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Yoga and the Effects on Balance, Hamstring Flexibility, and Blood Pressure

Shannon Lee Sorenson
University of North Dakota

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YOGA AND THE EFFECTS ON BALANCE,
HAMSTRING FLEXIBILITY,
AND BLOOD PRESSURE

by

Shannon Lee Sorenson
Bachelor of Science in Physical Therapy
University of North Dakota, 2000

An Independent Study

Submitted to the Graduate Faculty of the

Department of Physical Therapy

School of Medicine

University of North Dakota

in partial fulfillment of the requirements

for the degree of

Master of Physical Therapy

Grand Forks, North Dakota

May
2001



This Independent Study, submitted by Shannon Sorenson in partial fulfillment of the requirements for the Degree of Master of Physical Therapy from the University of North Dakota, has been read by the Faculty Preceptor, Advisor, and Chairperson of Physical Therapy under whom the work has been done and is hereby approved.

Cindy Flom-Meland
(Faculty Preceptor)

Renee Malen
(Graduate School Advisor)

Thomas Mon
(Chairperson, Physical Therapy)

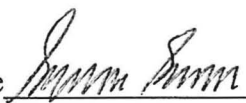
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Title The Effects of Yoga on Balance, Hamstring Flexibility, and Blood Pressure.

Department Physical Therapy

Degree Master of Physical Therapy

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TABLE OF CONTENTS

LIST OF FIGURES.....	vi
LIST OF TABLES.....	ix
ACKNOWLEDGEMENTS.....	x
ABSTRACT.....	xi
CHAPTER	
I INTRODUCTION.....	1
II LITERATURE REVIEW.....	4
Introduction.....	4
Yoga.....	4
Balance.....	9
Blood Pressure.....	11
Flexibility.....	12
Conclusion.....	14
III METHODS.....	15
Subjects.....	15
Pilot Study.....	16
Instrumentation/Assessment Procedures.....	17
Training Procedures.....	22
Data Analysis.....	23
Reporting Results.....	23

IV	RESULTS.....	24
V	DISCUSSION.....	27
	Limitations.....	29
	Recommendations.....	31
VI	CONCLUSION.....	33
APPENDICES		
A	Institutional Review Board Form/Participation Agreement.....	35
B	Consent Forms.....	45
C	Instructional Procedures.....	50
D	Yoga Pictures and Descriptions of Asanas.....	54
	REFERENCES.....	68

LIST OF FIGURES

Figure	Page
1. NBM [®]	18
2. Functional Reach 1.....	19
3. Functional Reach 2.....	19
4. Sit and Reach.....	21
5. Force Plate.....	51
6. Deep Breathing 1.....	55
7. Deep Breathing 2.....	55
8. SSA 1.....	56
9. SSA 2.....	56
10. SSA 3.....	56
11. SSA 4.....	56
12. SSA 5.....	56
13. SSA 6.....	56
14. SSA 7.....	57
15. SSA 8.....	57
16. SSA 9.....	57
17. Reed 1.....	57
18. Reed 2.....	57

19. Tree 1.....	58
20. Tree 2.....	58
21. Dancer 1.....	59
22. Dancer 2.....	59
23. Chair 1.....	60
24. Chair 2.....	60
25. Chair 3.....	60
26. Warrior 1.....	61
27. Warrior 2.....	61
28. Triangle 1.....	62
29. Triangle 2.....	62
30. Hiker 1.....	63
31. Hiker 2.....	63
32. Staff Pose.....	63
33. IWS 1.....	64
34. IWS 2.....	64
35. Bridge 1.....	65
36. Bridge 2.....	65
37. Child's 1.....	65
38. Child's 2.....	65
39. RAT 1.....	66
40. RAT 2.....	66
41. Corpse 1.....	67

42. Corpse 2.....	67
43. Corpse 3.....	67

LIST OF TABLES

Table	Page
1. Descriptive Statistics for the Yoga Group ^Y and Walking Group ^W	25
2. Paired Samples t-test Results Before and After Training for the Yoga Group.....	26
3. Paired Samples t-test Results Before and After Training for the Walking Group.....	26
4. Wilcoxon Results Before and After Training for the Yoga Group.....	26
5. Wilcoxon Results Before and After Training for the Walking Group.....	26

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ABSTRACT

Yoga is an ancient form of exercise and meditation that has recently gained popularity in the United States. Medical research regarding the benefits of yoga, however, continues to be in demand. The purpose of this study was to determine the effects of yoga on normal, healthy individuals. The focus of this study revolved around balance, hamstring flexibility, and blood pressure changes after six weeks of yoga training.

Eighteen normal, healthy individuals between 20-33 years of age participated in this study. Subjects were assessed using the NeuroCom[®] Balance Master test for rhythmic weight shift (RWS), the Functional Reach Test (FRT), the measure of blood pressure (BP), the Sit-and-Reach Test (SRT), and the Single-Limb Stance Timed Test (SLST). The yoga group performed a random combination of 14 asanas and one pranayama in a six-week yoga-training program that met for 45 minutes, three times per week. The walking group (control group) walked below their target heart rates and performed basic hamstring stretching three times per week for six weeks.

Paired samples t-tests indicated significance for diastolic blood pressure (Sig. .04) and on-axis velocity RWS anterior-posterior (Sig. .048) for the yoga group and for SLST on the left with eyes closed (Sig. .005) for the walking group. Wilcoxon tests indicated significance for the yoga group in the SRT (Sig. .003) and SLST on the right with eyes open (Sig. .003) and eyes closed (Sig. .021). These findings provide evidence that the practice of yoga is beneficial in improving physical well-being.

CHAPTER I

INTRODUCTION

With a history of nearly five thousand years, yoga is one of the world's most ancient traditions. However, Americans have only become familiar with it in the last century. In a culture focused on body image, it is no surprise that yoga rapidly gained popularity as a method of exercise. Since yoga's emergence in the United States, it has been used by healthy individuals for health maintenance and meditation. More recently, health care professionals have integrated yoga into their treatment plans for various mental and physical dysfunctions. It has also been used by athletes and others to strengthen the body and the mind as well as to prevent injuries.

Problem Statement

Yoga is emerging as a supplemental therapy for patients with diagnoses ranging from carpal tunnel syndrome, arthritis, stroke, and high blood pressure. However, few statistical studies have been conducted to support the efficacy of yoga therapy.

Purpose

The purpose of this study was to determine the effects of yoga on normal, healthy individuals. The main focus revolved around balance, hamstring flexibility, and blood pressure (BP) changes after six weeks of yoga training.

Research Questions

In order to reach the purpose of this study, the researchers attempted to answer the following questions:

1. Is there a statistically significant difference between the balance results obtained before and after a six-week yoga-training program for normal, healthy individuals?
2. Is there a statistically significant difference between the hamstring flexibility results obtained before and after a six-week yoga-training program for normal, healthy individual?
3. Is there a statistically significant difference between the blood pressure results obtained before and after a six-week yoga-training program for normal, healthy individuals?
4. Does a six-week non-strenuous walking program present with the same results for balance, hamstring flexibility, and blood pressure as a six-week yoga-training program?

Hypothesis

It is hypothesized that a six-week yoga program will produce significant results regarding balance and hamstring flexibility in normal, healthy individuals. The researchers expect to see slight changes in blood pressure, because the population consists of individuals without blood pressure abnormalities. Additionally, it is expected that the group receiving yoga training will have more significant changes in balance, hamstring flexibility, and blood pressure when compared to a walking group.

Significance

The results of this study, if significant, will provide physical therapists and other healthcare professionals with a viable alternative in treating patients with various deficits. Studies that prove physical therapy interventions to be effective are essential in the delivery of safe and effective therapy, as well as reimbursement. The data collected along with the literature review will provide beneficial information concerning yoga therapy as a treatment technique.

CHAPTER II

LITERATURE REVIEW

Introduction

Yoga has been the subject of many studies due to the increasing popularity of alternative therapies. According to Micozzi,¹ 80 percent of people living in the United States have used at least one form of alternative medicine once in their lives. Yoga is among the many different types of alternative medicine. Due to the lack of supporting research for the alternative therapies, the western cultures have been hesitant to accept the beliefs into the main stream. The modern form of yoga was first introduced into this country in Chicago in 1893.² Yoga has since been very popular and practiced regularly.

Yoga

Developed 5,000 years ago by an ancient Hindu culture, yoga has endured many years and cultural changes and is still seen by many as a philosophy of living.³ Yoga, meaning to “yoke“ or to join the mind, body, and spirit, addresses the timeless questions of life, reality, and self. According to Taylor³ a certified yoga therapist, yoga is a science of self that is open-ended and pleasurable. The goal many yoga practitioners try to attain is to keep oneself physically, spiritually, and mentally healthy.⁴

There are seven different styles of yoga, including Raja, Bhakti, Jana, Mantra, Laya, Karma, and Hatha yoga.⁵ The main style practiced in western cultures is Hatha yoga. The word Hatha is derived from Sanskrit,⁵ "Ha" meaning sun and "tha" meaning

moon; translated to mean bringing opposites together and balancing different aspects of the mind, body, and spirit. Hatha yoga incorporates asanas (postures) and pranayamas (breathing techniques) and is seen as a method of physical culture, a meditation doorway, and a practice that forms the understanding that enlightenment is through the body.³ Hatha yoga has evolved throughout the years into different styles that tend to represent the instructor's (masters) approach. These styles of Hatha yoga have been practiced alone, as in many American facilities, or combined with other styles to gain the maximal effects of yoga practice.

Yogic lifestyles are formed with a combination of asanas, pranayamas, relaxation, healthy diet, and proper thinking.⁶ This way of life is based upon becoming a better person mentally, physically, and spiritually. Fulfillment in these three areas has been sought after for ages, and has been achieved by the individuals that believe in this way of living

Asanas

In the practice of yoga there are over 84,000 postures or asanas. Asanas can be explained as postures held in yogic practice to obtain the physical benefits of yoga.⁴ Taylor³ defines asanas as a "position of dis-equilibrium, deviating the head and trunk from the center of gravity, which are maintained purposefully for a length of time." Asana names are derived from nature and are said to represent the theory of evolution.⁵

There are two aspects of yoga asanas, the dynamic phase and the static or stationary phase.⁴ The dynamic aspects include the movements needed when one assumes a pose or comes back to a normal stance after the pose. These movements

should be performed in slow and steady stages, without pain or tension, and without undue stress placed upon breathing.

The static aspects of asanas are when the "postural pattern" has been assumed and is being maintained in an isometric contraction. The posture should be held in a comfortable, steady, pain free position, with a minimal amount of effort expended by the individual. During this phase the muscles, ligaments, and joint are passively stretched, muscle tone is regulated,³ circulation is improved to the viscera and extremities,⁴ and the joints are compressed or decompressed depending on their position.

Asanas can be assigned to one of three groups: meditative, relaxation, or cultural.⁴ Meditative postures focus mainly on spirituality. The individuals find a focal point or a drishti and concentrate on their breathing to clear their mind for thoughts of prana (mind body connection or energy). Relaxation poses are used to achieve physical and mental relaxation. During these postures the eyes are closed, muscles are relaxed, and minds are quiet. Cultural asanas are used to overcome imbalances in skeletal muscles by holding isometric contractions for extended periods of time.

Pranayama

Pranayama is defined as a state of voluntary regulated breathing. During pranayama the mind is directed to the flow of breath and prana, translated from Sanskrit⁷ to mean universal energy. Prana is thought to be brought into the body through breathing.⁵ Singh V, Wisniewski A, Britton J, et al.⁸ state there are four objectives in pranayama performance: a reduction in breathing frequency, attainment of the 1:2 ratio of inhalation to expiration duration, a period of breath holding at the end of inspiration that lasts twice the length of expiration, and mental concentration on breathing.

Pranayama is a deep breathing technique that is held at the end of inspiration to attain the full effects of the breath. A form of pranayama that is commonly taught is the three-part breath. This technique should be a full inhalation filling the lungs from the bottom up, holding the breath for a count of eight and exhaling in the opposite direction, top down.⁵ Single-nostril breathing is another common yogic breathing technique where the individuals are trained to focus their breath to enter one nostril and exit the other. Visualization techniques, in which the individuals are told to visualize the air as it flows into and out of the body, are common during the practice of pranayama. By concentrating on where the breath is flowing throughout the body the mind is focused and quieted. These practices enhance oxygen circulation by encouraging the use of the total lung capacity and all of the muscle of respiration.

Benefits of Yoga

Many studies exist on yoga and its effects on the body systems. Positive effects have been found in the cardiovascular, musculoskeletal, pulmonary, and neurological systems. A study conducted on 40 high school students found significant improvements in ideal body weight, body density, anaerobic power and cardiovascular endurance.⁹ Duhme and Duhme,¹⁰ in their study, showed that yogic meditation can improve the balance and concentration of people taking Dexamphetamine, an amphetamine, when compared to a control group. Athletes that practice pranayama have been shown to achieve higher work rates and reduce oxygen consumption per unit work, without increased blood lactate levels when compared to athletes that did not practice pranayama.

The effects of yoga have been studied in conjunction with many ailments. Yoga is claimed to have a positive effect on individuals with various conditions such as multiple

sclerosis (MS), carpal tunnel syndrome, asthma, mental retardation, and arthritis. A randomized trial of individuals with carpal tunnel syndrome was shown to have significant increases in grip strength and decreases in pain using 11 yoga postures for eight weeks.¹¹ Asthmatic individuals have also found relief using forms of pranayama.⁸

The practice of yoga has shown positive changes in individuals with MS. This practice allows the individuals to maintain their core body temperature without overheating, while getting the exercise that their body needs to maintain function.⁶ After nine months of yogic practice mentally retarded children demonstrated improvements in psychomotor coordination, general mental ability, intelligence, and social behavior.¹²

Because of yoga's emphasis on gentle movements, stretching and relaxation training, it is very effective for individuals with arthritis. These movements prevent deformity and increase muscle strength, two things that are very valuable to these individuals.

It is a mystery to some how yoga has such a dramatic impact on the body. Yoga focuses on the linkage of the mind, body, and spirit; this way of thought is common in many eastern cultures. Western cultures have had a difficult time with accepting the concept that the mind, body, and spirit are physiologically linked. Studies have shown that the limbic system is involved in regulating the homeostatic mechanisms through endocrine secretions, and parts of the central nervous system (CNS) have been shown to regulate behavior. When an individual encounters stress, this can upset these systems and, in turn, upset the body's homeostasis. Yoga meditation may condition the CNS to maintain homeostasis during such times of stress.¹³

During times of physical and emotional stress, the sympathetic nervous system (SNS) is dominant in most individuals. The SNS creates a rise in blood pressure and heart rate, changes in the respiratory and gastro-intestinal systems, and endocrine disturbances.⁶ Practices such as yoga and meditation diminish the sympathetic dominance and maintain an increase in the balance between the sympathetic and parasympathetic systems to establish and help to maintain equilibrium.

Balance

Balance is a vital component to performing activities in the efficient and independent performance of activities of daily living (ADL). Balance is maintained by keeping the individuals center of gravity (COG) over his base of support (BOS). The central nervous system (CNS) controls balance by receiving data from the sensory systems. These sensory systems include the visual, somatosensory (proprioceptive), and the vestibular systems.^{14,15} After receiving the data, the CNS interprets and integrates the information. This information is then used by the musculoskeletal system to make the appropriate modifications to maintain balance. Sensory organization must also occur in the CNS, by deciding what information is correct when it is presented with conflicting reports from one or more systems.

The CNS usually relies on several systems in the body, but is most efficient if it can use only one balance system at a time. The visual system gives information on changes in the environment and is the system most commonly relied on in healthy individuals.

This system is most helpful in supplying information regarding the position and motion of the head in relation to surrounding objects. Although the visual system is used a majority of the time in most individuals, it is not always accurate, especially when the body is in motion.

The somatosensory system is the preferred method of maintaining balance. This system provides information regarding the position and motion of various parts of the body in regards to the body as a whole.^{14,15} Joint and muscle proprioceptors in addition to other pressure receptors in the body, send information to the CNS in reference to their positions.

The vestibular system is used the least amount out of the three^{14,15}; it provides information regarding the position and movement of the head in relation to gravity. This system is only active in a situation that would cause disruption of the other systems, such as obstructed vision, the BOS being moved, or displacement of the COG. During these situations the visual and somatosensory systems are relaying incorrect information to the CNS, and it must rely on the vestibular system.

Balance can be broken into two categories, static and dynamic balance. Static balance is determined by the ability to maintain the COG over a fixed BOS on a firm surface.^{14,16} A popular way to determine static balance is the unilateral stance test. Dynamic balance is the ability to maintain the COG within a moving, unstable BOS. Tests are also available to determine dynamic balance. The most accurate of these tests use force plate technology like the Neurocom[®] Balance Master (NBM[®]).

Poor balance can lead to many disruptions in a person's life. Balance strategies tend to diminish with age and lead to an increased incidence of falls. Up to two-thirds of

the accidental deaths in people over the age of 75 are caused by falls.¹⁷ This may be due in part to the deterioration of all three of the balance systems as an individual ages.¹⁸

Exercise training can have an effect on balance, due to the increases in muscle mass and the proprioceptive input through the joints. Messier, Royer, Craven, et al.¹⁹ have shown significant balance improvements in the unilateral stance test for older adults with osteoarthritis after an aerobic and weight training program, when compared to a health education group. It is also reported that those elderly individuals who participate in a physical and/or sporting activity have the best balance control when compared to those who have not participated and those who used to participate in these activities.²⁰ Another study shows that dynamic stability significantly improved in older women who participated in a 12-month regular exercise program when compared to a control group.²¹

Blood Pressure

According Webster's 3rd International Unabridged Dictionary,²² "blood pressure is the pressure exerted by the blood on the walls of the blood vessels varying with the efficiency of the heart, the blood volume and viscosity, the age of the individual, and the state of the vascular wall." Blood pressure is measured by calculating two numbers, systolic and diastolic blood pressures. Systolic blood pressure is the estimate of the work of the heart and the strain exerted against the arterial walls during ventricular contraction.²³ Diastolic blood pressure is an estimate of the peripheral resistance and the ease at which the blood can flow from the arteries into the capillaries.

Normal adult blood pressure ranges from 120-129 mmHg systolic and 80-84 mmHg diastolic.²³ General guidelines to follow for high blood pressure or hypertension are a systolic number >140 mmHg and a diastolic number >90 mmHg. Hypertension is of

great concern to our society, considering that one out of four individuals have abnormally high blood pressure one time in their lives. Hypertension is known to cause coronary heart disease²⁴ and in most cases can be controlled by medications, diet, and exercise.²³

It has been proposed that exercise in general has a positive effect on the heart. Studies state that moderate exercise can produce a higher level of cardiovascular function and even protect against early mortality.^{25,26} Exercise has also been shown to lower blood pressure measurements when the exercise is performed for more than ½ hour, three or more times per week, at an intensity level of 60% of their maximal workload.²⁷ This study also reports that 40% of the subjects receiving antihypertensive drug treatments were able to reduce or discontinue them when engaging in the training program. Aerobic exercise also has the ability to decrease blood pressure, especially if there is no family history of hypertension.²⁸

Meditation, similar to what is performed in yoga practice has also been found to have a significant effect on blood pressure. Blackwell, Bloomfield, Gartside et al.²⁹ found a decrease in blood pressure ranging from 8-12 mmHg for systolic and 5-8 mmHg for diastolic after a 12-week individual meditation regimen.

Flexibility

Flexibility is defined by Anderson and Burke³⁰ as, "The range of motion available in a joint or a group of joints that is influenced by muscles, tendons, ligaments and bones." Flexibility is a topic of discussion for most health care professionals including those with a sports related emphasis. Athletes are commonly injured during physical activity and up to 30% of those injuries are stretch induced, creating a disruption in the muscle-tendon unit causing a muscle strain.³¹ The muscles most susceptible to injury

include ones that cross two joints such as the hamstrings, gastrocnemius, and rectus femoris. Claims have been made that increasing flexibility will decrease the incidence of muscle injuries³²⁻⁴⁵ and improve athletic performance.^{33,34,42}

The physiology of stretching is the lengthening of the individual muscle fibers to improve the joint's range of motion. There are three main techniques used to stretch muscles: proprioceptive neuromuscular facilitation (PNF), ballistic, and static stretching. Studies have compared the three techniques measuring hamstring flexibility.^{46,47} PNF stretching uses a combination of static stretching and isometric contractions in a hold relax or contract relax technique. The PNF technique requires the assistance of an experienced therapist. Ballistic stretching is a technique that uses bouncy, jerky movements at the point of resistance to increase the amount of motion at that joint. The medical profession does not accept the use of this technique because it has been shown to be damaging to the muscle.^{33,48} The static stretch is the most widely recognized and effective stretching technique.⁴⁹ It consists of going to the point of resistance and holding that position for a determined length of time. All three techniques have been shown to increase flexibility right after the stretch was applied.^{46,47} The static stretch is by far the most widely use of the three.⁴⁹

A study comparing nonballistic (static), active knee extension in neural slump position and static stretch techniques on hamstring flexibility found that after six weeks of stretching, both techniques improve flexibility, but neither proved statistically more effective than the other.⁵⁰ In another study conducted by Brandy, Irion, and Briggler,⁴⁹ the investigators explained that the amount of stretching time needed to produce

statistically significant results ($p < .05$) in hamstring flexibility during a static stretch, like the one used in yoga practice, was 30 seconds one time per day.

Positive results have been noted when stretching programs are implemented in the workplace. Claims have been made that stretching certain muscle groups that are prone to fatigue could lead to a decrease in muscle strains⁴³ and improve overall physical and mental health.⁴⁴ Moore⁴⁵ found after implementing a stretching program that 60 individuals enrolled in, there were significant increases in flexibility, conditioning, and how they viewed themselves in terms of body attractiveness and personal self worth. In the study he reported that during the two-month trial, zero occurrences of musculoskeletal injuries occurred to the participants, yet no prior data was available to compare to.

Conclusion

Although there are many claims regarding the positive effects that yoga may have on balance and flexibility, few studies have been conducted to support these claims. More studies are available pertaining to yoga and blood pressure, but conclusive research is lacking. Therefore, by exploring the effects of yoga on balance, blood pressure, and hamstring flexibility an increased awareness of the scientific basis for yoga as an alternative form of therapy will be the result.

CHAPTER III

METHODOLOGY

Prior to the start of the study, final approval was obtained from the University of North Dakota Institutional Review Board for the use of human subjects. HealthSouth[®] of Grand Forks, North Dakota also agreed to participate in the study by instructing yoga classes at their facility. Copies of the Institutional Review Board (IRB) form and the HealthSouth[®] Participation Agreement are located in Appendix A. During the recruitment process, the researchers informed the individuals that participation in the study was strictly voluntary. They were also informed that those individuals who decided to participate in the study were free to drop out at any time before the final data had been collected. Components of the study were explained to the individuals, and they were given the opportunity to address questions and concerns prior to deciding to participate. Those participating in the study signed the Information and Consent Form developed by the researchers (Appendix B).

Subjects

To conduct the study, 22 subjects (8 males, 14 females) between the ages of 20-33 years were recruited from within the University of North Dakota School of Medicine and Health Sciences. Subjects were selected for the study if they were within the age range of 20-39 years and met the health criteria. Pregnant women, as well as those with a history of cardiac problems or abnormalities in blood pressure, were excluded from the

study. Those who performed aerobic exercise more than 40 minutes, three times per week were also excluded. The researchers determined that four applicants did not meet the criteria and were unable to participate in the study.

Eighteen subjects (6 males, 12 females) met the study criteria and were randomly placed in one of two groups. Group 1 (N=11) served as the experimental group and participated in a yoga class three times per week for six weeks. Group two (N=7) also served as a control group and participated in a mild walking program three times per week for six weeks. More subjects were able to participate in Group one due to scheduling conflicts, which accounts for the greater number of participants in this group. It should also be noted that two subjects from Group two dropped out during the course of the study due to lack of participation.

The testing process of all subjects took place at the University of North Dakota Physical Therapy Department. Subjects were tested initially at the beginning of the research project and then again six weeks later.

Pilot Study

Following instruction and practice on the Neurocom Balance Master[®] (NBM[®]), a pilot study was conducted to determine intrarater (test-retest) reliability for the single investigator that conducted the NBM[®] test. A population of N=9 ranging in age from 20-60 years old was assessed twice on the on-axis velocity right-left, anterior-posterior, and composite components of the rhythmic weight shift (RWS) test in the same manner as described below in Instrumentation/ Assessment Procedures. The SPSS Version 10.0 was utilized to perform calculations of intrarater reliability.

Intrarater Reliability

A repeated measures analysis of variance (ANOVA) was used to calculate an intraclass correlation coefficient (ICC) to prove test-retest reliability for the single investigator using the NBM[®].

The intrarater reliability was statistically determined for the RWS using the ICC. On-axis velocity ICC values are as follows: left-right of .9031, anterior- posterior of .9351, and composite of .9758. According to Munro and Page, a value of .9-1.00 is interpreted as a very high correlation.⁵¹ Therefore, intrarater reliability was established on the NBM[®] for the preceding components of the RWS test.

Instrumentation/Assessment Procedures

NeuroCom[®] Balance Master (NBM[®])

Founded in 1984 by Lewis M. Nashner⁵², ScD, the NBM[®] has been used by physical therapists and other medical disciplines as an assessment, training, and analysis tool. Reliability has been established for RWS (.88) according to Liston and Brouwer.⁵³ In the same study, the test was compared to the Berg Balance Scale and concurrent validity was also established (p=.025).

The NBM[®] consists of two 9" x 60" forceplates.⁵⁴ During testing, the subject stands on forceplates that measure the force under each foot through load sensors. The computerized system interprets the input from the sensors in a quantitative manner. The NBM[®] provides visual feedback by displaying the subject's center of gravity (COG) on the computer monitor. This allows the subject to modify his/her sway during testing.



Figure: 1 NBM®

The NBM® was used to assess rhythmic weight shift. This assessment was chosen to quantify the subject's ability to move his/her COG from left to right and forward to backward in a rhythmic manner at three degrees per second. The measured parameters are on-axis (intentional) sway velocity and off-axis (extraneous) sway velocity.⁵² This test requires the subject to sway reciprocally between two lines. An on-screen cue in the shape of a stick figure person indicates the direction of sway, anterior-posterior or left-right, of the individual being tested.⁵⁴ The monitor also shows a square moving at three degrees per second between the two lines denoting the end ranges of movement.

The RWS test was consistently conducted last to ensure the same degree of fatigue for every individual. Subjects were also given at least one practice session before the investigator began scoring. The verbal instructions given to each subject prior to the test are found in Appendix C.

Functional Reach Test (FRT)

The Functional Reach Test was selected to measure the subject's margin of stability during voluntary forward maximal reach. Developed and tested by Duncan et al.⁵⁶⁻⁵⁷ the FRT is an effective screening tool for balance problems and is often used by

physical therapists in the clinic. Duncan has established validity and reliability for the FRT. For this reason, the test was chosen as an objective measure of the subject's margin of stability during a routine daily maneuver such as reaching forward.

A 3-inch x 48-inch measurement stick (yardstick) was taped to a wall parallel to the floor to measure the functional reach distance. Each subject stood on a large piece of paper that was taped on the floor next to the wall. The subject's feet were traced to assure that the same base of support (BOS) was used during the re-test period. All subjects performed the test barefoot and with the dominant arm placed nearest the wall. The verbal instructions given to each subject prior to the test are found in Appendix C.

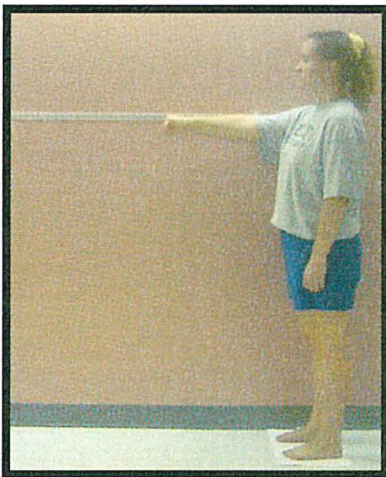


Figure: 2 Functional Reach 1

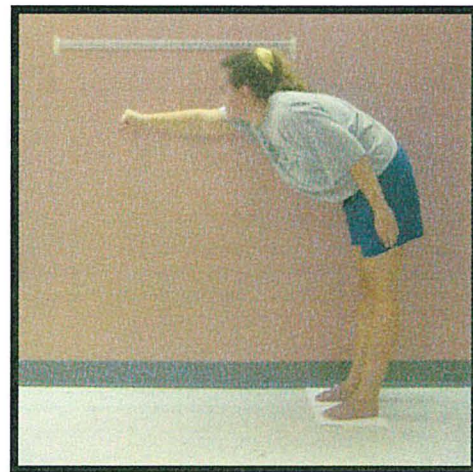


Figure: 3 Functional Reach 2

During the re-test period at the end of the six weeks, the subjects were instructed to stand within the foot tracing that was done at the initial test. The subjects were monitored and instructed to avoid protraction, retraction, and elevation of the scapula at the initial position with the shoulder at 90 degrees. One researcher measured the initial position by using a ruler as a straight edge to align the third metacarpalphalangeal joint with the point on the yardstick. A second researcher recorded the position to the nearest 1/8-inch. The subject was then told to reach forward as far as possible using any strategy

but staying within the restrictions mentioned in the instructions. The end reach was then measured and recorded. Each subject was given two practice trials followed by three recorded trials. The dominant hand was recorded for each subject along with the reach measurements. An average of three trials was recorded for each subject.

Blood Pressure (BP)

A standardized blood pressure machine was used to measure each subject's blood pressure. Prior to the study, Altru Biomedical Resources calibrated the machine. Blood pressure was consistently measured at the beginning of testing, prior to all other tests given, to ensure a resting blood pressure. Each subject was questioned to determine the cause of any abnormalities in blood pressure. The main focus of questioning was in regards to the individual's consumption of caffeine intake that day. Protocol for measuring blood pressure is also included in Appendix C.

Sit and Reach Test (SRT)

The sit and reach test is a common procedure used to evaluate the length of the hamstring muscles.⁵⁸ Hamstring flexibility is important to prevent muscle strains during activity or exercise. Jackson and colleagues^{59,60} compared the standard passive straight leg raise test to the sit and reach test to determine hamstring flexibility. According to their findings, the SRT was found to have moderate criterion-related validity when used to measure hamstring length.^{59,60} Reliability for the sit and reach test has been determined (>.84) by the Texas Governor's Commission on Physical Fitness.⁶¹ With validity and reliability determined, this test is a valuable measure of hamstring flexibility.

The sit and reach device consists of a 19 5/8" x 12 6/8" wood box along with a 26 6/8" ruler that bisects the box. This device was placed against a wall to maintain stability

during testing. Each subject was seated on the floor with his/her knees extended, ankles in neutral dorsiflexion, and plantar surfaces of the feet placed against the front of the box. All subjects performed the test with shoes off. The verbal instructions given to each subject prior to the test are found in Appendix C.

The researcher visually determined the position of the tip of the third phalanx of the top hand to the nearest 1/8-inch. Each subject did three trials of the test, and an average was established.

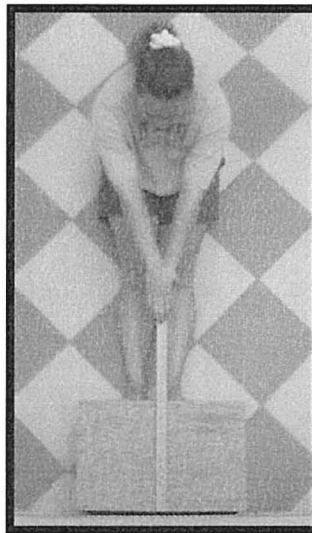


Figure: 4 Sit and Reach

Single Limb Stance Timed Test (SLST)

The SLST is used commonly to assess static balance.⁶² This test can be administered with eyes open (EO) and eyes closed (EC) to elicit different central nervous system (CNS) sensory systems. The visual system is stimulated with the EO portion of this test. During the EC portion of the test, the visual system is inhibited and the subject must rely on the somatosensory and vestibular systems alone.⁶³ According to Rikli & Busch,⁶⁴ reliability for the SLST has been established (.85 -.95).

Subjects performed both the EO and the EC portions of the SLST by balancing on one leg keeping their hands on their hips. For both, the subjects completed three timed trials using a stopwatch. A mean was established to determine his or her scores.

This test was consistently performed prior to the testing on the NBM[®] to ensure similar fatigue levels between subjects. The verbal instructions given to each subject prior to the test are found in Appendix C.

Training Procedures

Yoga Training

The yoga group participated in a six-week yoga-training program that met for 45 minutes three times per week. Each 45-minute yoga session consisted of the group performing a random combination of the same 14 asanas and one pranayama.⁶⁵ They are as follows: Deep Breathing, Sun Salutation A, Reed Pose, Tree Pose, Dancer Pose, Chair Pose, Warrior Pose, Triangle Pose, Hiker Pose, Staff Pose, Intense West Stretch, Bridge, Childs Pose, Revolved Abdominal Twist, and the Corpse Pose. Pictures along with a description and indications of each of the asanas are included in Appendix D.

The yoga sessions were led twice a week by a combination of 4 yoga instructors at HealthSouth[®] in Grand Forks, North Dakota. The third session each week was led by one of the three researchers in the laboratory classroom at the physical therapy department at the University of North Dakota School of Medicine. All sessions were held in the evenings.

The Walking Group

The walking group participated in an individual walking and hamstring-stretching program and was instructed to walk three times per week progressing from 30 to 40

minutes in the first week. The written instructions given to each subject for the walking and stretching procedures are found in Appendix C.

Data Analysis

The statistical analysis was performed using SPSS Version 10.0 using an alpha level of .05 for all statistical tests. Descriptive statistics for pre and post testing were run, thereby establishing means, standard deviations, skewness, kurtosis, and ranges. Scores between the pre and post-test assessments were then calculated. Paired Samples t-tests and Wilcoxon tests were run for the two groups to identify any significant improvements between the pre and post-tests. The Paired Samples t-tests were used for all of the tests with a normal distribution. The Wilcoxon Related Sample test was used to report results if any skewness was present among the tests. The independent variables tested were pre-test and post-test times, with the dependent variable being the subjects' scores for each test.

Reporting of Results

Upon completion of this study, a copy of this independent study was given to HealthSouth[®] and the University of North Dakota Department of Physical Therapy. This study was completed in partial fulfillment of the requirements for the University of North Dakota School of Health Sciences Program of Physical Therapy.

CHAPTER IV

RESULTS

Subject Profile

Eighteen subjects participated in this study. Individuals ranged in age from 20-33 years and were considered to be normal and healthy for all purposes in this study. Two training groups were established consisting of a yoga group (N=11) and a walking group (N=7). However, during the study, two of the individuals from the walking group were dropped from the study due to lack of participation. This resulted in five participants in the walking group (N=5).

Descriptive Statistics

Descriptive statistics including mean and standard deviation were calculated for the data gathered during the pre and post assessments for the two groups. See Table 1 for the yoga and walking results.

Analytical Statistics

Analytical statistics were used to answer the research questions and to determine if there is a significant difference between assessments. Paired Samples t-tests were run to analyze data that was determined to have a normal distribution, using an alpha level of .05. These results are shown in Table 2 and Table 3. Table 2 demonstrates significance for diastolic blood pressure (Sig. .04 and $M_{diff}=7.45$) and on-axis velocity RWS anterior-posterior (A-P) (Sig. .048 and $M_{diff} = -.45$) for the yoga group. Table 3 identifies significance only in SLST on the left with EC (Sig. .005 and $M_{diff} = -9.45$) for the

walking group. Wilcoxon tests were run to interpret the data from both groups that did not meet the criteria for a normal distribution, using a significance level of .05. Results of these statistics are shown in Table 4 and Table 5. Table 5 illustrates significance for the yoga group in the sit and reach test (Sig. .003 and $M_{diff} = -2.94$), SLST with EO on the right (Sig. .043 and $M_{diff} = 2.02$), and SLST with EC on the right (Sig. .021 and $M_{diff} = -2.31$). Table 5 shows no significance for any of the tests in the walking group.

In answer to the research questions, there was significance in each of the three variables of balance, hamstring flexibility, and blood pressure after a six-week yoga-training program. A six-week non-strenuous walking program, in comparison to the yoga-training program, did not show the same results in each of the three variables.

Table 1. Descriptive Statistics for the Yoga Group^Y and Walking Group^W

Variable	N ^Y	Mean ^Y	SD ^Y	N ^W	Mean ^W	SD ^W
Sit and reach test 1*	11	17.88	2.57	5	13.85	4.46
Sit and reach test 2*	11	20.04	1.82	5	14.92	4.20
Functional reach test 1	11	17.36	3.50	5	15.62	3.29
Functional reach test 2	11	16.58	1.91	5	16.467	3.49
Systolic blood pressure test 1*	11	127.73	6.48	5	122.80	12.56
Systolic blood pressure test 2*	11	122.83	10.18	5	112.20	12.99
Diastolic blood pressure test 1+	11	73.45	10.05	5	68.40	11.26
Diastolic blood pressure test 2+	11	66.00	8.09	5	60.20	7.09
SLST right EO test 1*+	11	85.03	43.33	5	95.76	24.76
SLST right EO test 2*+	11	117.45	8.44	5	107.40	28.17
SLST right EC test 1*+	11	16.60	19.58	5	18.91	10.95
SLST right EC test 2*+	11	36.40	33.28	5	27.02	6.26
SLST left EO test 1*+	11	96.08	36.44	5	96.93	33.15
SLST left EO test 2*+	11	118.23	5.88	5	108.40	25.94
SLST left EC test 1*	11	21.70	16.95	5	15.91	7.08
SLST left EC test 2*	11	27.40	21.72	5	25.37	7.52
On-axis velocity RWS L-R test 1	11	7.10	.59	5	6.40	.39
On-axis velocity RWS L-R test 2	11	6.96	.78	5	6.20	.51
On-axis velocity RWS A-P test 1	11	3.68	.68	5	4.12	.54
On-axis velocity RWS A-P test 2	11	4.14	.67	5	3.88	.86
On-axis velocity RWS C test 1	11	5.40	.48	5	5.26	.42
On-axis velocity RWS C test 2	11	5.55	.60	5	5.06	.66

* Not a normal distribution yoga

+ Not a normal distribution walking

Table 2. Paired Samples t-test Results Before and After Training for the Yoga Group

Variable	Mean	SD	t	df	Sig. (two-tail)
Functional reach test 1-2	.7756	3.3060	.778	10	.455
Diastolic blood pressure test 1-2	7.4545	10.4534	2.365	10	.040*
On-axis velocity RWS L-R test 1-2	.1455	.7090	.680	10	.512
On-axis velocity RWS A-P test 1-2	-.4545	.6684	-2.256	10	.048*
On-axis velocity RWS C test 1-2	-.1545	.5574	-.920	10	.379

* Significant at alpha level of .05

Table 3. Paired Samples t-test Results Before and After Training for the Walking Group

Variable	Mean	SD	t	df	Sig. (two-tailed)
Sit and reach test 1-2	-1.0640	2.4739	-.962	4	.391
Functional reach test 1-2	-.8400	1.0546	-1.781	4	.150
Systolic blood pressure 1-2	10.6000	13.8852	1.707	4	.163
SLST left EC test 1-2	-9.4560	3.6844	-5.739	4	.005*
On-axis velocity RWS L-R test 1-2	.2000	.3000	1.491	4	.210
On-axis velocity RWS A-P test 1-2	.2400	.3782	1.419	4	.229
On-axis velocity RWS C test 1-2	.2000	.2550	1.754	4	.154

* Significance at alpha level of .05

Table 4. Wilcoxon Results Before and After Training for the Yoga Group

Variable	z	Asymp. Sig. (two-tailed)
Sit and reach test 1-2	-2.936	.003*
Systolic blood pressure test 1-2	-1.825	.068
SLST right EO test 1-2	-2.023	.043*
SLST right EC test 1-2	-2.312	.021*
SLST left EO test 1-2	-1.826	.068
SLST left EC test 1-2	-1.423	.155

* Significant at alpha level of .05

Table 5. Wilcoxon Results Before and After Training for the Walking Group

Variable	z	Asymp. Sig. (two-tailed)
Systolic blood pressure test 1-2	-1.355	.176
SLST right EO test 1-2	-1.069	.285
SLST right EC test 1-2	-1.214	.255
SLST left EO test 1-2	-.447	.655

CHAPTER V

DISCUSSION

The medical profession has explored the use of yoga for many years, especially in Eastern nations. Many studies have been conducted on the affects of yoga on different conditions and body systems. Hamstring flexibility and balance are areas that were not often explored in yoga research. More studies have been performed on yoga and blood pressure, but no conclusive evidence has been obtained. This study focused on normal, healthy individuals and found significant improvements in balance, blood pressure, and hamstring flexibility in this specific population of normal, healthy adults.

When conducting this study the researchers attempted to answer four research questions. The answers to these questions varied. The first question answered was “Is there a statistically significant difference between balance results obtained before and after a six-week yoga-training program for normal, healthy individuals?” To answer this question the researchers conducted eight balance tests on each subject. The results show that after comparing the means, three of the balance tests show significance improvements including; RWS A-P, SLST on the right EO and EC. Positive statistical trends in SLST on the left EO and EC were also found. These changes can be attributed to the challenging balance strategies used during the yoga asanas, along with practicing them for a six-week period, to improve balance. Duhme and Duhme⁹ found similar results in their study they concluded that yoga can improve balance and concentration.

The second research question asked; “Is there a statistically significant difference between the hamstring flexibility results obtained before and after a six-week yoga-training program for normal, healthy individuals?” The sit-and-reach test was conducted to assess hamstring flexibility this test demonstrated a statistically significant improvement after the yoga training. In the past it has been reported that yoga asanas contain many stretching activities and may help to increase range of motion.⁶ There is little documented research on if yoga does in fact significantly increase range of motion, or flexibility. A key component to yoga is the static stretch. The asana regimen used by the subjects in this study concentrated on the hamstring muscle group and therefore significant improvements were noted.

The third research questions asked, “Is there a statistically significant difference between the blood pressure results obtained before and after a six-week yoga-training program for normal, healthy individuals?” The results show a significant decline in diastolic blood pressure with a trend towards lower systolic blood pressure measurements. This may be a result of the relaxation aspect of yoga. Blood pressure has been shown to decrease with the practice of yoga and another factor such as meditation, or biofeedback.^{66,29,67} Studies have not been conducted on yoga alone and its affect on blood pressure.

The fourth and last research question asked “Does a six-week non-strenuous walking program present with the same results for balance, flexibility, and blood pressure as a six-week yoga-training program?” The results were not the same for the yoga and walking groups. The walking group showed only significant improvement in the SLST

EC on the left. This result is very random and the researchers are unsure as to why this improvement did occur.

Limitations

This study contains many variables, in creating a research design the researchers attempted to eliminate as many confounding factors as possible. It was, however, not possible to eliminate them all. The limitations that the researchers found in their study include; 1) the auditory distraction in the environment in which the testing took place, 2) the independence of the walking program, 3) the walking group was not given a percentage of their maximum heart rate ($MHR = 220 - \text{age}$) that they were supposed to work at, 4) the small number of participants in the walking group, 5) the high learning curve of the NBM[®], 6) the amount of instructors that taught the yoga classes.

The first limitation of the study was the auditory distractions during testing process. The researchers attempted to keep them at a minimum. The facilities where the researchers performed their research were very cramped and did not allow the subjects to be secluded from these distractions. It has been written that noise can lead to distraction and falls when performing a difficult balance skill.⁶⁸

Three other limitations the researchers felt may have had an impact involved the walking group. The first limitation was the independence of their program and the lack of supervision. The walking program was originally set up to have an investigator or a volunteer leading the sessions, but with conflicting schedules, this was not possible. In an attempt to account for this the investigators led a one time a week session where the subjects walked with the group, this also conflicted with schedules, and the participation was minimal. The second limitation the walking group posed was they were not given a

percentage of their MHR at that they were supposed to walk at. Research shows that exercise benefits are seen when an individual exercises at 70% of their MHR⁶⁹ Finally, the walking program was, deemed independent and the subjects were to keep a diary on the events of their walking and hamstring stretching. The diaries were received from all five participants who completed the final testing. Since the program was independent there was no way of knowing if the group kept accurate records of their walking and stretching routines, therefore, it was difficult to know whether the results from this group were accurate. It was also impossible to monitor if the walkers were walking the same speed or on the same terrain since these sessions were independent.

The other limitation the walking group posed was the small number of participants who successfully completed the program. With an N of five, it is difficult to have accurate statistical data. To have accurate statistical analysis you need at least an N=10 to represent the population and for the best results the N should equal 30.⁵¹ For these reasons the statistical results attained from the walking group are questionable. The walking group's results may have been better or worse if the amount of participants had been greater.

The Neruocom[®] Balance Master posed the fourth limitation, even though the participants had the same practice time and the same exposure to the machine, there is a very high learning curve.⁵⁴ This learning curve can affect the subject's results by making them better every time they participate in the testing. This may account for the significance in the RWS A-P.

The fifth limitation discussed by the researchers was, the many different instructors that led the yoga classes. The yoga classes were taught at HealthSouth[®] by a

combination of three instructors, and at the Physical Therapy Department and University of North Dakota by a combination of three different instructors. Even though the material covered in these classes was similar, the instructors' styles varied. The subjects were also told that if they could not make all three classes held during a week, they could participate in a make up session. During these sessions, the asanas covered were not always the same as the ones required in the regular classes. These inconsistencies may have led to a poor learning environment for the subjects.

Recommendations

In order to achieve the best results during future studies one may want to take into account these suggestions. The research facility in which the testing is taking place should be quiet, with no distractions to allow for better balance and concentration by the subjects. The second recommendation is that in order to have a more effective walking group it is suggested that a larger number of subjects be recruited. The group would then be a better representation of the entire population, and help ensure the results are more valid and reliable. For the walking group it is also suggested that it be mandatory for them to walk together in a group, to eliminate any questions of honesty and to have consistencies in speed and terrain. The fourth recommendation includes having the walking group monitor their heart rate and try and stay around 70% of their MHR. This would improve the validity of the walking group. The fifth recommendation is to eliminate the learning curve on the NBM. The learning curve may be eliminated with numerous practice sessions prior-to each of the testing, so the individual is proficient prior-to both testing periods. This may allow for "true" results, and not just ones attributed to the learning curve. The sixth suggestion would be to eliminate the

inconsistencies in the yoga training by having only one instructor lead all of the yoga classes. This would allow the subjects to concentrate more on the poses instead of concentrating on the different styles of teaching brought forth by the different instructors. In following these recommendations, further studies in this area may have more accurate, successful results. The training program may also be more successful and enjoyable for the subjects.

The sample used for this study was all normal, healthy individuals, but it may be beneficial to see if positive results are found in individuals with balance and flexibility deficits. A population of individuals with cardiac problems or abnormalities in blood pressure would also be interesting to study on the affects of yoga. I believe that in these studies greater significance will be found than in this particular study because they will be starting off with lower scores on the first assessment.

CHAPTER VI

CONCLUSION

Yoga has been practiced for over 5,000 years and in the United States since the 1800s. During yoga's long life many studies have been published on its affects on different ailments. Studies have suggested improvements in different diagnoses such as carpal tunnel, arthritis, MS, stroke, asthma, and mental retardation.^{5,11,12,13} Although there are many published studies on yoga, there are very little on its affects on balance, blood pressure, and hamstring flexibility.

This study sought to find the answer to the question; what are the affects of yoga on balance, blood pressure, and hamstring flexibility in normal, healthy individuals? The 11 individuals who participated in the six-week yoga-training program were assessed prior to and after the six weeks. The assessment was also performed on five individuals in a six-week walking/hamstring-stretching group. The results of this study concluded that yoga does, significantly increase balance and hamstring flexibility, and decreases blood pressure in these individuals. The walking group demonstrated little to no improvements except in one balance test SLST EC on the left. This answered the question of whether or not yoga would have more improvement than a walking/hamstring-stretching program on normal, healthy individuals.

Further research in the area of yoga is needed. In these future studies it would be nice to include non-healthy individuals. This may include elderly individuals with high blood pressure and balance deficits.

Clinical Implications

The results of this study may prove to be helpful because it was conducted on normal, healthy individuals, who have no known problems in these areas. This could mean that in a population with abnormalities in these areas would show marked improvements.

This information may be helpful in many health care settings, including Physical Therapy. The discipline of Physical Therapy provides services for many individuals with different diagnoses, including those with hypertension, balance deficits, and flexibility problems. This study may prove useful in creating an alternative therapy technique for individuals with these deficits. Some physical therapists have already incorporated yoga into their clinics and have been very successful in doing so.⁵

APPENDIX A

EXPEDITED REVIEW REQUESTED UNDER ITEM _____ 3 (NUMBER[S]) OF HHS REGULATIONS
 EXEMPT REVIEW REQUESTED UNDER ITEM _____ (NUMBER[S]) OF HHS REGULATIONS

UNIVERSITY OF NORTH DAKOTA HUMAN SUBJECTS REVIEW FORM
FOR NEW PROJECTS OR PROCEDURAL REVISIONS TO APPROVED
PROJECTS INVOLVING HUMAN SUBJECTS

Please include ALL information and check ALL blanks that apply.

PRINCIPAL

INVESTIGATOR: Cindy Flom-Meland, Shannon Sorenson, TELEPHONE: 777- DAT:
OR: Katie Rood, Kendra Van Valkenburg NE: 2831 E: 2/23/00

ADDRESS TO WHICH NOTICE OF APPROVAL
SHOULD BE SENT:

Cindy Flom-Meland, Box 9037 PT

SCHOOL/COLLEGE:

Medicine
(E.g., A&S, Medicine, EHD, etc.)
(Month/Day/Year)

DEPARTMENT: Physical Therapy

PROPOSED

PROJECT DATES: 3/20/00-12/15/00

PROJECT

TITLE: Yoga and the Effects on Balance, Hamstring Flexibility, and Blood Pressure

FUNDING AGENCIES (IF APPLICABLE):

TYPE OF PROJECT (Check ALL that apply):

NEW PROJECT CONTINUATION RENEWAL DISSERTATION OR THESIS RESEARCH STUDENT RESEARCH PROJECT

CHANGE IN PROCEDURE FOR A PREVIOUSLY APPROVED PROJECT

DISSERTATION/THESIS ADVISER, OR STUDENT ADVISER:

Cindy Flom-Meland

PROPOSED PROJECT:

INVOLVES NEW DRUGS (IND)

INVOLVES NON-APPROVED USE OF DRUG

INVOLVES A COOPERATING INSTITUTION

IF ANY OF YOUR SUBJECTS FALL IN ANY OF THE FOLLOWING CLASSIFICATION, PLEASE INDICATE THE CLASSIFICATION(S):

<input type="checkbox"/> MINORS (<18 YEARS)	<input type="checkbox"/> PREGNANT WOMEN	<input type="checkbox"/> MENTALLY DISABLED	<input type="checkbox"/> FETUSES	<input type="checkbox"/>
<input type="checkbox"/> PRISONERS	<input type="checkbox"/> ABORTUSES	<input checked="" type="checkbox"/> UND STUDENTS (>18 YEARS)		

IF YOUR PROJECT INVOLVES ANY HUMAN TISSUE, BODY FLUIDS, PATHOLOGICAL SPECIMENS, DONATED ORGANS, FETAL MATERIAL, OR PLACENTAL MATERIALS, CHECK HERE _____

IF YOUR PROJECT HAS BEEN WILL BE SUBMITTED TO ANOTHER INSTITUTIONAL REVIEW BOARD(S), PLEASE LIST NAME OF BOARD(S): _____

Status: _____	Submitted; _____	Approved; _____	Pending _____
	Date	Date	ng

1. ABSTRACT: (LIMIT TO 200 WORDS OR LESS AND INCLUDE JUSTIFICATION OR NECESSITY FOR USING HUMAN SUBJECTS.)

Yoga has been found to have a significant reduction in stress levels and may have a positive effect on balance and flexibility. This study will investigate what influences yoga can have on balance, hamstring flexibility, and blood pressure.

A total of 20-30 subjects that are 20-39 years of age are required for this study. All subjects will initially complete a balance test utilizing the Balance Master and the standardized Sit and Reach test for hamstring flexibility. Blood pressures will also be taken. Subjects will randomly be assigned to a yoga exercise group or a walking group. The exercise groups will participate for 45 minutes three times/week for six weeks. At the end of six weeks, the initial testing will be repeated.

The investigators expect to find improvements in balance, hamstring flexibility, and blood pressure. The most significant improvements are anticipated to be among the subjects participating in the yoga group.

PLEASE NOTE: Only information pertinent to your request to utilize human subjects in your project or activity should be included on this form. Where appropriate attach sections from your proposal (if seeking outside funding).

2. PROTOCOL:(Describe procedures to which humans will be subjected. Use additional pages if necessary. Attach any surveys, tests, questionnaires, interview questions, examples of

interview questions (if qualitative research), etc., the subjects will be asked to complete.)

Recruitment: The investigators will recruit subjects from the population of the University of North Dakota by speaking with various classes on campus. A total of 20-30 subjects are required for this study.

Selection: Subjects will meet the study requirements if they are 20-39 years of age. Subjects will be excluded if they have a history of cardiac problems, abnormalities in their blood pressure, or if they are currently pregnant. Those who perform aerobic exercise more than 40 minutes, three times per week will also be excluded.

Procedures: All subjects will initially complete a balance test utilizing the Balance Master and a standardized sit and reach test for hamstring flexibility. Blood pressures will also be taken. Subjects will be randomly assigned to a yoga exercise group or a walking group. The yoga group will participate 2x/week in a 45-minute yoga exercise class taught by a yoga instructor along with a mandatory practice session 1x/week led by an investigator for a total of six weeks. The walking group will participate in supervised 45-minute sessions 3x/week for six weeks. At the end of six weeks, both groups will repeat the initial testing. Previously established normative data will be used to compare our results. The yoga classes will take place at Healthsouth and UND PT Department. The testing sessions will be conducted at UND PT Department.

Informed consent: Informed consent will be obtained through an information and consent form (See attached form).

Risk: Yoga is a form of exercise; consequently, there is a risk of personal injury. The investigators believe the risk to be minimal, since yoga is a very gentle form of exercise. All subjects who are currently pregnant or those with a history of cardiac problems or abnormalities in blood pressure will be excluded from our study. Those who performed aerobic exercise more than 40 minutes, three times a week will also be excluded. The yoga instructor and at least one of the investigators will be present at each yoga session. An investigator will supervise all practice sessions. In addition, all subjects will be informed that they may stop the activity at any time. Should a personal injury occur during a yoga session, the individual will be encouraged to receive prompt medical attention. The subject will be responsible for payment of necessary medical interventions.

Compensation: Subjects will receive no compensation for participating in the study.

3. BENEFITS: (Describe the benefits to the individual or society.)

The study is designed to determine the effects that yoga has on balance, hamstring flexibility, and blood pressure. Although the population involved in the study consists of individuals without extreme balance deficits, the investigators feel the results will develop a baseline for future research studying individuals with deficits such as balance problems. Our subjects will have variable hamstring flexibility deficits, which the investigators feel will reflect a normal population.

Minimal research exists relating the effects of yoga on balance, flexibility and blood pressure. The goal of the study is to provide further information and create awareness of yoga as an alternative therapy.

Further benefits for the subjects include relaxation and reduction of stress. Yoga classes are usually of cost to the individuals. However, these classes will be free of charge to our subjects.

4. RISKS:(Describe the risks to the subject and precautions that will be taken to minimize them. The concept of risk goes beyond physical risk and includes risks to the subject's dignity and self-respect, as well as psychological, emotional or behavioral risk. If data are collected which could prove harmful or embarrassing to the subject if associated with him or her, then describe the methods to be used to protect the confidentiality of data obtained, debriefing procedures, storage of data, how long data will be stored (must be a minimum of three years), final disposition of data, etc.)

Yoga is a form of exercise. Consequently, there is a risk of personal injury. The investigators believe the risk to be minimal, since yoga is a very gentle form of exercise. Subjects will be excluded if they are currently pregnant, have a history of cardiac problems, or have abnormalities in blood pressure. Those who perform aerobic exercise more than 40 minutes, three times per week will also be excluded. The yoga instructor and at least one of the investigators will be present at each yoga session. In addition, all subjects will be informed that they may stop the activity at any time.

Should a personal injury occur during a yoga session, the individual will be encouraged to receive prompt medical attention. The subject will be responsible for any necessary medical intervention.

All materials will be held in a locked office at the UND physical therapy department for three years or longer if further research is to be done. At the end of three years, the materials will be destroyed. At no time will subject names be used during the study or to report the results of the study. Obtained information, in association with the study that can identify the subject, will remain confidential, and will be disclosed only with their permission.

5. **CONSENT FORM:** Attach a copy of the **CONSENT FORM** to be signed by the subject (if applicable) and/or any statement to be read to the subject should be attached to this form. If no **CONSENT FORM** is to be used, document the procedures to be used to assure that infringement upon the subject's rights will not occur. Describe where signed consent forms will be kept and for how long (must be a minimum of 3 years), including plans for final disposition or destruction.

All confidential materials from this study are to be retained in Cindy Flom-Meland's office in the UND Physical Therapy Department for three years following completion of this study. After three years, all documents are to be destroyed if they are not needed for a further study. Data collected will be published, but will in no way identify the subjects by name. A copy of the consent forms used will be attached to this form.

6. For **FULL IRB REVIEW** forward a signed original and fifteen (15) copies of this completed form, including fifteen (15) copies of the proposed consent form, questionnaires, examples of interview questions, etc. and any supporting documentation to the address below. An original and 19 copies are required for clinical medical projects. In cases where the proposed work is part of a proposal to a potential funding source, one copy of the completed proposal to the funding agency (agreement/contract if there is no proposal) must be attached to the completed Human Subjects Review Form if the proposal is non-clinical; 7 copies if the proposal is clinical medical. If the proposed work is being conducted for a pharmaceutical company, 7 copies of the company's protocol must be provided.

Office of Research & Program Development
University of North Dakota
Grand Forks, North Dakota 58202-7134

On campus, mail to: Office of Research & Program Development, Box 7134, or drop it off at Room 105 Twamley Hall.

For **EXEMPT** or **EXPEDITED REVIEW** forward a signed original, including a copy of the consent form, questionnaires, examples of interview questions, etc. and any supporting documentation to one of the addresses above. In cases where the proposed work is part of a proposal to a potential funding source, one copy of the completed proposal to the funding agency (agreement/contract if there is no proposal) must be attached to the completed Human Subjects Review Form.

The policies and procedures on Use of Human Subjects of the University of North Dakota apply to all activities involving use of Human Subjects performed by personnel conducting such activities under the auspices of the University. No activities are to be initiated without prior review and approval as prescribed by the University's policies and procedures governing the use of human subjects.

SIGNATURES:

Katie Rood, Kendra Van Valkenburg, Shannon Sorenson 3-2-00
Principal Investigators: Katie Rood, Kendra Van Valkenburg, Shannon Sorenson Date

Cindy Flom-Meland 3-2-00
Project Director or Student Adviser: Cindy Flom-Meland Date

Training or Center Grant Director Date

(Revised 2/2000)

STUDENT RESEARCHERS: As of June 4, 1997 (based on the recommendation of UND Legal Counsel) the University of North Dakota IRB is unable to approve your project unless the following "Student Consent to Release of Educational Record" is signed and included with your "Human Subjects Review Form."

STUDENT CONSENT TO RELEASE OF EDUCATIONAL RECORD¹

Pursuant to the Family Educational Rights and Privacy Act of 1974, I hereby consent to the Institutional Review Board's access to those portions of my educational record which involve research that I wish to conduct under the Board's auspices. I understand that the Board may need to review my study data based on a question from a participant or under a random audit. The study to which this release pertains is The Effects of Yoga on Balance, Hamstring Flexibility, and Blood Pressure

I understand that such information concerning my educational record will not be released except on the condition that the Institutional Review Board will not permit any other party to have access to such information without my written consent. I also understand that this policy will be explained to those persons requesting any educational information and that this release will be kept with the study documentation.

3-2-00
Date

Katie Rood, Kendra Van Valkenburg, Shannon Sorenson
Signature of Student Researchers
Katie Rood,
Kendra Van Valkenburg, Shannon Sorenson

HEALTHSOUTH.

February 22, 1999

This letter is to confirm that Healthsouth and its instructors will be involved in a study with the UND Physical Therapy School.

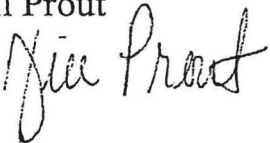
The study will be on improvements in balance from participating in yoga.

Sincerely,

Jill Bisson, Healthsouth Fitness Director



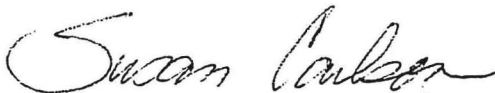
Jill Prout



Shannon Ysteboe



Susan Carlson



REPORT OF ACTION: EXEMPT/EXPEDITED REVIEW
University of North Dakota Institutional Review Board

Date: March 21, 2000

Project Number: IRB-200003-178

Name: Cindy Flom-Meland, Shannon Sorenson, Katie Rood, Kendra Van Valkenburg

Department/College: Physical Therapy

Project Title: Yoga and the Effects on Balance, Hamstring Flexibility, and Blood Pressure

The above referenced project was reviewed by a designated member for the University's Institutional Review Board on 3-22-00 and the following action was taken:

Project approved. EXPEDITED REVIEW Category No. 7
Next scheduled review is on: 3-22-01

Project approved. EXEMPT REVIEW Category No. _____
No periodic review scheduled unless so stated in the Remarks Section.

Project approved PENDING receipt of corrections/additions. These corrections/additions should be submitted to ORPD for review and approval. **This study may NOT be started UNTIL final IRB approval has been received.** (See Remarks Section for further information.)

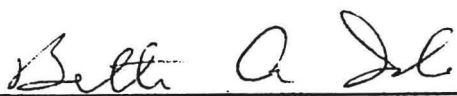
Project approval deferred. **This study may not be started until final IRB approval has been received.** (See Remarks Section for further information.)

Project denied. (See Remarks Section for further information.)

REMARKS: Any changes in protocol or adverse occurrences in the course of the research project must be reported immediately to the IRB Chairperson or ORPD.

PLEASE NOTE: Requested revisions for student proposals **MUST** include adviser's signature.

cc: Cindy Flom-Meland, Adviser
Chair, Physical Therapy
Dean, School of Medicine



Signature of Designated IRB Member
UND's Institutional Review Board

3-22-00
Date

If the proposed project (clinical medical) is to be part of a research activity funded by a Federal Agency, a special assurance statement or a completed 310 Form may be required. Contact ORPD to obtain the required documents.

APPENDIX B

Information and Consent Form

Title: The Effects of Yoga on Balance, Hamstring Flexibility, and Blood Pressure

You are being invited to participate in a study conducted by Katie Rood, Kendra Van Valkenburg, and Shannon Sorenson, students in the masters of physical therapy program at the University of North Dakota. The purpose of this study is to determine the effects of yoga on balance, hamstring flexibility, and blood pressure. The balance testing will be performed on The Balance Master, a machine objectively measuring changes in balance. The hamstring flexibility will be measured, using a standardized sit and reach test.

Participants will be selected and assigned to one of two groups randomly (yoga or walking). Only subjects 20-39 years of age with no history of cardiac problems or abnormalities in blood pressure and those who are not currently pregnant will be asked to participate in the study. All those who exercise more than 40 minutes, three times per week will also be excluded.

You will be asked to participate in an initial testing period located in the Physical Therapy Department on the campus of UND. We anticipate this testing to take 30 minutes. The testing will consist of a "practice session" on the Balance Master to familiarize you with the machine. Then you will perform the balance tests on the Balance Master. Next, a sit and reach test for hamstring flexibility will be performed and blood pressure will be checked. For the testing we recommend wearing loose fitting clothing.

Your participation in this study will require you to attend Yoga classes at Healthsouth twice a week along with a mandatory practice session that will be held on campus once a week for a total of six weeks. At least one of the evaluators will be present at all sessions. Alternative times are available if you cannot make these sessions. If you are selected for the walking group, you will be participating in a one hour supervised walking session three times a week as opposed to the yoga classes. After the six week period you will be asked to participate in one more testing session at the Physical Therapy Department using the Balance Master and the sit and reach test to evaluate your progress. Blood pressure will also be taken at this time.

We (the evaluators) realize that the time commitment is great. However, we expect to find significant improvement in balance, flexibility, and blood pressure with yoga training and believe the commitment is well worth your time as well as ours.

The results of this study will be confidential, and a number known only by the investigators will identify the data. The results of this study will be published, but will in no way identify you as a subject. The results will be stored for three years after the study has ended, unless they are required for continuing studies. Whether or not you participate in this study will in no way reflect on your relationship with the physical therapy department, the University of North Dakota, or Healthsouth.

The investigators involved will be available to answer any questions or concerns you may have about this study. You may contact the investigators by calling Shannon at 701-777-9867, Katie at 701-746-6933, Kendra at 701-772-0025, and Cindy 701-777-4130. A copy of this consent form is available to all participants in this study.

As with any exercise there are risks of injury. If you decide to participate, you are free to discontinue at any time until the data collection is completed. In the event that this research activity (conducted at UND and Healthsouth) results in physical injury, medical treatment will be available, including the following: first aid, emergency treatment and follow-up care as it is customary to members of the general public in similar circumstances. You and/or your third party payer must provide the cost of treatment.

ALL OF MY QUESTIONS HAVE BEEN ANSWERED AND I AM ENCOURAGED TO ASK ANY QUESTIONS THAT I MAY HAVE OF THIS STUDY IN THE FUTURE. MY SIGNATURE INDICATES THAT I HAVE READ THE ABOVE INFORMATION, AND I HAVE DECIDED TO PARTICIPATE IN THE RESEARCH PROJECT.

Participants signature

Date

Investigators signature

Date

FITNESS CENTER

AGREEMENT AND RELEASE OF LIABILITY

1. In consideration of gaining membership or being allowed to participate in the activities and programs of HealthSouth Fitness Center and to use its facilities, equipment, and machinery in addition to this payment of any fee or charge, I do hereby waive, release and forever discharge HealthSouth Fitness Center and its officers, agents, employees, representatives, executors, and all others from any and all responsibilities or liability for injuries or damages resulting from my participation in any activities or my use of equipment or machinery in the above mentioned facilities or arising out of my participation in any activities at this facility. I do also hereby release all of those mentioned and any others acting upon their behalf from any responsibility or liability for any injury or damage to myself, including those caused by the negligent act or omission of any of those mentioned or others acting on their behalf or in any way arising out of or connected with my participation in any activities of HealthSouth Fitness Center or the use of any equipment at HealthSouth Fitness Center. **(Please initial _____)**

2. I understand and am aware that strength, flexibility, and aerobic exercise, including the use of the equipment, is a potentially hazardous activity. I also understand that fitness activities involve a risk of injury and even death and that I am voluntarily participating in these activities and using equipment and machinery with knowledge of the dangers involved. I hereby agree to expressly assume and accept any and all risks of injury or death. **(Please initial _____)**

3. I do hereby further declare myself to be physically sound and suffering from no condition, impairment, disease, infirmity, or other illness that would prevent my participation in any of the activities and programs of HealthSouth Fitness Center or use of equipment or machinery except as hereinafter stated. I do hereby acknowledge that I have been informed of the need for a physician's approval for my participation in an exercise/fitness activity or in the use of exercise equipment and machinery. I also acknowledge that it has been recommended that I have a yearly or more frequent physical examination and consultation with my physician as to physical activity, exercise, and use of exercise and training equipment so that I might have recommendations concerning these fitness activities and equipment use. I acknowledge that I have either had a physical examination and have been given my physician's permission to participate, or that I have decided to participate in activity and/or use of equipment and machinery without the approval of my physician and do hereby assume all responsibility for my participation and activities, and utilization of equipment and machinery in my activities. **(Please initial _____)**

Name (please print): _____

Address: _____
Street Apt #

City State Zip

Signature: _____ Date: _____

Parent signature if under age 18: _____

2 Forms of ID: _____
Driver License # and other; SS# or ID#
Confirm Address

APPENDIX C

NBM[®] Verbal Instructions

1. Remove your shoes and socks.
2. Step onto the forceplate, and I will line you up properly.

*Subjects feet were aligned on the forceplate with the medial malleolus aligned with the wide blue line, and the lateral calcaneus was aligned with the "M" or "T" line according to NBM[®] guidelines regarding the subject's height.

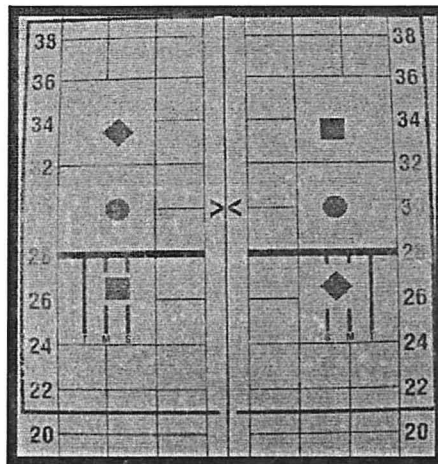


Figure: 4 Force plate

3. Shift your weight back and forth (side to side) to make your cursor follow the blue square.
4. Try to move the same speed that the square moves.
5. Try to move as straight and as smoothly as you can.
6. Change directions at the lines just like the square does.
7. I can score whenever you are ready. Just say “ready”, and I will begin scoring.

Functional Reach Test Verbal Instructions

1. Stand with feet apart in a comfortable stance.
2. Make a fist with your dominant hand and bring your shoulder to 90 degrees of forward flexion.
3. Reach forward as far as you can, keeping your heels on the floor and your knees straight. Do not twist at the waist.

Blood Pressure Procedure

1. Have the subject sit in a chair with their right arm resting on a table at the level of their heart.
2. Place the blood pressure cuff on their right arm with the arrow on the cuff pointing to the brachial artery.
3. Push the start button and wait for the reading.

Sit and Reach Test Verbal Instructions

1. Overlap your hands with your middle fingers aligned evenly.
2. Reach forward as far as you can by sliding your hands on the ruler surface, maintaining knee extension and your feet in contact with the box at all times.
3. You will perform a total of three repetitions. The first two will be practice, and you will hold the third repetition until I tell you to relax.

Single Limb Stance Test Verbal Instructions

1. Remove your shoes and socks.
2. Stand with you hands on your hips at all times.
3. Bend your right/left knee to 90 degrees and hold it there throughout the testing.

4. Keep your knees separated and do not let them come in contact with one another.
5. a. EO: I will start timing when you say “ready”.
b. EC: I will start timing when you close your eyes.
6. I will stop the test if your foot comes in contact with the floor, if you open your eyes, if you take your hands off your hips, or at the end of two minutes, denoting the end of the test.

Written Instructions for the Walking group

- You will be walking three times per week for a total of six weeks.
- The first week, walk 30 minutes the first time, 35 minutes the second time, and then 40 minutes throughout the duration of the remaining five weeks.
- Do not exercise in your walking program above your maximal heart rate (MHR). ($MHR = 220 - \text{age}$)
- You should be able to perform the “talk test” throughout the duration of your walk.
- Perform a standing hamstring stretch five times before and after walking, holding for 20 seconds each.
- Keep a journal of when you walked, including the date, how long, and that you did/did not perform the hamstring stretches before and after walking.
- You must report your recordings to one of the investigators weekly.
- The subjects were all instructed on the proper techniques for conducting the “talk test”, monitoring heart rate, and hamstring stretching.

APPENDIX D

Description of Yoga Asanas

Deep Breathing

Deep breathing is a technique that helps to increase the circulation of blood flow, increase lung expansion, relax the mind and nervous system, and prepare the muscles for activity.⁶⁵ Subjects performed this technique six times at the beginning of each yoga session. This breathing technique is performed by placing the feet together and interlocking the fingers. Place the fingers under the chin while keeping the elbows as close together as possible. With the chin and knuckles in contact with one another throughout the exercise, inhale slowly through the nose while lifting the arms to the side and bringing the head back for a count of six. Then, bring the head back to neutral as the lungs fully expand, and a new cycle is initiated.



Figure 6: Deep Breathing 1



Figure 7: Deep Breathing 2

Sun Salutation A

Sun Salutation A (SSA) is an asana that assists with overall toning of the body.⁶⁵ This asana was done three times during each training session. The following steps are followed while performing this pose: 1. Inhale and bring the arms overhead with the palms together. Tighten the quadriceps while looking upward and making sure to avoid

arching the back. 2. Exhale. Slowly, try and place the palms flat on the floor while tucking the chin inward to look toward the navel. 3. Inhale while lifting the head up and keeping the tips of the fingers as close to the floor as possible. 4. Walk or jump both feet back and lower the body to the floor into the “push-up” position. 5. Perform the “upward facing dog pose” by starting in the prone position. Then fully straighten the elbows to extend the trunk. Look upward toward the ceiling, avoiding shoulder elevation and sagging the back. 6. Perform the “downward facing dog” by turning the feet under and walking both hands backward until the body is in an inverted “V” position. The palms should be in direct contact with the floor, with the fingers spread apart. 7. Walk the feet forward individually to the hands and look upward on inhalation. This is the same position as number three. 8. Exhale and tuck the head into the knees, assuming the same position as number two. 9. Slowly bring the body back into the fully erect position and begin a new cycle.



Figure 8: SSA 1



Figure 9: SSA 2



Figure 10: SSA 3



Figure 11: SSA 4

Figure 12: SSA 5

Figure 13: SSA 6





Figure 14: SSA 7



Figure 15: SSA 8



Figure 16: SSA 9

Reed Pose

The Reed is beneficial in stretching the upper body, firming and slimming the waistline, and stimulating blood flow to the abdominal organs.⁶⁵ This asana was performed once to each side in every yoga session. To perform the Reed, stand upright with the arms straight overhead and the palms touching one another. Then, exhale keeping the arms straight overhead and bend to the R/L side until resistance is felt, holding for 10 to 20 seconds. Before switching the Reed to the opposite side, slowly return to the starting position.



Figure 17: Reed 1



Figure 18: Reed 2

Tree Pose

The Tree Pose helps to improve concentration, balance, and lower extremity strength.⁶⁵ Subjects demonstrated this technique once on each side during the yoga training program. During this pose, it is important to first find a focal point. This will allow for increased concentration and assist in improving balance. Initiate the Tree Pose by standing with both feet together then shifting weight onto one foot. The plantar surface of the non-weight bearing foot is placed on the medial side of the opposite calf making sure to avoid contact with the knee joint. A more challenging alternative is to place the foot on the medial side of the thigh above the knee joint. The elbows are then straightened and raised overhead with the palms in contact with one another. This position is held for 10 to 20 seconds before the leg is lowered to the ground. The individual is now ready to perform this asana on the opposite extremity.

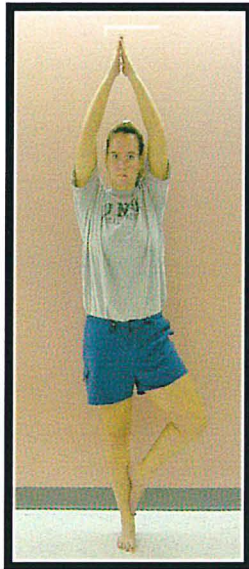


Figure 19: Tree 1

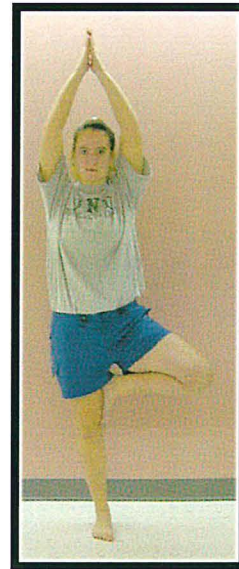


Figure 20: Tree 2

Dancer Pose

The Dancer has been known to be beneficial for increasing balance, flexibility of the quadriceps, and strength of the extremities.⁶⁵ This pose was performed at every session once on each side. Again, it is important to find a focal point to assist with concentration and balance. To perform the dancer, shift all the weight onto the right leg and reach back with the left hand to grab the left ankle. Extend the right arm overhead keeping the elbow straight. Next, separate the knees by leaning forward. This position is held for a 10 to 20 seconds before returning to the neutral position and performing the Dancer on the opposite side.



Figure 21: Dancer 1

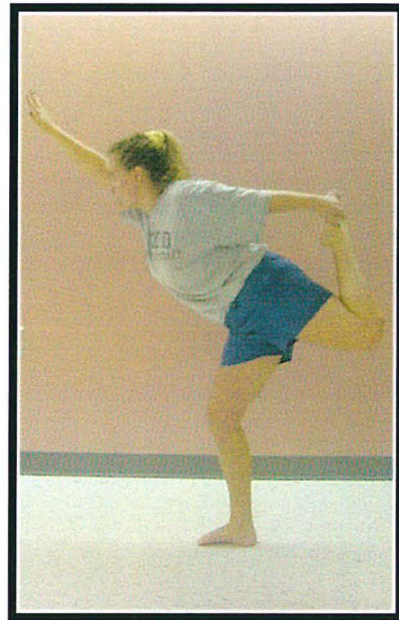


Figure 22: Dancer 2

Chair Pose

The Chair Pose can be used to strengthen the muscles of the leg, increase flexibility of the hip and ankle joints, and improve concentration.⁶⁵ Each subject demonstrated this asana once at each session. The Chair Pose is achieved by standing fully erect and flexing both arms out in front to 90 degrees, while bending at the knees and hips as if to sit down in a chair. Make sure to keep the back straight with the weight maintained through the heels. An alternative position is to come up on the balls of the feet. Hold this pose for 10 to 20 seconds and slowly return to a relaxed standing position.

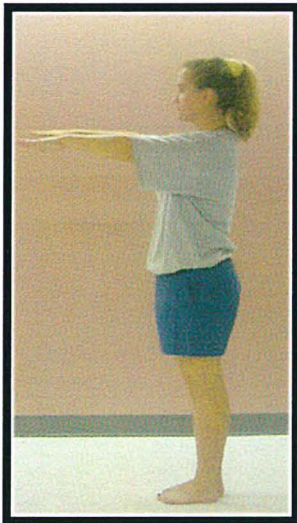


Figure 23: Chair 1



Figure 24: Chair 2

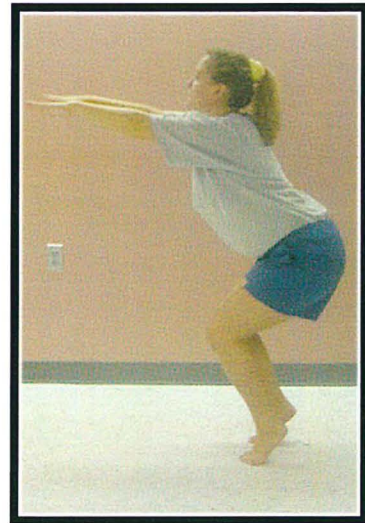


Figure 25: Chair 3

Warrior Pose

The Warrior Pose is an asana that can improve upper and lower extremity strength.⁶⁵ The pose was completed once to each side during every yoga session. To begin the Warrior, the individual must start in a standing position and walk the feet three to four feet apart. Turn the left foot inward 30 degrees and the right foot outward approximately 90 degrees. Abduct the shoulders, with elbows fully extended, out to the side 90 degrees. Turn the head to the right and lunge forward by keeping the left knee

straight and bending the right knee. To prevent overstressing the knee joint, it is important to make sure that the knee does not go past the ankle. Slowly return to standing and repeat the asana to the opposite side.

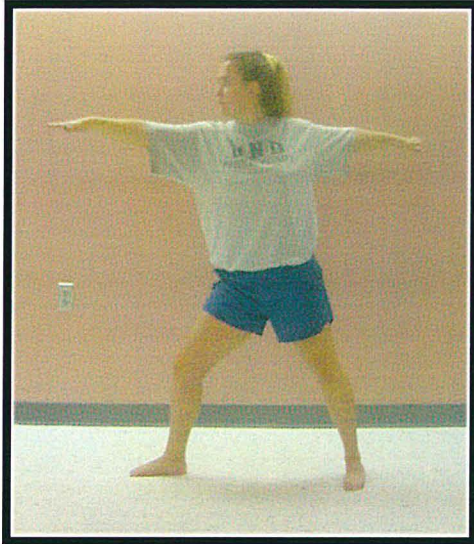


Figure 26: Warrior 1

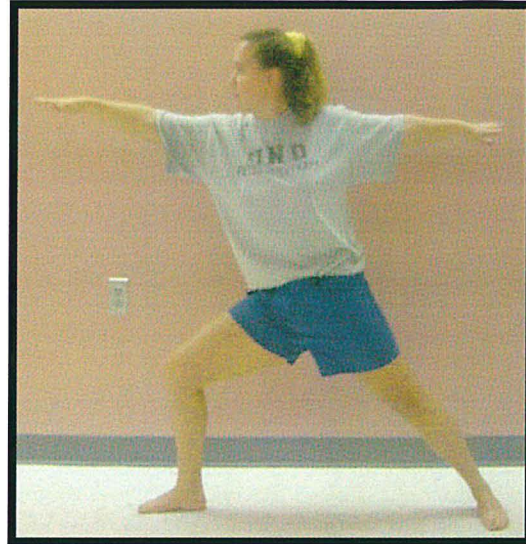


Figure 27: Warrior 2

Triangle Pose

The Triangle Pose benefits the lower extremities by increasing strength.⁶⁵ Other benefits include increasing flexibility of the arms, neck, back, and hips while tightening the abdominal muscles and assisting with an increase in chest expansion. This technique was completed once to each side during each the yoga session. To perform the Triangle Pose, the upper and lower extremities are in the same starting position as in the Warrior, prior to the lunge. For the Triangle Pose, tilt the upper body and arms in a straight line until they are parallel with the bent lower leg. Reach the left arm to the ceiling as the right arm stretches down with the fingertips barely in contact with the floor. Once the parallel position has been reached, the head should turn to look upward to the left thumb.

The pelvis should remain forward to avoid flexion at the waist. Hold for 10 to 20 seconds. Return to standing, and repeat to the other side.

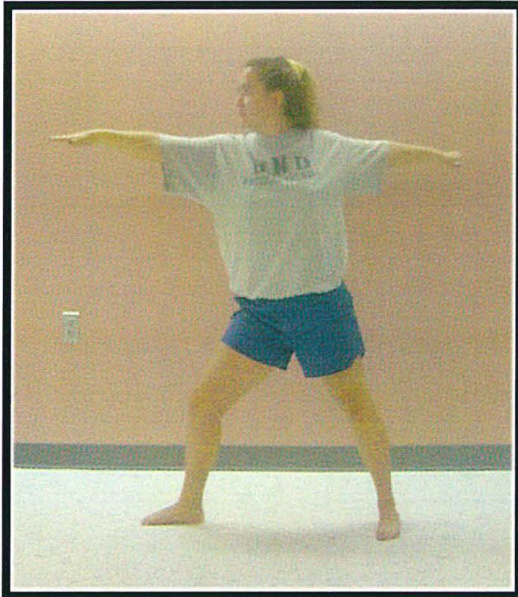


Figure 28: Triangle 1

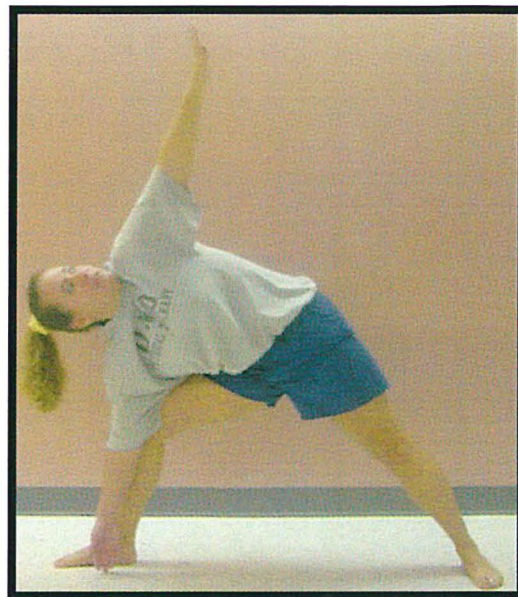


Figure 29: Triangle 2

Hiker Pose

Benefits for the Hiker Pose include upper and lower extremity strengthening, increasing hamstring flexibility, and improving balance.⁶⁵ The Hiker was performed once per side during each session. To perform this asana, position the lower extremities slightly greater than shoulder width apart. Place the hands in a prayer position with palms facing one another and elbows flexed. Slowly inhale and fully extend the arms up overhead. While bending at the waist, exhale down with the palms flat on the floor and fingertips facing each other and hold for 5 to 10 seconds. Next, extend one arm toward the ceiling as the head follows to look at the thumb. Hold this position for 10 to 20

seconds. Slowly bring the hand back down to the floor with the fingertips facing each other. Starting from this position, repeat to the other side.



Figure 30: Hiker 1



Figure 31: Hiker 2

Staff Pose

The Staff Pose can be used to increase body awareness and proprioception.⁶⁵ During each yoga session this position was performed once and held for 10 to 20 seconds. Starting in a long sitting position, fully extend the elbows and place the hands on the floor next to the hips. Press the back of the thighs into the floor by contracting the quadriceps.

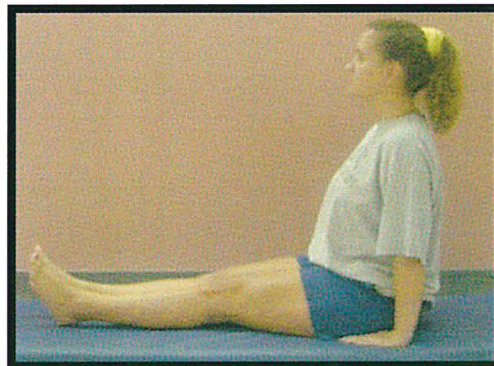


Figure 32: Staff Pose

Intense West Stretch

This posture will increase flexibility of the hamstrings and the back musculature.

⁶⁵ In the training program the group performed the Intense West Stretch (IWS) one time each session and held it for 20 seconds. In order to perform this pose, attain a long sitting position and tighten the quadriceps, while maintaining a neutral spine. Inhale and sit up tall. Exhale and reach forward to try and grab hold of both feet. While maintaining this position, inhale slowly. As the chest begins to deflate, attempt to increase the stretch by reaching further forward.

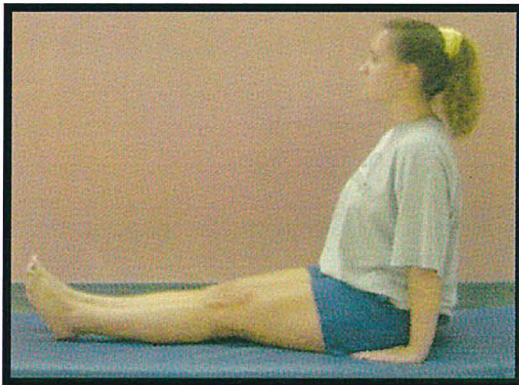


Figure 33: IWS 1

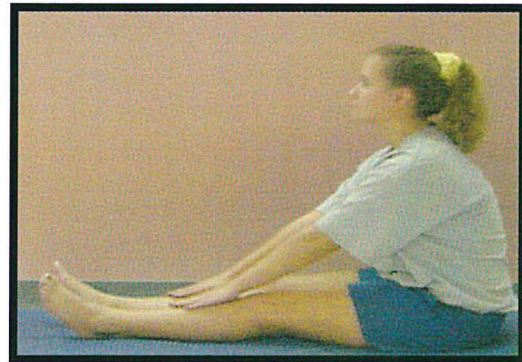


Figure 34: IWS 2

Bridge Pose

The Bridge Pose helps to increase circulation to the head and face along with decreasing back pain and fatigue.⁶⁵ This posture was held for 20 seconds and performed once during each yoga session. Begin in the supine position and bend both knees up with feet flat on the floor at approximately hip width apart and parallel to each other. Place the arms on the floor next to the body with the palms facing downward. Exhale and push

the small of the back into the floor by rotating the pelvis backward. Inhale and lift the back off of the floor in a segmental manner, while contracting the gluteal muscles.



Figure 35: Bridge 1



Figure 36: Bridge 2

Child's Pose

Relaxation is the main benefit of the Child's Pose.⁶⁵ This pose was performed once during each session and held for 50 to 60 seconds. To perform this pose, kneel down with the heels resting on the buttocks and bend forward until the forehead comes in contact with the floor. The arms should be extended behind the body with the dorsal surface of the hands resting on the floor and palms facing upward next to the feet.



Figure 37: Child's 1



Figure 38: Child's 2

Revolved Abdominal Twist

The Revolved Abdominal Twist (RAT) is a technique that assists with increasing flexibility in the shoulder and trunk regions.⁶⁵ During the training, the subjects demonstrated this asana once to each side during each session holding for 20 seconds. This pose is performed in supine with arms abducted to 90 degrees in a “T” position. Slowly bend the lower extremities up to the chest, lower the knees down to the left, and turn the head to the right. Return the bent legs to midline before performing to the other side.

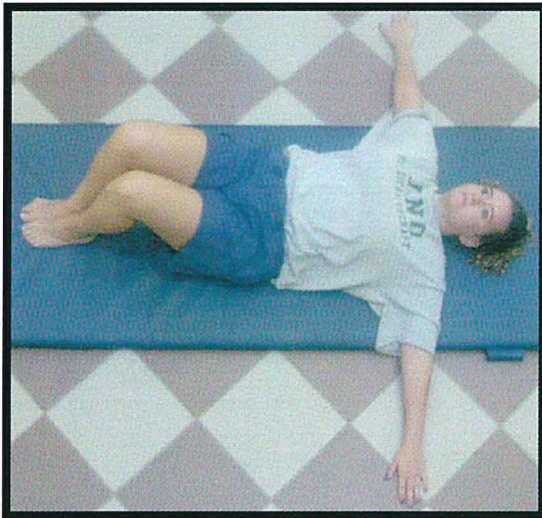


Figure 39: RAT 1

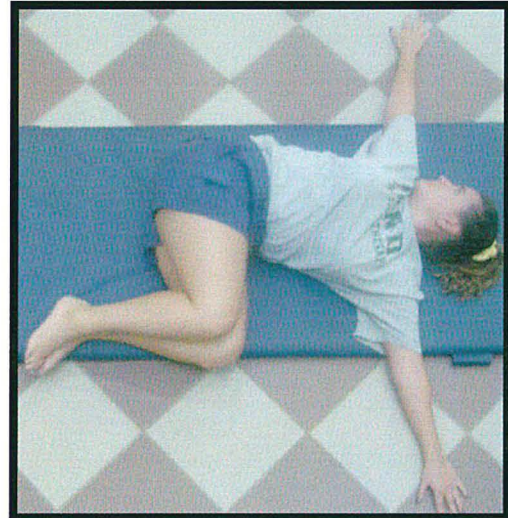


Figure 40: RAT 2

Corpse

The Corpse Pose is the primary asana for relaxation.⁶⁵ The goal is to relax all voluntary muscles and clear the mind with concentration on breathing. This posture was held for a minimum of five minutes at the conclusion of every session. Begin in the supine position with the elbows and knees fully extended in a comfortable position,

palms facing upward. Eyes should remain closed throughout the exercise. After five minutes slowly roll onto one side in the fetal position. End the asana by coming to a sitting position with forearms resting on thighs with palms up.



Figure 41: Corpse 1



Figure 42: Corpse 2



Figure 43: Corpse 3

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1. Micozzi, Marc. *Fundamentals of Complimentary and Alternative Medicine*. New York, NY: Churchill Livingstone; 1996.
2. Feuerstein, G. The history of yoga [Yrec.org]. 1998. Available at: <http://www.yrec.org/shorthistory.html> Accessed: June 10,2000.
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