitude of improvement in flexibility is much lower in the present study. A logical explanation may be, in part, due to the lower volume of training employed in this study than in previous studies (17,18). Nevertheless, performing hatha yoga for at least 100 minutes per week is expected to increase trunk flexion.

Summary and Conclusions. Hatha yoga is commonly employed by many adults in the United States as means for improving health-related physical fitness. Health clubs typically offer 45 to 90 minute hatha yoga classes to their members as an alternative to conventional forms of aerobic dance classes. Although it has become a very popular form of physical activity, research has not been able to confirm whether hatha yoga, as practiced in the United States, produces an adequate training stimulus for improving health-related physical fitness. Results of this study indicate that a 50-minute hatha yoga class performed 2 days per week for 8 weeks will increase flexibility more than an aerobic dance class performed for the same duration and frequency. However, results of this study indicate that 50 minutes of neither aerobic dance nor hatha yoga are sufficient enough to enhance body composition, cardiorespiratory endurance, or muscular fitness. Future studies, employing both control and comparable exercise groups, are warranted to identify the minimal training threshold (i.e., minimal frequency and duration) for improving health-related physical fitness with hatha yoga and to determine if this minimal training threshold is practical.

APPENDIX A

HYPOTHESIS, DELIMITATIONS, SIGNIFICANCE OF THE STUDY

Hypothesis

It is hypothesized that hatha yoga will produce a significant difference on flexibility, but not on cardiorespiratory fitness, muscular fitness, and body composition.

Delimitations

This study is delimited by female college students, ages 18-46, with no previous hatha yoga experience.

Significance of the Study

Hatha yoga has become a widely practiced for of physical activity, often times replacing other more appropriate forms of physical activity (i.e. activities that meet recommended guidelines). There is little research to support that hatha yoga will give the same HRPF benefits as that of a more appropriate form of physical activity.

There is a need to determine whether hatha yoga is an adequate form of physical activity as described by the ACSM. Hatha yoga has a gentler, less rigorous feel and is often more appealing to a wider array of people.

APPENDIX B

REVIEW OF LITERATURE

Review of Literature

In order to maintain optimal levels of cardiorespiratory fitness and body composition, the American College of Sports Medicine (ACSM) recommends that an individual perform 20 to 60 minutes of continuous or intermittent aerobic exercise at an intensity of 50 to 85% of maximum oxygen consumption reserve (VO_2R) 3 to 5 days per week (1). In addition, in order to maintain optimal levels of muscular strength and endurance, one should also exercise 2 to 3 days per week with a minimum of one set (8 to 12 repetitions to volitional fatigue) of 8 to 10 exercises targeting the major muscle groups (1). Finally, flexibility conditioning of the major muscle groups should also be performed 2 to 3 days per week to optimize health-related fitness physical fitness (HRPF) (1). Typically, these guidelines are met through conventional forms of exercise such as walking-hiking, running-jogging, cycling-bicycling, aerobic dance, and resistance training (1). Surprisingly, no more than 15% of adults participate in physical activities with sufficient intensity and regularity to meet minimum ACSM recommendations (1).

With levels of obesity and physical inactivity approaching epidemic proportions (3,4,30), there is a need to look beyond conventional forms of exercise to promote physical activity and maintain health. In recent years, the popularity of yoga in the United States has increased due to its gentle style and purported stress-relieving (3) and physical fitness (5,6) benefits. In the United States, there has been a three-fold increase in yoga participants since 1994, with the current number of participants approaching 20 million (3,4). Briefly, yoga is a multifaceted approach to wellness that employs a combination of breathing, flexibility, muscular strength, and muscular endurance exercises to calm one's mental and emotional state (31). Because yoga incorporates a variety of exercises into one gentle activity, the following literature review will address whether this alternative form of physical activity offers an adequate training stimulus to significantly impact one or more of the HRPF components (i.e., body composition, cardiovascular endurance, muscular strength, muscular endurance, and flexibility) (28).

History of Yoga. Yoga dates back as far as 5000 years ago in India (6,7). Although difficult to define, traditional yoga (i.e., eastern yoga), in the most generic sense, incorporates a sequence of postures (asanas), breathing techniques (pranayamas), and mental exercises (meditation) (32) in order to achieve mental equanimity (33) and self awareness (8). Practitioners claim that yoga allows them to free their minds, and thereby, enables them to focus solely on a specific object of contemplation (8,34). For example, when entering an asana (i.e., a posture), the mind should focus not on the movement, but rather on the stretch of the muscle and the rise and fall of the chest (34). According to practitioners, such focus should result in complete understanding of oneself (8).

Hatha yoga, i.e., the yoga of physical discipline, is one of the eight branches of yoga (6) and is the most widely practiced form of yoga in the United States (5,6). Since the late 1960's (6,7), all branches of eastern yoga, including hatha yoga, have undergone various modifications in the U.S. (6) For instance, eastern hatha yoga uses meditation, asanas, and pranayamas with the intention of purifying the body and mind (7,8). However, since its introduction to western cultures, the focus of hatha yoga has shifted away from long, tedious hours of strenuous routines performed almost daily to compacted exercise routines of complex postures, with limited pranayamas and meditation, geared towards enhancing physical fitness (5,8). Therefore, western-style Hatha yoga has become a tool for physical fitness and health maintenance (6) rather than for spiritual growth and self-realization (5,8).

Although hatha yoga has become a popular form of physical activity in the U.S. (3,4), research has not determined whether it is an acceptable form of exercise to improve HRPF. As previously mentioned, the five components of HRPF have been linked directly to the prevalence of chronic illness (35) and have been shown to be enhanced through conventional forms of exercise, such as running, walking, aerobic dance, and weight training (35). If regular practice of western hatha yoga results in similar HRPF improvements compared to conventional forms of exercise, then it can be considered appropriate for promoting health and physical fitness.

Training Responses to Regular Yoga Practice. Most of the studies on the effect of regular hatha yoga practice on one or more components of HRPF have been performed in India (11-17). As previously mentioned, traditional eastern hatha yoga, consisting of yamas, niyamas, asanas, and pranayamas (9), is typically incorporated into the practitioners daily life. In contrast, more contemporary western hatha yoga is often limited to no longer than a 90-minute routine of asanas and pranayamas practiced a few times per week. Due to the difference in style, caution should be taken when discerning from previous studies whether western hatha yoga has an impact on HRPF. Therefore, in order to determine whether western hatha impacts HRPF eastern studies that have incorporated asanas into the hatha yoga training program will be reviewed. Other studies that investigate pranayamas only are not generalizable to western hatha yoga and thus were excluded from this review. From review of the literature, regular traditional eastern hatha yoga practice has been shown to improve body composition (11,12), cardiovascular endurance (11,13,14), muscular strength (15,16), and flexibility (17).

Muscular Strength. Of the five HRPF components, the impact of regular hatha yoga practice on muscular strength has been one of the most extensively investigated. In particular, isometric hand grip strength (HGS), one of the most commonly used methods for determining muscular strength, has been shown to improve with regular hatha yoga practice (15,16). For example, Madanmohan et al. (15) investigated the effects of hatha yoga training on muscular strength in 27 males, ranging in age from 18 to 21 years. The 12-week training program, which included 30 minutes of hatha yoga 6 days per week, resulted in a 21% increase in isometric HGS. Although a control group was not used, this study confirms that regular hatha yoga practice increases isometric HGS.

Dash and Telles (16) compared isometric HGS after a hatha yoga training program on 37 'normal' adults, 86 children, and 20 patients with rheumatoid arthritis to an equal number of 'normal' adults, children, and patients with rheumatoid arthritis who did not participate in the hatha yoga training. The training period varied according to age or health, i.e., adults trained for 1 month, children trained for 10 days, and the rheumatoid arthritis group trained for 14 days. Comparison of pre- and post-tests showed a significant increase in isometric HGS among all the training groups. The greatest significance was found among the women with rheumatoid arthritis. Most interestingly, the female adult volunteers and female rheumatoid arthritis patients had a 2 and 3 times greater increase in isometric HGS, respectively, than the corresponding males.

Although previous studies (15,16) indicate that regular hatha yoga training increases isometric HGS, caution should be employed when using these results to characterize the impact of western hatha yoga practice on isometric HGS. Each of the studies were limited by one of the following: 1) no control group, and 2) short training period. Furthermore, isometric HGS is considered an indirect measure of muscular strength (18) and is, thus, not a sufficient measure of overall muscular strength. Therefore, future studies should overcome the limitations of the studies reviewed as well as employ other more direct measures of muscular strength.

Cardiorespiratory Endurance and Body Composition. In the 1970's studies showed that when compared to controls, regular hatha yoga training did not improve body composition and muscular endurance (17,36). However, in one study both treatment and control groups performed daily police training (17) and in the other study the control participated in daily athletics (36). Due to the physical regimen of the control groups, these early studies may have underestimated the possible gains associated with regular hatha yoga training. Since the 1980's studies although limited, indicate that regular hatha yoga practice improves cardiovascular endurance. Ganguly (13) studied the effect of an intense hatha yoga training program on cardiovascular endurance in 17 males with the mean age of 37.94 years. One hour of yoga 6 days per week for 3 weeks significantly increased cardiovascular endurance as determined by the Harvard Step test, from a mean of 17 to 69.23. Although there was no control group and the measurement for cardiovascular endurance was indirect, results of this study suggest that even a short hatha yoga training program can have a significant effect on aerobic fitness.

Balasubramanian B and Pansare MS (14) investigated the effects of aerobic power in 17 students, ages 16-18. Each student practiced 1 hour a day, every day for 6 weeks. After 6 weeks of hatha yoga training the students showed a significant increase in aerobic power from pre test, 1.95 $L\,min^{-1}$ to post test, 2.29 $L\,min^{-1}$. Although this study is limited to VO_2max, it supports findings from previous studies indicating regular hatha yoga training can increase cardiorespiratory endurance.

Telles, Nagarathan et al. (12) reported the physiological changes over 12 weeks in 40 male physical education teachers ages 25-48. The males were attending a residential yoga campus, which made the living environment approximately constant. Each physical educator participated in asanas for 1.5 hours a day, pranayamas for 1 hour a day, cleansing practices 2 times a week, meditation for 15 minutes and cyclic meditation for 60 minutes everyday, devotional sessions for 60 minutes, and 2 one hour lectures a day. The males spent a total of 6 hours and 45 minutes on hatha yoga not including the cleansing sessions. After 3 months of this intense hatha yoga training period the results supported some claims to a reduction of body weight from 59.50 kg to 58.60 kg. Interestingly, these coaches had an average of 8.9 years of physical training and hatha yoga still offered significant changes.

The impact of regular yoga training on cardiovascular endurance and body composition have been confirmed by subsequent research (11). For instance, Raju et al. (11) investigated the effects of an intensive yoga-training program on 6 females with a mean age of 25.6 years. The subjects participated in yoga for 90 minutes, two times each day. Four weeks of hatha yoga training resulted in an average increase in maximal workload of 33 $Watts \cdot min^{-1}$ and resulted in, for a given submaximal workload, an average reduction in heart rate and VO_2 of 9.34 bpm and 1.37 $ml \cdot Watt^{-1}$, respectively. Although body weight did not change, lean body mass (LBM) increased by an average of 0.39 kg, fat mass (FM) deceased by an average of 0.38 kg, and percent body fat decreased an average of 2.82%. Clearly, 180 minutes per day of hatha yoga training will improve cardiorespiratory endurance and body composition. However, the feasibility of such a training program seems impractical since the average hatha yoga routine is no more than 90 minutes in duration and is performed only a few days a week.

Although previous studies indicate that regular hatha yoga training improves cardiovascular endurance and body composition several of these findings have impractical durations and intensities not common to western-style hatha yoga. In addition to the impracticality of the sessions most of the studies took place in controlled environments found in India. Therefore, the findings of these studies should be carefully interpreted and not generalized to the West, since it is unlikely that hatha yoga training classes are longer than 90 minutes in duration and usually do not encompass community living quarters to the participants.

Flexibility. Suprisingly, the least investigated HRPF component is flexibility. In an older study by Gharote and Ganguly[17] the effects of hatha yoga training on 49 young males enrolled in a police training school were compared to a control group which was also enrolled and participating in the school. Both groups performed the daily police training workouts, and in addition the treatment group performed hatha yoga training. The treatment group showed a greater mean improvement in, extension flexibility, and left ankle flexibility following a 9-week yoga training program. However, as mentioned before both groups performed intensive police training and could possibly limit the findings of flexibility.

Western Hatha Yoga Studies. Tran et al. (18), performed a recent study in the United States, investigating the effects of regular hatha yoga practice on the HRPF components. The 10 subjects (9 females and 1 male) were volunteers from a local campus community. Ages ranged from 18-27 years. The yoga class consisted of 10 minutes of pranayamas, 15 minutes of warm-up poses, 50 minutes of asanas, and 10 minutes of relaxation which was performed a minimum of 2 days (offered 4 times) a week for 8 weeks. Muscular strength showed a significant increase of 31% in elbow extension, 19% in elbow flexion, and 28% in knee extension. Muscular endurance showed improvement only at knee flexion, 57% change. Flexibility increased 13% in ankle flexibility, 155% in shoulder elevation, 188% in trunk extension, and 14% in trunk flexion. Absolute and relative VO_2 increased by 7 and 6% respectively. However no significant changes in body composition were found. In evaluating current research this study is the only one that incorporates all the HRPF components into one study, however a small sample size and no control limits the generalizability of the study.

Summary of Training Studies. Specifically, 10 days to 1 year of regular eastern hatha yoga training, primarily consisting of pranayamas, asanas, meditation, or a combination of two or more, have been shown to produce, in participants of all ages, significant improvements in cardiorespiratory fitness (11,13,14), body composition (11,12), muscular strength (15,16), and flexibility (17). The one study found on western hatha yoga training has shown improvements in cardiovascular endurance, muscular strength and endurance, and in flexibility, but not in body composition (18). However, studies are warranted to determine whether regular western-style hatha yoga practice offers an adequate training stimulus to significantly impact one or more of the HRPF components. Therefore, results of these eastern studies cannot be generalized to the effects of regular western hatha yoga practice.

Undoubtedly, research agrees that conventional forms of exercise training produce improvements in cardiorespiratory fitness, muscular strength, muscular endurance, and body composition. However, its feasibility and appeal to a wide variety of participants has not been investigated. Anecdotally, its often-times loud music, young female audience, and intense style may not be appealing to both men and women of all age groups and socioeconomic status. Therefore, other alternatives that produce similar HRPF improvements should be explored. For instance, for those wanting an unconventional form of physical activity that is gentler on the joints, that targets both stress reduction and enhancement of physical fitness, and that does not involve loud music or difficult choreography, then hatha yoga might be an appealing alternative to group exercise. However, studies on western-style hatha yoga are warranted to determine whether hatha yoga suitably impacts HRPF.

History of Aerobic Dance. Cardiovascular endurance training includes 20 to 60 minutes of continuous or intermittent activity that employs large muscle groups and is both rhythmical and aerobic in nature (1,27). Traditionally, cardiovascular endurance training was primarily limited to walking, running, swimming, and cycling (37). In an effort to maintain high levels of interest in cardiovascular endurance training, alternatives to these common forms of aerobic activities were developed. In particular, group exercise (2), formerly referred to as dance aerobics, became a popular form of leisure activity enjoyed by individuals of all ages (23). Because it involves continuous, coordinated, and choreographed dance and calisthenic movements performed to music (13,26), aerobic dance became more appealing than conventional forms of exercise to some (26). The direct benefits for group exercise are tremendous, suggesting increases in resting heart rate, and strength of respiratory muscles, and decreases in body composition, just to name a few (38). In the 1980's, ACSM recognized dance aerobics as an effective form of exercise for promoting cardiovascular endurance (39). Many different versions of group exercise (e.g., jazzercise, step aerobics, and kick boxing) (39,40) have since been developed in order to reduce monotony and maintain adherence to exercise (39).

ACSM suggests that a typical aerobic exercise session, consisting of a 10 minute warm up, a 20 to 60 minute endurance phase, and a 5 to 10 minute cool down, should be performed 3 to 5 days per week (27). In addition, a resistance training session should be performed 2 to 3 days per week. Although endurance and resistance training are often performed on separate days, ACSM states that "both activities can be combined into the same workout (27)." Over the years, group exercise has evolved and began to incorporate both endurance and resistance training. A typical group exercise session, lasting 60 minutes, includes a 5 to 10 minute warm-up, a 20 to 30 minute aerobic period, a 20 to 30 minute resistance training period, and a 5 to 10 minute cool down with flexibility training.

Physiological Responses to Group Exercise Training. Research has been conducted to determine the impact of group exercise training on some of the components of health-related physical fitness (HRPF). More specifically, the impact of various forms of group exercise, such as continuous aerobic dance, combined resistance training and aerobic dance, interval and continuous aerobic dance, and step aerobics on cardiorespiratory fitness (19-24), body composition (24), and muscular endurance (25), has been investigated. However, from review of the relevant research, the impact of group exercise on muscular endurance and flexibility has not been investigated.

Although limited and discordant, some research suggests certain components of HRPF will change following 8 to 24 weeks of group exercise training. For instance, Milburn and Butts (23) compared the physiological effects of aerobic dance on 15 college sedentary females to that of jogging on 19 college sedentary females, ranging in age from 18 to 29 years old. Both groups were compared to a bowling/control group (n=12). Both treatment groups exercised for 30 minutes at an intensity of 75% of MHR on 4 days per week for 7 weeks. An 8 to10 minute warm-up preceded all training sessions. For both treatment groups, VO_2max and maximal treadmill running times increased while maximal HR decreased.

In a follow-up study by Garber et al. (20), the physiological effects of aerobic dance training on 22 males and females were compared to that of a walk-jog training on 23 men and women, ranging in age from 24 to 50. Both groups were compared to a control group (n=15). Each treatment group exercised for 50 minutes at an intensity of 60-80% of Heart Rate Reserve on 3 alternate days per week for 8 weeks. For the aerobic dance group and the walk-jog group, body weight did not change; however, peak oxygen uptake (VO_2peak) increased by 10 and 11%, respectively, and peak heart rate decreased by an average of 4 and 3 b min^{-1}, respectively. When compared to walk-jog regimens, results indicate that aerobic dance produces similar improvements in cardiorespiratory fitness, and thus, may be recommended as an alternative to conventional training programs.

In order to determine whether young children will also experience improvements in cardiorespiratory fitness from aerobic dance training, Alpert et al. (19) examined the effect of aerobic dance training on cardiorespiratory fitness, knowledge of health habits, self-esteem, and motor activity in preschoolers (3 to 5 years old). Twenty-four girls and boys were randomly assigned to either the aerobics class (n=12) or the playground freeplay (n=12). The treatment group performed 20 minutes of aerobics at 60 to 80% of MHR (with a 5 minute warm-up and 5-minute cool down period), 5 days per week, for 8 weeks. The treatment group demonstrated lower exercise heart rates post-test for 3 given submaximal workloads. Also, for the treatment group, agility and self-esteem significantly improved, but baseline HR, knowledge of health habits, and motor activity did not change during the 8-week period. Results confirm that dance aerobics does not only benefit adult's cardiorespiratory fitness, but also young children's cardiorespiratory fitness.

Studies that have looked beyond body weight and investigated actual changes in body composition have shed more light on the beneficial effects of aerobics dance. For example, Perry et al. (24) compared the effects of continuous aerobic dance on 21 subjects to the effects of interval aerobic dance on 24 subjects. Both groups were compared to a control group (n=21). Each treatment group exercised for 3 hours per week for 12 weeks at a training intensity of 80 to 85% of maximal heart rate (MHR). The interval aerobic class consisted of a warm up, 7-10 aerobic dance routines, 3 to 5-minutes in duration, and a cool down. Between each routine, brisk walking or jogging was performed for up to 3 minutes. In contrast, the continuous aerobic class consisted of a warm-up, a 30 to 35-minute aerobic dance, and a 10-minute cool down. For both treatment groups, adiposity decreased, anaerobic threshold increased, relative and absolute VO_2max increase, and oxygen pulse ($ml\ bt^{-1}$) increased. However, the improvements were significantly greater in the interval aerobic group than the continuous aerobic group. This study supports that dance aerobics, either performed continuously or intermittently, will improve cardiorespiratory fitness and body composition.

These results have been confirmed and extended by subsequent research(22). Malbut et al. (22) investigated the effects of aerobic dance with resistance training on body weight and cardiorespiratory fitness in 18 men and women, ages 79 to 91. Weekly, each subject attended 3 exercise sessions, consisting of 13 to 15-minute warm-up, 13 to 20-minute aerobic dance, 10-minute warm down, and a10 to 15-minute strength training, flexibility, and relaxation phases. Over the 24-week training period, in the women, there was, on average, a 15% increase in maximal oxygen consumption (VO_2max in $mlO_2 \cdot kg^{-1} min^{-1}$), a 14% decrease in exercise HR at a given workload (i.e., 10 $mlO_2\ kg^{-1} min^{-1}$), and a 13% decrease in resting HR (RHR). In contrast, following the same training period, the men experienced no change in VO_2max and RHR while only achieving a 7% reduction in exercise HR at the given workload. For both men and women, there was no change in body weight, maximal HR, isometric knee extensor strength, isometric elbow flexor strength, and lower limb extensor power.

Kraemer et al. (21) explored the physiological effect of several variations of step aerobics (SA). Thirty-five women were randomly assigned to one of four groups: 1) a 25-min SA (SA25) group, n=8; 2) a 25-min SA, with a multiple set of upper and lower body resistance exercises (SAR), group, n=9; 3) a 40-min SA (SA40) group, n=12; or 4) a control group, n=6. Each treatment group exercised at an intensity of 80-90% of MHR on 3 days per week for 12 weeks. All treatment groups had an increase in peak VO_2 (3.7 to 5.3 $mlO_2\,kg^{-1}\,min^{-1}$), with the SAR group having a significantly greater increase in aerobic capacity than the SA25 group. In addition, all treatment groups had similar decreases in percent body fat (4.7 to 6.1%), pre-exercise HR (9), and post-exercise systolic blood pressure (SBP, 19.2). While the SA25 group had a decrease in post-exercise HR and the SA40 had a decrease in resting DBP, the SAR group had decreases in post-exercise HR, resting diastolic blood pressure (DBP), and post-exercise SBP.

Muscular performance was also investigated in this study by Kraemer et al. (21). All treatment groups showed similar increases in jump squat power at 30 and 60% of 1-RM. The SAR group had a significant increase in 1-RM squat, 1-RM shoulder press, cycle time to exhaustion, shoulder power at 30% of 1-RM, and peak vertical jump power (26%, 17%, 11%, 50%, and 14%, respectively). Results from this study suggest that a minimal amount of SA combined with resistance training results in similar improvements in aerobic fitness when compared to SA of longer duration. In addition, regardless of the duration of aerobics, overall improvements in muscular performance will not be seen unless the aerobics is supplemented with resistance training.

In order to determine whether older individuals would benefit from regular aerobic dance, Shigematsu et al. (25) investigated the effects of aerobic dance on falling rates in older women (72 to 87 years). Twenty women participated in an aerobic dance class for 60 minutes, 3 days per week, for 12 weeks. Over that same period, 18 controls were instructed to carry out their usual activities, but not attend the exercise classes. A typical exercise class consisted of a 10-minute warm up, a 35-minutes dance aerobics phase, and a 10-15 minute cool-down. Post-study tests showed significant improvements in one-leg balance with eyes closed, functional reach, and locomotion around two cones (46%, 10%, and 19%, respectively), but not in muscular strength or motor processing. The results support the findings by Kraemer et al. (21) and that, regardless of age, dance aerobics alone, will not produce substantial gains in muscular strength.

Based on previous research, a typical 8 to 24 week group exercise, consisting of continuous or intermittent aerobic activity, will produce, in participants of all ages, significant improvements in cardiovascular endurance (19-24) and percent body fat (21,24), but not in body weight (20,22), or muscular strength (21,25). More encouraging, group exercise, consisting of both aerobic dance and resistance training, appear to be the most beneficial form of group exercise in promoting overall fitness (21). However, to date, the impact of group exercise on flexibility and muscular endurance has not been investigated.

Undoubtedly, limited research agrees that regular group exercise training produces improvements in cardiorespiratory fitness, muscular strength, muscular endurance, and body composition. However, its feasibility and appeal to a wide variety of participants has not been investigated. Anecdotally, its often-times complex choreographaphy, loud music, young female audience, and intense style may not be appealing to both men and women of all age groups and socioeconomic status. Therefore, other alternatives that produce similar HRPF improvements should be explored. For instance, for those wanting an unconventional form of physical activity that is gentler on the joints, that targets both stress reduction and enhancement of physical fitness, and that does not involve loud music or difficult choreography, then hatha yoga might be an appealing alternative to group exercise. However, studies on western hatha yoga are warranted to determine whether hatha yoga suitably impacts HRPF.

APPENDIX C

INFORMED CONSENTS

Statement of Informed Consent

You are invited to participate in a study investigating the effects of Hatha yoga compared to aerobic dance on various health-related physical fitness components. In other words, we are trying to determine whether Hatha yoga is a significant form of exercise as compared to aerobic dance. I am a graduate student and a graduate teaching assistant at Texas State University-San Marcos, in the Health, Physical Education, and Recreation Department. I am performing this study to fulfill my master's thesis requirement. I hope to learn that Hatha yoga and aerobic dance show no significant difference, therefore proving that Hatha yoga is an acceptable form of exercise. You have volunteered as a possible participant in this study because your class was chosen to be an experimental class to test ways to make the class more beneficial as well as more effective in meeting your health, fitness, and wellness goals. You will be one of 90 students chosen to participate in this study.

If you decide to participate, you will be given: a) submaximal or maximal cardiorespiratory test; b) a battery of health and fitness tests (3-site sum of skinfold, push-up test, curl-up test, upper body muscular strength and endurance tests, and flexibility test (sit and reach), and c) regular class activities.

There are minimal risks to healthy individuals participating in exercise testing and during group exercise training. It is important to be aware that the potential risks associated with exercise include muscle soreness, temporary breathlessness, and minimal bouts of fatigue. The effort required during this study is very similar to the physical efforts required of an individual during any other physical fitness and wellness class at Texas State University-San Marcos. The investigators are experienced and have conducted numerous group exercise classes and exercise tests. In addition, emergency equipment is located nearby in the athletic training offices and is available at all times.

Any information that is obtained in connection with this study and that can be identified with you will remain confidential and will be disclosed only with your permission.

If you have any questions, please feel free to ask me now. If you any additional questions later, feel free to contact me, (512) 245-1973, or the chair of my thesis, Dr. Lisa Lloyd, (512) 245-8358, and we will be happy to answer them.

You will be offered a copy of this form to keep.

Your decision whether or not to participate in this study will not prejudice your future relations with Texas State University-San Marcos or with me. If you decide to participate, you are free to discontinue participation at any time without prejudice (i.e., your grade will not be affected if you decide to withdraw from this study).

Your signature indicates that you have read the information provided above and have decided to participate.

I have read this form, and I understand the test procedures, risks, discomforts, and benefits of the study that I am about to participate in. Knowing these risks and discomforts, and having had an opportunity to ask questions that have been answered to my satisfaction, I consent to participate in this study.

__________________________________ ________________

Signature of Participant Date

__________________________________ ________________

Signature of Witness Date

__________________________________ ________________

Signature of Investigator Date

Texas State University-San Marcos HPERD Informed Consent for Comprehensive Fitness Testing

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1. **Purpose and Explanation of the Test**

   You will perform a maximal exercise test on a motor-driven treadmill to determine your aerobic fitness level. You will also: 1) perform several muscular strength and endurance tests (curl-ups, push-ups, 1-repetition max bench and squat test); 2) perform a flexibility test (sit-and-reach) and 3) have your body composition assessed. For the aerobic fitness test, the exercise intensity will begin at a low level and will be advanced in stages depending on your fitness level. We may stop the test at any time because of signs of fatigue or development of unusual symptoms. It is important for you to realize that **you may stop when you wish because of feelings of fatigue or any other discomfort.**

2. **Purpose and Explanation of the Classes**

   Your class has been selected to be part of a study to determine if Hatha yoga is an acceptable form of exercise, as compared to aerobics. If you are enrolled in Hatha yoga, your class will consist of a 10 minute warm up, 30 minutes of asanas, 5 minutes of inverted or balance poses, and 5 minutes of relaxation. If you are enrolled in aerobics, your class will consist of a 10-15 minute warm up, 30 minutes of aerobic dance routines, including, but not limited to step, floor, kickboxing, and resistoball work, 5 minutes of cool down, and 5 minutes of light stretching. The subjects will spend designated days fulfilling the tests above, class time will be allotted for most of the tests, however the maximal test must be performed on designated times and days.

3. **Attendant Risks and Discomforts**

There exists the possibility of certain changes occurring during the fitness tests. These include abnormal blood pressure, fainting, irregular, fast or slow heart rhythm, musculoskeletal injury, and in rare instances, heart attack, stroke or death. Every effort will be made to minimize these risks by evaluation of preliminary information relating to your health and fitness and by careful observations during testing. Emergency equipment and trained personnel are available to deal with unusual situations that may arise.

4. **Responsibilities of the Participant**

Information you possess about your health status or previous experiences of heart-related symptoms (such as shortness of breath with low-level activity, pain, pressure, tightness, heaviness in the chest, neck, jaw, back and/or arms) with physical effort may affect the safety of your exercise test. Your prompt reporting of these and any other unusual feelings with effort during the exercise test itself is of great importance. **You are responsible for fully disclosing your medical history**, as well as symptoms that may occur during the test. You are also expected to report all medications (including non-prescription) taken recently and, in particular, those taken today, to the testing staff.

5. **Benefits to be Expected**

The results obtained from the exercise test may be used to classify your level of fitness, develop an optimal exercise program, and/or monitor your progress in an already established training program. Results can also be used to determine whether you are at risk for a chronic disease, such as cardiovascular disease, diabetes type II, and/or osteoporosis.

6. **Inquiries**

Any questions about the procedures used in the exercise test or the results of your test are encouraged. If you have any concerns or questions, please ask us for further explanations.

7. **Use of Medical Records**

The information that is obtained during exercise testing will be treated as privileged and confidential. It is not to be released or revealed to any person except Dr. Lloyd (Director of the Human Performance Lab) without your written consent.

8. **Freedom of Consent**

I hereby consent to voluntarily engage in an exercise test to determine my exercise capacity and state of cardiovascular health. My permission to perform this exercise test is given voluntarily. **I understand that I am free to stop the test at any point, if I so desire.**

I have read this form, and I understand the test procedures, risks, discomforts, and benefits of the test that I am about to perform. Knowing these risks and discomforts, and having had an opportunity to ask questions that have been answered to my satisfaction, I consent to participate in this test.

_______________ ______________________________________

Date Signature of Participant

_______________ ______________________________________

Date Signature of Witness

_______________ ______________________________________

Date Signature of Test Administrator

APPENDIX D

RAW DATA

Subjec t	Waist to Hip Ratio1	Waist to Hip Ratio2	% Body Fat1	%Body Fat2
1	0.719577	0.730871	21.091	20.74436
2	0.746114	0.718593	29.7663	26.62919
3	0.787402	0.785714	19.79708	18.76349
4	0.646226	0.666667	23.69095	24.06775
5	0.822055	0.819512	28.31111	28.83121
6	0.717808	0.722689	22.73566	22.23901
7	0.736264	0.755618	17.84783	16.06622
8	0.7009859	0.726761	19.67798	21.03927
9	0.739583	0.746032	24.98926	23.14026
10	0.726368	0.73	28.72288	29.01877
11	0.758242	0.818697	24.01937	26.94734
12	0.746032	0.770492	22.97691	22.67637
13	0.673367	0.651515	24.60828	25.0313
14	0.769231	0.745358	25.77289	24.85147
15	0.678392	0.690537	21.71811	18.99857
16	0.80292	0.8	29.55665	29.55665
17	0.721925	0.730345	18.48828	19.87399
18	0.690608	0.702247	20.13851	17.36402
19	0.694737	0.707124	23.57365	22.07266
20	0.820809	0.848837	22.96849	22.50396
21	0.7075	0.706329	30.41316	32.36398
22	0.723577	0.735849	21.00699	22.33923
23	0.732997	0.752577	19.10956	18.70567
24	0.726804	0.715736	19.62578	20.30864

25	0.690909	0.761394	27.24156	29.32153
26	0.772222	0.763736	22.91401	24.52863
27	0.724138	0.732759	15.703	17.57512
28	0.71475	0.704787	21.11004	22.33468
29	0.713896	0.70442	20.26286	21.44616
30	0.756522	0.716418	39.44957	36.80853
31	0.759434	0.766667	27.6963	25.85409
32	0.732673	0.736453	29.97561	30.16767
33	0.734104	0.731638	18.70957	18.99857
34	0.870558	0.891753	22.16154	20.71003
35	0.73494	0.771784	45.45239	42.93438
36	0.738579	0.740933	29.30412	28.88619
37	0.717391	0.734463	24.83066	25.43637
38	0.708333	0.758721	13.02394	16.65527
39	0.751351	0.752688	22.27195	24.50561
40	0.833333	0.777778	33.50874	30.76858
41	0.7075	0.688442	33.44017	31.01087
42	0.646789	0.642512	22.69615	22.39951
43	0.739583	0.734043	26.82092	25.57468
44	0.695531	0.677778	18.30319	17.30771
45	0.677249	0.681941	19.56377	17.36402
46	0.733509	0.746114	25.57468	27.80181
47	0.759894	0.739362	22.97691	25.12112

48	unable	unable	43.43423	44.23202
49	0.743316	0.756303	20.94139	16.95561
50	0.720548	0.713896	19.06043	19.57808
51	0.758242	0.754098	18.83316	18.31335
52	0.734375	0.713178	19.92625	22.78267
53	0.726496	0.733138	14.91839	14.37188

Subject	**Gender (M=1 F=0)**	**Age**	**Age2**	**VO2 max (ml/kg/min)**	**VO2 max2 (ml/kg/min)**
1	0	18	18	27.8	26.7
2	0	19	19	37.6	38.6
3	0	19	19	36.1	38
4	0	20	20	25.5	31.3
5	0	20	20	34.4	32.8
6	0	23	23	17.9	35.9
7	0	24	24	30.6	31.4
8	0	18	28	40	35.2
9	0	19	19	31.9	34.9
10	0	21	21	23.1	25.6
11	0	46	46	28.4	30.3
12	0	19	19	31	33.1
13	0	18	18	43.6	42.6
14	0	21	21	32.3	30.4
15	0	20	20	38	43.1

16	0	18	18	32.2	29.8
17	0	23	23	29	34.5
18	0	19	19	34	34.9
19	0	22	23	31.6	31.2
20	0	18	18	31.3	28.9
21	0	19	20	34	30
22	0	18	18	ASTHMA	ASTHMA
23	0	19	19	39.8	33.8
24	0	19	19	38.6	39.9
25	0	19	20	33	38.2
26	0	18	18	35.5	33.2
[redacted]					
27	0	21	21	38.2	41.3
28	0	21	21	35.7	40.6
29	0	21	21	26.6	30.1
30	0	19	19	24.8	25.8
31	0	19	19	23.3	23.9
32	0	20	20	30.4	32.6
33	0	20	20	41.6	33.1
34	0	20	20	41.7	41.5
35	0	21	21	24.1	22.5
36	0	22	22	25.5	28.8
37	0	19	19	UNABLE	UNABLE
38	0	19	19	26.3	34
39	0	20	21	25.2	35.1
40	0	19	19	31	23.8

41	0	22	22	29.8	23.5
42	0	25	26	31.8	36.6
43	0	22	22	32.2	30
44	0	20	20	34.4	33.8
45	0	18	19	ASTHMA	ASTHMA
46	0	22	23	43.8	41.5
47	0	19	19	33.3	UNABLE
48	0	25	25	25.8	24.7
49	0	21	21	42.9	40.6
50	0	21	21	35.6	38.9
51	0	22	23	31.8	34.5
52	0	22	22	44.6	41.4
53	0	20	20	36.4	35.2

Subject	**VO2 max (l/min)**	**VO2 max2 (l/min)**	**MAX**	**MAX2**	**1 Rep Bench**	**1 Rep Bench2**
1	1.71	1.64	Y	N	70	75
2	2.25	2.32	Y	Y	75	
3	2.23	2.32	N	N	65	
4	1.71	2.09	Y	Y	70	70
5	2.44	2.04	N	Y		
6	0.96	1.93	Y	Y		

7	1.79	1.8	Y	N	75	70
8	2.13	1.88	Y	N	65	
9	1.87	1.98	Y	N	45	couldn't lift bar
10	1.52	1.7	N	N		65
11	1.59	1.77	Y	Y	65	70
12	1.66	1.71	Y	Y		55
13	2.63	2.63	Y	Y	75	85
14	2.14	1.89	N	N	75	65
15	2.78	3.09	N	N	70	70
16	2.4	2.29	N	Y	95	100
17	1.48	1.77	Y	Y	65	
18	1.75	1.76	Y	N		65
19	1.86	1.83	N	N		70
20	1.7	1.54	Y	N	70	
21	2.19	1.95	Y	N		70
22	ASTHMA	ASTHMA	ASTHMA	ASTHMA	45	
23	2.33	2.15	N	N	100	100
24	2.63	2.72	Y	Y		85
25	1.88	2.27	N	N	65	70
26	1.9	1.8	Y	Y		
[redacted]						
27	1.81	1.95	N	N		65
28	1.96	11.6	Y	Y		
29	1.45	1.64	Y	Y	85	
30	2.35	2.4	N	N	70	70
31	1.66	1.66	N	N	50	55

32	2.16	2.34	N	N		70
33	2.16	1.74	Y	N		55
34	2.93	2.91	Y	N	95	
35	2.32	2.2	Y	N	70	80
36	1.51	1.72	N	N	60	60
37	UNABLE	UNABLE	UNABLE	UNABLE		UBABLE
38	1.32	1.95	N	Y	60	60
39	1.38	1.91	N	Y		60
40	2.15	1.57	N	N	85	
41	1.83	1.52	N	N	55	55
42	2.15	2.38	Y	N		60
43	2.08	1.91	N	N	50	55
44	1.85	1.83	Y	N		
45	ASTHMA	ASTHMA	ASTHMA	ASTHMA	70	
46	2.77	2.66	Y	N	75	85
47	2	UNABLE	Y	UNABLE	85	
48	3.51	3.38	N	N		180
49	2.52	2.28	Y	Y	85	85
50	1.92	2.14	Y	N	85	80
51	1.73	1.91	Y	Y	65	65
52	2.68	2.5	Y	N	80	90
53	1.75	1.68	N	Y	50	

Subject	Est of 1-RM	Est of 1-RM2	Curl ups	Curl ups2	Push ups	Push ups2
1			11	17	5	8
2		78.5	15	12	10	9
3		70	24	42	17	19
4			25	26	2	9
5	73.5	79	54	55	5	5
6	47	52.5	26	41	3	4
7			25	30	9	15
8		70	29	21	20	15
9		UBABLE	21	27	0	0
10	58		16	17	2	23
11			30	75	13	12
12	52.5		0	6	10	2
13			65	30	19	17
14			26	29	10	12
15			36	59	17	14
16			31	27	4	8
17		70	5	0	17	15
18	64.5		25	29	15	21
19	59		39	27	8	12
20		68.5	0	0	18	12
21	68.5		43	49	12	14
22		60	16	20	0	0
23			43	45	31	18
24	89.5		100	71	14	17

25			20	23	10	10
26	54	54	14	22	0	1
27	70		0	8	26	38
28	58	61	24	0	5	12
29		84	16	15	17	20
30			2	17	0	0
31			24	26	0	0
32	70		35	28	0	3
33	74		34	37	6	6
34		100	7	75	12	8
35			4	8	2	8
36			18	39	0	1
37	48	UBABLE	21	22	5	UNABLE
38			0	7	7	8
39	55.5		10	14	9	16
40		58	24	26	0	3
41			21	22	0	1
42	54		19	23	0	3
43			0	0	3	5
44	52.5	55.5	31	41	8	5
45		73.5	18	29	16	14
46			36	34	22	24
47		91.5	23	17	20	14

48	184		0	0	5	12
49			35	36	28	26
50			44	43	15	19
51			0	0	8	10
52			3	0	20	19
53		52.5	38	50	8	9

Subject	**Flexibility1**	**Flexibility2**	**1 rep Squat**	**1 rep Squat2**	**ESTIMATE**
1	10.75	12.5	BAD KNEE	BAD KNEE	BAD KNEE
2	16	16.25	135	145	
3	11.75	11.5		135	131.5
4	13.75	13.25	BAD KNEE	BAD KNEE	BAD KNEE
5	12.75	12	95	105	
6	7.5	7.5	60	75	
7	12.75	14.5	105	135	
8	13.75	14	135	140	
9	9.75	11	85	85	
10	8.75	9.5		105	94.5
11	12	11.25	70	90	
12	10.75	12	95	115	
13	13.25	14.5	155	160	
14	13.5	15.25	115	125	
15	13.5	14	135	135	
16	14.25	13.5		155	152.5

17	8.25	9.75		145	116
18	13.75	14		165	113
19	13.25	13.25		130	123.5
20	10.75	12.75	155	165	
21	14.5	13.5	115	130	
22	6.5	5	95	100	
23	15.25	15.5	BAD KNEE	BAD KNEE	BAD KNEE
24	14.75	15.75		155	134.5
25	15	15	135	165	
26	10.5	11.5	80	95	
[redacted]					
27	10.75	12		115	109
28	13.5	16			116
29	8.25	8.75	160	165	
30	15	16.75	BAD KNEE	BAD KNEE	BAD KNEE
31	14.75	15.5		90	50
32	11.25	11.75		85	80.5
33	14.75	14.5	100	105	
34	15.5	16	155	165	
35	9.5	12.5	105	125	
36	9.25	10.75	BAD FOOT	BAD FOOT	BAD FOOT
37	13	14.75	75	80	
38	17.5	17.5	95	125	
39	9.75	11	115	110	
40	11	13.25	85		
41	7.5	10.5	90	115	

42	11.75	12.75		115	102
43	14.5	14.75	110	105	
44	15.25	16.5	140	125	
45	12	13	115	125	
46	16	16.5	125	140	
47	12.5	11.75	BAD KNEE	BAD KNEE	BAD KNEE
48	10.5	11.25	340	345	
49	13.5	12.75	165	175	
50	12.75	14.25		165	194.5
51	14	13.75	125	135	
52	16	17	145	170	
53	13.75	13.75	100	105	

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VITA

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After graduating I continued on. During the past two years of my graduate studies, I became a certified health and fitness instructor with the American College of Sports Medicine (ACSM), a graduate assistant, a research assistant, as well as a professional. I have joined and presented at professional organizations, and have had a recent publication.

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