2001

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

Katie M. Rood

University of North Dakota

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

by

Katie M. Rood
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 Katie M. Rood 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)

Pamela J. Melnyk
(Graduate School Advisor)

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(Chairperson, Physical Therapy)
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To my research partners, Shannon Sorenson and Kendra Van Valkenburg, thank-you for all of the long hours of work that you put into our study. Finally, thank-you to all of my classmates for making the past three years a great experience!
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 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 5,000 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 complementary 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 individuals?

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-training 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 significantly more 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

Yoga

In recent years, yoga has emerged in the Western culture as a popular form of exercise and meditation. Yoga classes are now offered in most major cities in the United States. Although many believe that yoga is a new trend, literature reports that it has been around for thousands of years.\(^1\) It is important to explore its history and benefits as the popularity of yoga arises as a form of patient therapy.

**History of Yoga**

Yoga is one of India's oldest traditions. Yoga literature traces the history of yoga back approximately 5,000 years.\(^{1,2}\) In the early 1920s, archeologists discovered the ancient Indus civilization. Depictions of figures that resemble yoga poses were engraved on the ruins of the ancient cities of Mohenjo Daro and Harappa. Although the term is most commonly associated with Hinduism, Buddhism and Jainism also contain yogic teachings.

The history of yoga is ancient and complex, and it continues to grow and evolve as it blends into the Western culture.\(^3\) Today, many forms of yoga exist throughout the world. In order to understand and appreciate yoga, it is important to gain a broad perspective on the topic. For instance, the word "yoga" is derived from the root of the Sanskrit verb "yuj" which means "to yoke" or "to join." The practice
of yoga seeks to join the mind, body, and spirit. Patanjali\(^3\) defined yoga as "the restriction of the whirls of consciousness." Yoga aims to focus attention to whatever object is being contemplated, excluding all other thoughts. The yoga practitioner is referred to as a "yogin," specifically "yogi" for males and "yogini" for females. In recent years, the term "yogist" has been used to refer to the Western practitioner, who has focused on the physical, rather than the spiritual, aspect of yoga.

In 5,000 years of existence, the yoga tradition has been handed down to several generations. Throughout the years, various additions and changes have been made to the practice. Consequently, several schools of yoga have emerged. Every school of yoga has a different focus of practice. There are two main types of yoga that are commonly practiced in the United States. The first is Raja yoga, meaning "royal" yoga.\(^3\) This type of yoga may also be called Classical, Ashtanga, or Patanjala yoga. The main focus of this branch of yoga is meditation.\(^4\) One who practices Raja yoga seeks to clear his mind and body and enter into a transcendent state.\(^4\)

Patanjali\(^2\), from the period 200 B.C.E. to 200 C.E., compiled the Yoga Sutras, which are the primary teachings of this form of yoga. In his teachings, he outlined the eight limbs of the yogic path: (1) Moral Discipline (yama) (2) Self-Restraint (niyama) (3) Posture (asana) (4) Breath Control (pranayama) (5) Sensory Inhibition (pratyahara) (6) Concentration (dharana) (7) Meditation (dyana) (8) Ecstasy (samadhi).\(^2\) The eight "limbs", also described as steps in a path, provide a systematic approach to the practice of yoga. Raja yoga claims to be the ultimate form of mind training. As Georg Feuerstein\(^3\) stated, "This meditative quest is intended to lead to
the discovery of the transcendental reality beyond thought and image, beyond worship and prayer, beyond ritual and magic."

For centuries, yoga practitioners ignored the physical body, focusing on the mind and the spirit. In Medieval times, yoga masters developed a new form of yoga that regarded the body as a temple of the immortal spirit that needs to be in optimal condition. This school of yoga, known as Hatha yoga, is the second main branch of yoga that is commonly practiced in the United States and throughout the world. It focuses primarily on postures (asanas) as well as breath control (pranayama). For the Hatha yogin, strengthening the body and purifying the nervous system are essential aspects of attaining enlightenment. He believes that by strengthening his body and adding years to his life, he will have more time to devote to his spiritual practice.

Yoga Therapy

The yoga tradition has grown and become more diverse over the years. The practice of yoga varies significantly throughout the world. In the Western hemisphere, "yoga therapy" developed from an interest by medical professionals. The difference between "yoga" and "yoga therapy" was best described when Georg Feuerstein stated, "Yoga therapy is of modern coinage and represents a first effort to integrate traditional yogic concepts and techniques with Western medical and psychological knowledge. Whereas traditional yoga is primarily concerned with personal transcendence on the part of a "normal" or healthy individual, yoga therapy aims at the holistic treatment of various kinds of psychological or somatic dysfunctions ranging from back problems to emotional stress." He also noted that
both approaches agree that the human being is an integrated mind-body system that functions best when in a dynamic state of balance.\(^2\)

Yoga therapy is a form of yoga that focuses on the health and wellness of the physical body.\(^5\) It also emphasizes the balance and integration of the mind and emotions. In yoga therapy, there is equal focus on the mind, body, and spirit. This distinguishes yoga therapy from traditional Western medical therapy, which focuses on the body.

Asanas are an important part of yoga therapy. There are over 84,000 postures used by various approaches to yoga.\(^5\) Despite the significant number of asanas, all can be described as positions of dis-equilibrium, deviating the head and trunk from the center of gravity.\(^5\) These postures are initiated, maintained for a length of time, and released in a smooth and effortless manner.

Asanas may be practiced to attain various goals.\(^6\) Three groups of asana practitioners are used to distinguish the separate goals. Spiritualists practice asanas for spiritual development, physical culturists for maintaining physical and mental health, and patients for treating diseases. Each group will vary in the type of the asanas that they perform along with the mode of performance.

In general, there are two aspects of asanas.\(^6\) The first is the dynamic aspect, which involves movement into a particular pose or movement back to a normal state after a particular pose. The movements should be performed in a relaxed manner, smoothly and without tension. For most asanas, there is a counter movement for each movement or a counter asana for the asana. They should be done consecutively in a
yoga session. Breathing should be done in a relaxed and effortless manner. The more experienced yogin will learn to inhale and exhale at certain stages of the asana. In contrast to the dynamic aspect, the static aspect of the asana involves maintaining the pose for some length of time. Each pose should be steady and comfortable. The steadiness should decrease the effort needed to maintain the pose. In turn, the decreased effort will allow the practitioner to contemplate on an infinite object and clear the mind.

Each asana can be broadly classified into one of three groups: (1) meditative, (2) relaxative, or (3) corrective. The aim of meditative asanas is to provide a steady and comfortable posture for the practice of breath control (pranayama), meditation (dyana), and concentration (dharana). These postures can be comfortably maintained for a considerable length of time. Relaxative asanas are often performed in supine or prone and are used to achieve physical and mental relaxation. Corrective asanas are used to preserve and promote optimal physical health. Regardless of classification, the main aim of all asanas is to develop physical and mental stability in order to remain in a posture for a suitable length of time.

Pranayama, like asanas, is of great importance in the practice of yoga. The importance becomes evident with the interpretation of the Sanskrit word prana, which refers to the life force. According to Telles and Desiraju, pranayama is “a state of voluntary regulated breathing while the mind is directed to the feeling of the flow of breath or prana.” The awareness and synchronization of breathing are important during the performance of yoga postures. There are different types of pranayamas practiced either during postures or separately. Alternate nostril
breathing, the complete yoga breath, and interval breathing are three techniques that are used by yoga practitioners. Incidentally, all breathing should be done through the nose, since yogins view the purpose of the mouth to be solely for eating and talking.

Yoga Research

The commonly reported psychological and physical changes noted by yoga practitioners have prompted several research studies to investigate these claims. Many scientists are interested in the effects of yoga. Significant results of the studies have led many to believe that medicine and yoga can be used to achieve optimal mental and physical functioning. The range of topics that have been studied is broad, and it continues to expand as more countries around the world develop an interest in yoga.

The effects of yoga on several different diagnoses have been studied. In a study by Singh, Wisniewski, Britten, and Tattersfield, a significant reduction in bronchial activity was found in patients with asthma who performed yoga breathing exercises (pranayama). Subjects in that study reported a decrease in bronchodilator use. Although not significant, increases in forced expiratory volume in one second (FEV₁) were also noted by the researchers. A study by Nagarathna and Nagendra that involved patients with asthma who underwent yoga training, including asanas and pranayama, found significantly greater improvement in the weekly number of asthma attacks and peak flow rate when compared to a control group. Other studies found that yoga can significantly increase pulmonary function and exercise capacity in patients with asthma.
Yoga has also been proven to be beneficial for patients with carpal tunnel syndrome (CTS). A study conducted by Garfinkel, Singhal, Katz, et al.\textsuperscript{13} found that a routine of yoga-based stretching and postural alignment significantly increased grip strength and decreased pain in patients suffering from CTS. The researchers believed that yoga increases postural awareness and may also prevent recurrences or symptoms of CTS. Significant results have also been found in yoga-based treatment for patients with arthritis,\textsuperscript{14} depression,\textsuperscript{15} diabetes,\textsuperscript{16} and epilepsy.\textsuperscript{17}

Various studies have been conducted on healthy subjects as well. In one study, six weeks of yoga training produced a significant increase in aerobic power and a significant decrease in anaerobic power.\textsuperscript{18} The researchers believed that the changes were due to a conversion of fast-twitch muscle fibers to slow-twitch muscle fibers. In a study conducted by Bera and Rajapurkar,\textsuperscript{19} the subjects performed yoga for 45 minutes per day, three times per week, for a total period of one year. As a result of the yoga training, significant improvement was found in ideal body weight, body density, cardiovascular endurance, and anaerobic power. Another study reported a significant decrease in visual and auditory reaction times and a significant increase in respiratory pressures, breath holding times, and handgrip strength in healthy volunteers.\textsuperscript{20}

Although some studies exist, significant research is lacking regarding the effects of yoga on balance, hamstring flexibility, and blood pressure. Dhume and Dhume\textsuperscript{21} found that yogic meditation (concentration) improved performance on the balance board by 27.8\%, compared to the controls. The researchers concluded "yogic meditation is of merit to achieve concentration for mental as well as physical task."\textsuperscript{21}
Meditation, which is the focus of some schools of yoga, has been shown to decrease blood pressure. In 1976, Blackwell, Bloomfield, Gartside et al.\textsuperscript{22} conducted a research study on groups of medical students that found a significant decrease in blood pressure, ranging from 8 to 12 mmHg for systolic and 5 to 8 mmHg for diastolic, after a 12-week individual meditation regimen. However, more current studies on the subjects of balance, hamstring flexibility, and blood pressure continue to be in demand in order to prove that yoga is an effective form of alternative therapy.
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 2 (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 1 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 1 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 Department of Physical Therapy. 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 Page23, a value of .9-1.00 is interpreted as a very high correlation. 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. Nashner, ScD, the NBM® has been used by physical therapists and other medical disciplines as an assessment, training, and analysis tool.24 Reliability has been established for RWS (.88), according to Liston and Brouwer.25 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.26 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.
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. 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. 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.,²⁷⁻²⁹ the FRT is an effective screening tool for balance problems and is often used by physical therapists in the clinic. Duncan²⁷ 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](image1)

![Figure 3: Functional Reach 2](image2)

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. Hamstring flexibility is important to prevent muscle strains during activity or exercise. Jackson and colleagues\(^{30,31}\) 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.\(^{30,31}\) Reliability for the sit and reach test has been determined (>.84) by the Texas Governor's Commission on Physical Fitness.\(^{32}\) 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. 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. According to Rikli & Busch, 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 deep breathing and a random combination of the same 14 asanas. A list of these 14 asanas are as follows: 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 or four 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 for 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 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 Mdiff=7.45) and on-axis velocity RWS anterior-posterior (A-P) (Sig. .048 and Mdiff = -.45) for the yoga group. Table 3 identifies significance only in SLST on the left with EC (Sig. .005 and Mdiff = -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 $\text{M}_{\text{diff}} = -2.94$), SLST with EO on the right (Sig. .043 and $\text{M}_{\text{diff}} = 2.02$), and SLST with EC on the right (Sig. .021 and $\text{M}_{\text{diff}} = -2.31$). Table 5 proves 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$^W$
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
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</thead>
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<td>1.91</td>
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<td>16.467</td>
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* 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

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>SD</th>
<th>t</th>
<th>df</th>
<th>Sig. (two-tail)</th>
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<tr>
<td>Functional reach test 1-2</td>
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<td>.778</td>
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<td>.379</td>
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</tbody>
</table>

* Significant at alpha level of .05

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

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<th>Variable</th>
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<th>SD</th>
<th>t</th>
<th>df</th>
<th>Sig. (two-tailed)</th>
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<tr>
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* Significance at alpha level of .05

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

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<th>Variable</th>
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<th>Asymp. Sig. (two-tailed)</th>
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</thead>
<tbody>
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</tr>
<tr>
<td>Systolic blood pressure test 1-2</td>
<td>-1.825</td>
<td>.068</td>
</tr>
<tr>
<td>SLST right EO test 1-2</td>
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<td>SLST right EC test 1-2</td>
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<td>.021*</td>
</tr>
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<td>SLST left EO test 1-2</td>
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<td>.068</td>
</tr>
<tr>
<td>SLST left EC test 1-2</td>
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</table>

* Significant at alpha level of .05

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

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<th>Variable</th>
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<th>Asymp. Sig. (two-tailed)</th>
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<td>SLST right EC test 1-2</td>
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<td>SLST left EO test 1-2</td>
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<td>.655</td>
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CHAPteR V

DISCUSSION AND CONCLUSION

Discussion

Despite the emergence in yoga’s popularity, the supportive evidence regarding the effects of yoga remains lacking. Today, more medical professionals are incorporating yoga into their patient interventions. Furthermore, many healthy and non-healthy individuals are enrolling in yoga classes throughout the United States. As a result, it has become increasingly important to research the effects of yoga. This study was designed to discover how yoga affects balance, hamstring flexibility, and blood pressure. The results support the hypothesis that yoga will produce significant results in balance and hamstring flexibility. Somewhat to the surprise of the researchers, a significant decrease in diastolic blood pressure and a trend toward a decrease in systolic blood pressure were also noted.

For centuries, yogis have claimed that yoga postures can improve balance. Many of the postures used in this study challenged the subjects’ balance. They involved single-limb standing or an alteration in the center of gravity for a period of time. During the postures, the subjects were instructed to concentrate on a point on the wall. As reported in Chapter II, a study by Dhume and Dhume found that yogic meditation (concentration) improved performance on the balance board by 27.8%, compared to the
controls. During re-testing, the yoga group used their skills in concentration during the single-limb stance test. This likely gave them an advantage over the walking group. Another important aspect of the yoga classes was that a number of the postures involved stretching the hamstrings. According to Bell and Seyfer, yoga involves stretching, which may increase flexibility. Static stretching has been proven to elongate muscles. Few studies, however, have compared yogic stretching to normal, non-postural stretching. The significant improvements that were found in this study may be due to the greater compliance and, therefore, more frequent stretching observed with the yoga program compared to the walking program.

The researchers did not predict a significant change in blood pressure, because the volunteers were young and healthy. Also, according to Fagard, Bieten, Hespel, et al., in order to decrease blood pressure, the exercise should be performed three or more times per week, the intensity should be at least 60% of the maximal work load, and the duration should be at least 30 minutes long. The frequency and duration of the yoga classes in this study complied with their recommendations. However, yoga is a low-intensity form of exercise.

**Limitations**

The researchers recognized several limitations that may have had a negative impact on this study. The limitations include the following: (1) Small sample size (2) Inadequate testing environment (3) Various yoga instructors involved (4) Independent walking and stretching program for the control group.

Prior to beginning the yoga and walking sessions, 18 subjects were placed into either the yoga group or the walking group. The total sample size reduced to N = 16,
because two subjects from the walking group eventually dropped out during the course of the study due to lack of participation. According to Gravetter and Wallnau,\textsuperscript{38} a sample size of at least 30 subjects is ideal to represent a population. The small sample size in this study may be an inaccurate representation of the population.

The testing took place at the University of North Dakota Department of Physical Therapy in a small, somewhat confined space. During the testing period, there were multiple subjects being tested simultaneously on the various tests. The confined space, combined with the audible distractions of simultaneous testing, may have decreased concentration and, therefore, performance on each test.

A total of six people were responsible for teaching the yoga sessions. The three HEALTHSOUTH\textsuperscript{®} instructors individually taught the sessions two times per week. The third session held each week was instructed by one of the three researchers. Each of the six instructors was unable to teach the class exclusively due to scheduling conflicts. And, although the same 14 asanas were performed at each session, the instructors had individual variations in teaching styles. The inconsistency may have impacted the results of this study.

The independence of the walking group may have also been a factor. Prior to the study, the researchers agreed to lead the walking and stretching program three times per week. After the subjects were recruited, it became evident that there was not a meeting time that worked for everyone. Therefore, the subjects were given written and verbal instructions regarding three times per week. Although the researchers questioned the subjects, there was no absolute way of knowing whether or not they complied with the frequency and components of the program. It is possible that some did not walk and
stretch as frequently as requested, while others may have increased the frequency and intensity beyond the guidelines.

**Recommendations**

The need for research on yoga is in high demand. In future studies, a larger sample size \((N = 30)\) would produce a greater representation of the population. It is also suggested that this study be done on individuals with deficits in balance, hamstring flexibility, and blood pressure, which would likely involve an older population. This population would be a greater representation of patients seeking medical care.

Removing the limitations previously discussed is recommended in future studies. The testing should be conducted in a spacious and quiet environment in order to allow the subjects to concentrate and perform at their highest level of functioning. One instructor should teach the yoga classes to maintain consistency. Ideally, all programs, including the walking program, should be led and supervised by one of the researchers.

During the course of the study, the researchers noted a greater compliance with the yoga program, compared to the walking program. Prior to the study, the majority of the subjects wanted to be placed in the yoga group. Some of the walking subjects complained that "walking is boring", and many would have preferred to be in the yoga group. If greater compliance is found to be associated with yoga, it may lead to a greater increase in physical health compared to those who are not compliant with their current exercise program.

**Clinical Implications and Conclusion**

The results of this study indicate that yoga is a valid supplement to traditional physical therapy. It is not recommended that yoga replace traditional therapy, rather, it
may be used to supplement other patient interventions. As physical therapists, it is important to provide effective treatment. Yoga therapy is another technique that will enable therapists to provide effective treatment. Also, many patients under the care of a physical therapist may be enrolled in yoga classes on their own. By understanding yoga, the therapist can recommend that the patient performs certain postures to assist in treating the dysfunction and avoids others that may aggravate his/her condition.

For the yoga group, significant improvements were found on 5 out of the 11 tests performed. Balance, blood pressure, and hamstring flexibility each had at least one test that was significant. These findings provide evidence that the practice of yoga is beneficial in improving physical well being.
APPENDIX A
EXPEDITED REVIEW REQUESTED
UNDER ITEM ___

EXEMPT REVIEW REQUESTED
UNDER ITEM ___

3 (NUMBER[S]) OF HHS REGULATIONS

3 (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,
Katie Rood, Kendra Van Valkenburg

ADDRESS TO WHICH NOTICE OF APPROVAL SHOULD BE SENT:
Cindy Flom-Meland, Box 9037 PT

SCHOOL/COLL: EGE: (E.g., A&S, Medicine, EHD, etc.)
DEPARTMENT: NT: (Month/Day/Year)

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

FUNDING AGENCIES (IF APPLICABLE): 

TYPE OF PROJECT (Check ALL that apply):

DISSEMINATION
NEW PROJECT  CONTINUATION  RENEWAL  THESIS  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)

INVESTIGATOR INVOLVES NON-APPROVED USE OF DRUG INSTITUTION

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

30
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
Principal Investigators: Katie Rood, Kendra Van Valkenburg, Shannon Sorenson

Cindy Flom-Meland
Project Director or Student Adviser: Cindy Flom-Meland

3-2-00
Date

3-2-010
Date

Training or Center Grant Director

Date

(Revised 2/2000)
STUDENT RESEARCHERS: As of June 4, 1997 (based on the recommendation of UNO 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 RECORD

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.

Date: 3-2-00
Signature of Student Researchers: Katie Rood, Kendra Van Valkenburg, Shannon Sorenson
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

Cindy Flom-Meland, Shannon Sorenson, Katie Rood, Kendra Van Valkenburg
Name: Valkenburg
Department/College: Physical Therapy
Project Number: IRB-200003-178
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 March 2-2-00 and the following action was taken:

☑ Project approved. EXPEDITED REVIEW Category No. 7
Next scheduled review is on: 3-22-00

☐ 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

Date 3-22-00

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.
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.
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: ____________________________________________________________________  

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. The lateral calcaneous was aligned with the
   "M" or "T" line according to NBM® guidelines regarding the subject's height.

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 your 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 – 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.
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. 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.

Sun Salutation A

Sun Salutation A (SSA) is an asana that assists with overall toning of the body. 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.
Reed Pose

The Reed is beneficial in stretching the upper body, firming and slimming the waistline, and stimulating blood flow to the abdominal organs. 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.
Tree Pose

The Tree Pose helps to improve concentration, balance, and lower extremity strength. 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 18: Tree 1

Figure 19: Tree 2
Dancer Pose

The Dancer has been known to be beneficial for increasing balance, flexibility of the quadriceps, and strength of the extremities.\textsuperscript{39} 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 20: Dancer 1

Figure 21: 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. 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.

Warrior Pose

The Warrior Pose is an asana that can improve upper and lower extremity strength. 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 25: Warrior 1  
Figure 26: Warrior 2

Triangle Pose

The Triangle Pose benefits the lower extremities by increasing strength. 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 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 27: Triangle 1**  
**Figure 28: Triangle 2**

**Hiker Pose**

Benefits for the Hiker Pose include upper and lower extremity strengthening, increasing hamstring flexibility, and improving balance. 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.

![Hiker 1](image1.png) ![Hiker 2](image2.png)

**Figure 29: Hiker 1**

**Figure 30: Hiker 2**

### Staff Pose

The Staff Pose can be used to increase body awareness and proprioception. 

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.

![Staff Pose](image3.png)

**Figure 31: Staff Pose**
Intense West Stretch

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

Bridge Pose

The Bridge Pose helps to increase circulation to the head and face along with decreasing back pain and fatigue. 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 34: Bridge 1  Figure 35: Bridge 2

Child’s Pose

Relaxation is the main benefit of the Child’s Pose. 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 36: Child’s 1  Figure 37: 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. 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 38: RAT 1](image1.png) ![Figure 39: RAT 2](image2.png)

**Corpse**

The Corpse Pose is the primary asana for relaxation. The goal is to relax all voluntary muscles and clear the mind with concentration on breathing. This posture was held for a minimum of 5 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 5 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 40: Corpse 1

Figure 41: Corpse 2

Figure 42: Corpse 3
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